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A valuable MRI examination method for prostate cancer screening

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Abstract

To investigate the value of the 1.5T magnetic resonance imaging (MRI) apparent diffusion coefficient (ADC) and the prostate imaging reporting and data system (PI-RADS) score in prostate cancer (PCa) screening.

Forty PCa patients diagnosed by pathology from December 2014 to September 2018 were recruited as the PCa group; 60 patients with benign prostatic hyperplasia (BPH) were recruited as the benign group. Patients from both groups underwent 1.5T MRI scanning. The prostate ADC values, exponential apparent diffusion coefficient (eADC) values, and PI-RADS scores of patients from the 2 groups were compared. The different methods for PCa diagnosis were compared.

The ADC values of patients in the PCa group were significantly lower than those in the benign group, whereas the eADC values of patients were significantly higher than those in the benign group, with statistically significant differences ($P < .05$). The differences in the PI-RADS scores of patients from the 2 groups were statistically significant ($P < .05$). Receiver Operating Characteristic (ROC) curve results showed that the ADC value combined with the PI-RADS score was superior to the ADC value or the PI-RADS score alone in sensitivity, specificity, and Youden index for PCa diagnosis. By comparing the area under the curve (AUC) of each ROC curve from the different diagnostic methods, the combination of ADC value and PI-RADS score showed the largest area.

The ADC value from 1.5T MRI combined with the PI-RADS score could be used as the standard for PCa screening, which would effectively improve screening for PCa and be valuable for clinical applications.

Abbreviations: ADC = apparent diffusion coefficient, AUC = area under the curve, Ax Dyn LAVA + C transverse 3D LAVA dynamic enhancement sequence, BMI = body mass index, BPH = benign prostatic hyperplasia, Cor LAVA + C = coronal 3D LAVA enhancement, DWI SNR = diffusion weighted imaging signal to noise ratio, DWI = diffusion weighted imaging, eADC = exponential apparent diffusion coefficient, FS T2FRFSE = fast spin echo T2 imaging sequence, GD-DTPA = gadolinium-diethylenetriamine pentaacetic acid, MRI = magnetic resonance imaging, PCa = prostate cancer, PI-RADS = prostate imaging reporting and data system, PI-RADSV2 = prostate imaging reporting and data system version 2.0, ROC = receiver operating characteristic, SI-T = signal-to-time curve, T1FSE = T1 fast spin echo imaging sequence.

Keywords: apparent diffusion coefficient value, magnetic resonance imaging, PI-RADS score, prostate cancer

1. Introduction

Prostate cancer (PCa) is one of the most common malignant tumors in the male genitourinary system,[1] and its pathogenesis involves multiple factors. Some clinical symptoms including progressive dysuria, hematuria, bone metastases may be observed in the advanced PCa, however, the vast majority or PCa are asymptomatic. Since clinical symptoms of PCa and benign prostatic hyperplasia (BPH) are usually the same, there can be misdiagnosis, and the patient's quality of life can be significantly reduced.[2,3] Currently, most medical centers employ magnetic resonance imaging (MRI) as one of the routine examination methods for clinical diagnosis of PCa.[4] In recent years, a variety of MRI techniques have been used in PCa diagnosis, and good imaging results have been obtained. Unfortunately, the cost of MRI is high and presents a heavy economic load for ordinary patients. We searched the literature and found that in 2011, Dr. Tan analyzed diffusion weighted imaging (DWI) and ADC in the diagnosis process of MRI in prostate cancer,[5] but this article did not mention PI-RADS. In 2017, Dr. Lin studied the important diagnostic performance of PI-RADS in prostate cancer,[6] however, this paper did not found the significant effect of the addition of objective ADC value measurements. In this study, we attempted to explore a simple and effective technical approach for PCa screening. We retrospectively analyzed cases where the 1.5T MRI prostate examination results were confirmed by pathological evaluation. We determined apparent diffusion coefficient (ADC) values and exponential apparent diffusion coefficients (eADC). The eADC values, prostate imaging reporting and data system (PI-RADS) scores, and ADC values combined with PI-RADS scores were compared.

