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Original Article

Diagnostic Efficacy of Bi-Parametric Versus Multiparametric Magnetic Resonance Imaging for Detection of Prostate Cancer in Thai Patients

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Abstract

Background: The bi-parametric MRI (bpMRI) was based on T2-weighted (T2W) imaging and functional sequence diffusion-weighted imaging (DWI). The multiparametric MRI (mpMRI) comprises bpMRI and dynamic contrast enhancement (DCE). However, the value of DCE in the detection of prostate cancer is still controversial. This study aimed to evaluate the diagnostic accuracy of bpMRI versus mpMRI for prostate cancer.

Methods: Retrospective analysis of 109 patients who underwent mpMRI with prostate biopsy from January 2015 to March 2021. The bpMRI included T2W, DWI, and the apparent diffusion coefficient (ADC) map, and DCE was added to the mpMRI with masked clinical and laboratory information. Two diagnostic radiologists interpreted both examinations separately. The performance, diagnostic test accuracy, and subgroup analysis were analyzed.

Results: Around one-third (31.2%) of 109 patients were positive malignancies. The diagnostic accuracy of bpMRI was less than mpMRI, especially in the PI-RADS 3 group. The intra-observer agreement between bpMRI and mpMRI was moderate. The inter-observer agreement between the two readers was minimal agreement. The mpMRI was more accurate in detecting prostate cancer than bpMRI, especially in the PI-RADS 3 group.

Conclusion: Our study showed that mpMRI was higher than bpMRI for detecting prostate cancer in both readers, especially diagnostic accuracy improvement in the PI-RADS 3 group.

Keywords: Prostate cancer, PCa, MRI prostate gland, bpMRI, mpMRI

Introduction

Prostate cancer was the 2nd most common cancer affecting men worldwide in 2020 and the fourth most common malignancy (9.2%) in the Thai male population.[1] Targeted prostate cancer screening was based on digital rectal examination (DRE) and serum PSA levels to reduce mortality.[2] Early diagnosis, targeted therapy, and accurate monitoring following the radical prostatectomy had a significant impact on the prognosis of these patients.[3]

MRI has been used for the non-invasive assessment of the prostate gland and surrounding structures. The standard biopsy did not cover all parts of the prostate; hence, the biopsy did not represent the whole gland in most cases.[4] The combination of diffuse tensor imaging (DTI) and dynamic contrast enhancement (DCE) had significantly better accuracy in prostate cancer diagnosis than either technique alone[5] before transrectal ultrasound-guided biopsies.[6] Diffusion-weighted imaging (DWI) and apparent diffusion coefficient (ADC)

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map imaging sequences could improve both qualitative and quantitative evaluation of prostate cancer.[7-8] Moreover, Gadolinium contrast administration helped detect prostate cancer.[9-11]

Normal anatomy of the prostate gland, from superior to inferior, consisted of the base (just below the urinary bladder), the mid-gland, and the apex. It was divided into four histological zones including: 1) The anterior fibromuscular stroma (AFS) contained no glandular tissue; 2) The transitional zone (TZ) contained 5% of the glandular tissue; 3) The central zone (CZ); contained about 20% of the glandular tissue and 4) The peripheral zone (PZ) contained 70-80% of the glandular tissue. Approximately 70-75 of prostate cancer originated in the PZ and 20-30% in the TZ.[12-14]

The overall objective of the revised Prostate Imaging Reporting and Data System (PI-RADS v2.1) was to improve patient outcomes, including detection, localization, characterization, and risk stratification in patients with suspected cancer in the treatment of naive prostate glands.[6] Bi-parametric MRI (bpMRI) protocol based on T2-weighted (T2W) images and the functional sequences DWI. Multiparametric MRI (mpMRI) based on T2W images, DWI, and DCE functional sequences. However, the value of mpMRI in the detection of prostate cancer was still controversial. Some studies showed that combining DCE with T2W images and DWI did not significantly improve the diagnostic accuracy of prostate cancer.[7] There were many advantages to using bpMRI rather than mpMRI for the diagnosis of prostate cancer; mpMRI had a longer scan time, needed IV gadolinium contrast, more cost, risk for contrast complications, and limitations in poor renal function patients.[2,7-8] Moreover, bpMRI prostate protocol was more feasible for prostate cancer detection than mpMRI protocol,[3] with no difference in diagnostic performance.[2-4,7-8,15-17]

Our study aimed to evaluate the diagnostic accuracy of bpMRI versus mpMRI for prostate cancer patients.

Materials and Methods

Ethical Consideration

A retrospective descriptive diagnostic study was conducted at a university-based tertiary referral center in Thailand. The study was conducted following the Declaration of Helsinki, and the Ethics Committee approved the protocol for Human Research.