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2. Materials and methods

2.1. Demography

2.1.1. General information. A total of 40 patients with PCa diagnosed by the Department of Pathology of the hospital were recruited as the PCa group, and 60 patients with BPH were recruited as the benign group. The PCa group included patients in the age range of 52 to 85 years old, with a mean age of 72.7 ± 7.86 years old. Their body mass index (BMI) value was in the range 19.27 to 30.36 kg/m^2, with a mean BMI value of 20.62 ± 2.05 kg/m^2. The symptoms included dysuria in 35 cases, acute urinary pain and hematuria in 5 cases. Gleason score showed that 6 cases were 4 points, 11 cases were 6 points and 14 cases were 8 points and 9 cases of 10 points. The mean PSA value was 14.7 ± 1.86. The benign group included patients in the age range of 54 to 86 years old, with a mean age of 70.6 ± 7.40 years old. Their BMI value was in the range 19.33 to 30.29 kg/m^2, with a mean BMI value of 20.57 ± 2.04 kg/m^2, and their PSA value was normal. There were no statistically significant differences in age, BMI values and prostate volume of patients in the two groups.

2.1.2. Inclusion and exclusion criteria.

(1) Inclusion criteria

Clinical symptoms of the patients and the results of biopsy were consistent with the diagnosis of prostate disease. The age of the included patients was less than 85 years old, all patients accepted tissue penetration needle biopsy, MRI, serum PSA tumor markers examinations. All patients signed informed consent before the study.

(2) Exclusion criteria

Excluding clinical diagnosis of urinary tract infection, prostatitis and urinary calculi. Patients who have received relevant symptomatic and supportive treatment were excluded. Patients with history of other primary tumor diseases were excluded. Patients with poor MRI imaging quality and incomplete clinical data were excluded. Patients with metal implants or clinical signs of fever, or heart, liver and lung dysfunction were excluded.

2.2. Methods

Both groups of patients were subjected to GE 1.5T-MRI examinations. The patients were placed in the advanced supine position using the 8-channel abdominal phased-array coil with the consent of the patients. This study has been approved by the Ethics Committee of the Second Affiliated Hospital of Bengbu Medical College.

2.2.1. Imaging parameters. Transverse transposition imaging of the prostate was as follows: first, T1 fast spin echo imaging sequence (T1FSE); then, a fat-suppression fast spin echo T2 imaging sequence (FS T2FRFSE); then a DWI sequence with diffusion sensitivity b values of 0 and 1000 s/mm^2. The direction of the diffusion-sensitive gradient was 6 and the number of excitations was 4. The coronal and sagittal positions were FS T2FSE. Enhanced scanning was as follows: the scanning sequence used the transverse 3D LAVA dynamic enhancement sequence (Ax Dyn LAVA + C) Coronal 3D LAVA enhancement (Cor LAVA + C). A high pressure syringe was used for cubital vein injection of contrast agent, gadolinium-diethylenetriamine pentaacetic acid (GD-DTPA), 20 ml, at the flow rate of 3 ml/s.

2.2.2. Image processing. Two senior diagnostic MRI deputy chief physicians analyzed the image data by the double-blind approach using the second edition of the PI-RADS released in the 2014 North American Radiation Conference.[7] The score was based on the shape, size, location, and signal characteristics of the lesion on T2WI. Meanwhile, the original data of the DWI scan was recorded at a Philips Nebula professional workstation, and the MR diffusion module software was used for post-processing. The ADC values and eADC values of the lesions were recorded, and the average values of ADC and eADC were plotted.

2.3. Indicator observation and criteria

In this study, either the focal low signal or the diffuse low signal of the prostate in the T2WI sequence was positive, and the PI-RADS score was used as the standard.[8,9] Postoperative prostate pathology results were used as indicators to evaluate ADC values, eADC values, and PI-RADS scores for diagnosis of prostate cancer sensitivity, specificity, and accuracy. Comparison of data on benign and malignant prostate cancer patients was performed to determine the impacts of different methods for the effectiveness of prostate cancer diagnosis.

2.4. Statistical methods

SPSS 22.0 software was used for data analysis. Measurement data were expressed as $(x \pm s)$. Data having a normal distribution were subject to t tests, and those not following a normal distribution were expressed as M (P25 ~ P75) using rank sum tests. MedCalc software was used for ROC curve analysis of diagnostic values of PCa using different strategies.

3. Results

3.1. MRI results

In total 100 cases, 32 cases of PCa patients and 47 cases of BPH were diagnosed by ADC values. In addition, 13 cases were misdiagnosed, and 8 cases were missed. Using the PI-RADS score, 30 cases of PCa were diagnosed, 44 cases of BPH were diagnosed, 16 cases were misdiagnosed, and 10 cases were missed. Using the ADC values combined with PI-RADS scores, 38 cases of PCa were diagnosed, 56 cases of BPH were diagnosed, 4 cases were misdiagnosed, and 2 cases were missed. PCa patients showed uniform low-signal nodules in the central region of the T2WI sequence, on DWI there was a high-signal nodule, and the ADC demonstrated a low-signal nodule. The signal-to-time curve (SI-T) appeared as a rapid-rising and slow-declining type (Fig. 1). In the central region of the T2WI sequence of BPH patients, a slightly lower signal nodule was seen on the right side, DWI showed a medium-high signal nodule, ADC showed a low signal nodule, and the SI-T curve was a slow-rising type (Fig. 2).

3.2. Comparison of ADC values, eADC values, and PI-RADS scores between the two groups

The ADC values from the PCa group were significantly lower than those of the benign group, while the eADC values of the PCa group were significantly higher than those of the benign group. The differences in ADC values and eADC values between the 2 groups were statistically significant ($P < .05$). There was statisti-

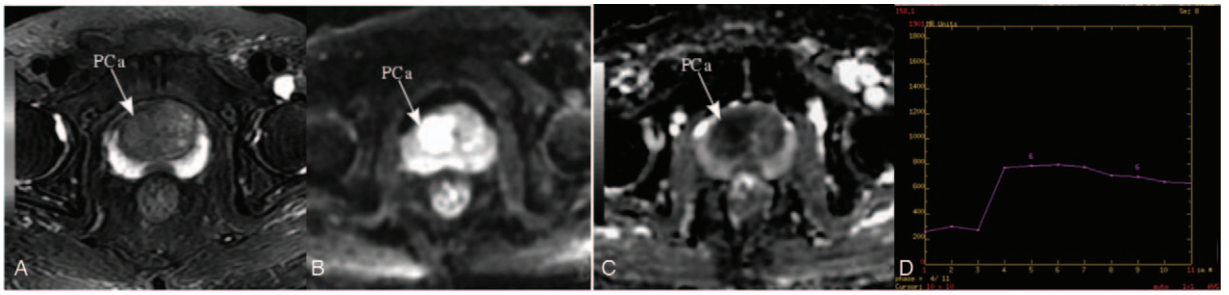

Figure 1. Magnetic resonance imaging examination of the central region of prostate cancer (PCa).

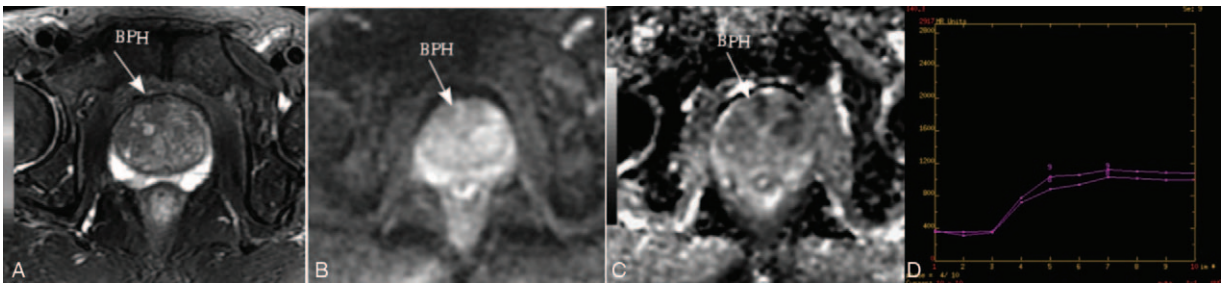

Figure 2. Magnetic resonance imaging results of the central region of benign prostatic hyperplasia (BPH).

cally significant difference shown by comparing the PI-RADS scores between the two groups ($P < .05$) (Table 1).

3.3. Analysis of effects of different methods for diagnosis of PCa

For ROC curve analysis, the method of combing the ADC value with the PI-RADS score was superior to using either the ADC value or the PI-RADS score alone in the diagnosis of PCa by sensitivity, specificity, and the Youden index. In regard to the area under the ROC curve (AUC) of different diagnostic methods, the combination of the ADC value and the PI-RADS score gave the maximum AUC value (Table 2).

4. Discussion

At present, whether prostate biopsy should be performed in patients with mild PSA abnormality and whether MRI examination should be performed before prostate biopsy is the main controversial issue. Some researchers believe that prostate MRI examination before prostate biopsy can improve the positive rate of prostate biopsy and avoid unnecessary biopsy for non prostate cancer patients. Many studies have shown that there is a significant correlation between the results of multi parameter MRI and the results of prostate biopsy. Especially for PI-RADS, there is a strong predictive value for bed significant prostate cancer.