Study Population

The MRIs of the prostate gland of suspected prostate cancer patients from January 2015 to March 2021 were retrospectively reviewed.

Inclusion criteria

1. Patients who were suspected of prostatic cancer.
2. Patients who underwent MRI of the prostate gland.
3. Patients who underwent prostatic biopsy with pathology confirmed.

Exclusion criteria

Patients who were treated before undergoing an MRI of the prostate gland, including surgery, radiation therapy, chemotherapy, or hormonal therapy.

Hardware and Data Acquisition

All examinations were performed in a 3T MRI scanner (Achieva dStream, Philips Healthcare) or 1.5T MRI scanner (Aera, Siemens AG 2012) without an endorectal coil.

All mpMRI included tri-planar (axial, sagittal, and coronal) views, according to European Society of Urogenital Radiology (ESUR) guidelines, involved T2W turbo spin-echo images, DWI in the axial plane with multiple b-values (b = 0, 100, 800, 1000, 1500) where b = 1,000 or 1,500 s/mm^2 was used for visual assessment and the remaining three b-values in the calculation of the ADC map and the DCE, T1-weighted (T1W) images in the axial plane.

Image interpretation

The image interpretation was independently done by two advanced body imaging radiologists (one was an experienced uro-genitourinary radiologist) with masked patient information. First, all MRI images were classified index lesions with a bi-parametric diagnostic approach involving T2W, DWI, and ADC-map images, according to the PI-RADS v2.1, whereas the DCE sequence was ignored. Second, DCE sequences were included in the same MRI images, and the whole mpMRI examination was re-classified according to PI-RADS v2.1. Diagnostic accuracy, tumor detection rate, and bpMRI and mpMRI sub-group analysis were compared. The study also categorized the PI-RADS scoring system as negative (PI-RADS 1-2), intermediate (PI-RADS 3), and positive (PI-RADS 4-5).

The pathological result was categorized as benign and malignant based on the Gleason score. Malignancy was significant PCa (Gleason ≥ 6, at least 3+3).

Statistical analysis

Categorical variables were demonstrated as numbers (percentages). Continuous variables were demonstrated as mean (standard deviation, SD) or median (interquartile range, IQR). Comparison of categorical and continuous variables of subgroups was performed using Fisher's exact test and/or Chi-square test, as appropriate. A *p*-value < 0.05 was considered statistically significant.

Sensitivity and specificity, likelihood ratio (LR), test yield (YD), and accuracy were calculated for both readers and both methods.

Results

A total of 400 MRI examinations of patients between January 2015 and March 2021 were retrospectively reviewed; 291 studies were excluded due to no clinical suspicion of prostate cancer, incomplete data, and prior treatments (including surgical, radiation, and hormonal therapy). Thus, 109 MRI studies met inclusion criteria and were included in analyses.

The patient's ages ranged from 50-89 years (mean ± SD, 66.8 ± 7.18), 34 of 109 patients (31.2%) were positive for PCa. The median of serum PSA levels was 10.59 ng/mL (IQR = 6.76 - 15.0), and the median of prostate volume was 39.62 cm3 (IQR = 19.81 - 63.49). There was no significant difference in serum PSA levels between benign and malignancy groups ($p = 0.073$). (Table 1).

A significantly larger proportion of cancer occurred in the peripheral zone (p = 0.001). The tumor in the transitional zone was not significantly different between the different PI-RADS groups (Table 2).

Table 1 Demographic and clinical data of the study population

Characteristic	Patients (n = 109)	*p*-value
Age (years)		
Mean (SD)	66.87 (7.18)	0.989
Minimum-Maximum	50.8-89.7	
Serum PSA levels (ng/mL)		
Median (IQR)	10.59 (6.76-15.9)	0.725
Serum PSA levels (ng/mL), median (IQR)		0.073
Benign	10.29 (6.49-14.90)	
Malignant	11.78 (9.11-21.95)	
Prostate gland volume (cm^3)		
Median (IQR)	39.62 (19.81-63.48)	0.843
Biopsy results, n (%)		
Benign	75 (68.8)	
Malignant	34 (31.2)	

Table 2 The location of the lesion with positive PCa

Location	Benign	Malignant	Total (n = 109)	*p*-value
Right lobe	34	14	48	0.809
Left lobe	35	18	53	0.807
Both lobes	6	2	8	0.873
Peripheral zone	30	25	55	0.001*
Transitional zone	45	9	54	0.2
Apex	20	8	8	0.650
Mid-gland	46	21	67	0.492
Base	7	1	2	0.539

*Statistical significance

There was a significant increase in the number of prostate cancers among the higher PI-RADS groups. The difference was significant in both bpMRI and mpMRI for both readers. The mpMRI showed less cancer in the intermediate group and more in the positive group than in the bpMRI (Table 3).