Studies have shown that the PI-RADS scoring system could be used as an international standard for interpretation and reporting of PCa images, which could easily identify PCa lesions.[10] The T2WI sequence, as the major component of the PI-RADS score, could be used as an independent parameter in the overall PI-RADS score. The ADC value is an important parameter index for DWI quantitative analysis of the intensity of the lesion signal. The ADC value objectively reflects the degree of diffusion of water molecules in biological tissues and correlates with the degree of malignancy of the tumor. The ADC value has been clinically used for screening of tumors in liver, pancreas, and in the gastrointestinal tract.[11,12] The eADC value is obtained by dividing the DWI signal by the SE-EPI sequence of the T2WI signal. The eADC value eliminates the T2 penetration effect[13,14] and is regarded as a quantitative indicator to measure the change of the diffusion rate of water molecules in living tissues.[15] At the present time, studies on eADC values have not been fully explored by multiple institutions. In this report, we found that the eADC value had similar effects to the ADC value in diagnosis of

Table 1

Comparison of PI-RADS scores between the two groups.

Group	n	PI-RADS score	ADC ($\times 10^{-3}$ mm^2/s)	eADC
PCa group	40	4 (2–5)*	$0.81 \pm 0.21^{**}$	$0.55 \pm 0.08^{**}$
Benign group	60	2 (1–3)*	$1.10 \pm 0.21^{**}$	$0.43 \pm 0.10^{**}$
Z/t		-4.763^{a}	6.832^{b}	6.430^{b}
P		<.001	<.001	<.001

(1) a: rank sum test, b: *t* test; (2) * M (P25–P75); $^{**}\bar{x} \pm s$; (3) ADC = apparent diffusion coefficient, eADC = exponential apparent diffusion coefficient, PCa = prostate cancer, PI-RADS score = prostate imaging reporting and data system score.

Table 2

Comparison of effects of different methods for diagnosing PCa.

Parameters	Sensitivity	Specificity	Youden index	AUC	Z	P
ADC ($\times 10^{-3}$ mm^2/s)	80.00%	78.33%	58.33%	0.871	10.736	<.001
PI-RADS	75.00%	73.30%	48.33%	0.833	8.669	<.001
PI-RADS combined with ADC	95.00%	93.30%	88.33%	0.942	18.536	<.001

ADC = apparent diffusion coefficient, AUC = area under the ROC curve, PI-RADS score = prostate imaging reporting and data system score.

PCa and BPH; this was statistically significant ($P < .05$). In particular, by using pseudo-color mapping to identify lesions, the eADC value enabled faster and more efficient identification of abnormal lesions than did ADC by a specific color. Nevertheless, it is very difficult to distinguish PCa and BPH by pseudocolors.

In this study, we found that the ADC value of the PCa group was significantly lower than that of the benign group using 1.5T MRI scanning. The eADC value and PI-RADS score of the PCa group were significantly higher than those of the benign group. Zhang et al reported that the PI-RADS score was beneficial for PCa examination.[16] PCa patients could be assessed and effectively diagnosed based on the ADC value and the PI-RADS score. The ADC value could be used to identify central prostate cancer,[17–19] as confirmed in the studies of Wen Shurong, Liu Li, and others. The ADC value in 1.5T magnetic resonance DWI can be used as the main strategy for PCa screening. By analyzing the ROC curve, it was found that the ADC value combined with the PI-RADS score was superior to either the PI-RADS score or the ADC value alone in the diagnostic sensitivity, specificity, and Youden index of PCa screening. The Youden index is also called the correct index, as it represents the total ability of the screening method to find real patients and non-patients. The higher the index, the better the screening data, and the greater the authenticity.[20,21] By comparing the AUC values of different methods, it was found that the AUC value of the combination of the ADC value and the PI-RADS score was the largest, suggesting that this combination showed a high value for PCa screening. This could effectively improve the screening capacity for small lesions, thereby improving screening accuracy for PCa.

In summary, the ADC value of 1.5T MRI is an important approach for PCa screening, and it also effectively improves the PCa screening efficacy of the PI-RADS score. The MRI ADC value combined with the PI-RADS score is worthy of further clinical application. Due to the limitation of the number of specimens and MRI system, in the future, large sample and multi center research is still needed to further confirm the accuracy of the conclusion. In addition, DWI signal to noise ratio (DWI SNR), Prostate Imaging Reporting and Data System Version 2.0(PI-RADSV2) and other MRI parameters provide multiple effective methods for the diagnosis and treatment of prostate cancer.[22]

Author contributions

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Formal analysis: Haiming Cao
Project administration: Xuezhen Yang
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Software: Xu Jiang

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