Table 3 Assessment of the categorized PI-RADS scoring system from both readers

PI-RADS score group	Reader 1				Reader 2			
	bpMRI		mpMRI		bpMRI		mpMRI	
	Benign	Malignant	Benign	Malignant	Benign	Malignant	Benign	Malignant
Negative	6	0	5	0	35	4	34	1
Intermediate	35	6	23	3	12	7	11	3
Positive	34	28	47	31	28	23	30	30

The sensitivity and specificity between bpMRI and mpMRI were similar. However, these parameters were quite different between both readers. The mpMRI resulted in a higher positive, negative, and overall test yield and slightly higher accuracy than bpMRI (Table 4).

Table 4 The accuracy of bpMRI and mpMRI from both readers.

Parameters	Reader 1		Reader 2	
	bpMRI	mpMRI	bpMRI	mpMRI
Sensitivity	1	1	0.852	0.968
Specificity	0.15	0.096	0.555	0.531
LR+	1.176	1.106	1.916	2.064
LR-	0	0	0.556	0.53
LR+-	0.378	0.287	1.287	0.602
Overall test yield	0.623	0.761	0.826	0.872
YD+	0.823	0.912	0.794	0.912
YD-	0.533	0.693	0.84	0.853
Accuracy	0.312	0.330	0.532	0.587

Intra-observer agreement between bpMRI and mpMRI was moderate; Cohen Kappa = 0.707 (reader 1) versus Kappa = 0.682 (reader 2). Inter-observer agreement (same and different modalities) was minimal (Cohen Kappa ranged from 0.245 to 0.335). The inter-observer agreement was weak for PIRADS 4-5 lesions (Cohen Kappa ranged from 0.411 to 0.582).

Discussion

The study found no significant difference in serum PSA levels between benign and malignant patients. Nevertheless, serum PSA levels and the number of patients were significantly increased in PI-RADS 5 group patients in both bpMRI and mpMRI of both readers, which were concordant with the high-risk prostatic cancer group and represented locally advanced prostatic cancer.

After subgroup analysis correlation of PI-RADS score and tumor grade group, the study showed the tumor in higher pathology grade groups (grade 3-5) was found more frequently in PI-RADS 4-5 groups in both readers. A higher PI-RADS score helped predict a higher Gleason score, indicating clinically significant PCa and poor prog-

nostic factors.[18] Not only does the PI-RADS score helps predict the Gleason score, but it also reduces the number of unnecessary biopsies while maintaining a high rate of diagnosis of clinically significant prostate cancers.[19]

The number of lesions in transitional zone cancers was not significantly different between the different PI-RADS groups, which could be from difficulty in achieving high accuracy in the diagnosis of PCa of the TZ due to the described stromal tissue in the TZ, similar to the previous study,[20] even mpMRI using the combination of sequences had the potential to improve the accuracy of TZ cancer detection and staging.[21-22]

Similar to another study,[23] both readers showed that mpMRI could improve diagnostic accuracy. Moreover, mpMRI resulted in a lower likelihood of intermediate results (PIRADS 3) from both readers, higher positive-, negative-, overall test yield, and slightly higher accuracy than bpMRI. The PROMIS study showed that incorporating mpMRI into the initial test before prostate biopsy reduced unnecessary biopsies, improved detection, and increased the cost-effectiveness of the prostate cancer diagnostic and therapeutic pathway.[24]

The interpretation of prostate MRI was operator-dependent, as was evidenced by the noticeable difference in the accuracy between both readers. The agreement between bpMRI and mpMRI was substantial for both readers. However, the agreement between the two readers was only minimal.

The limitation of this study was a retrospective design in which confounding factors may be presented. In addition, some pitfalls confounding prostate MRI interpretation included motion artifact, history of previous prostate biopsy, full urinary bladder, bowel artifact, and infection process such as a prostatic abscess. Furthermore, normal anatomic structures mimicked focal lesions such as stromal BPH nodules and technical challenges like anatomical distortion of high-b-value diffusion-weighted images that might lower the sensitivity for tumor detection.

Conclusion

Our study showed that mpMRI was higher than bpMRI for detecting prostate cancer in both readers, especially diagnostic accuracy improvement in the PI-RADS 3 group.

List of Abbreviations

ADC = Apparent diffusion coefficient; AFS = Anterior fibromuscular stroma
bpMRI = bi-parametric MRI; CZ = Central zone
DCE = Dynamic contrast enhancement; DRE = Digital rectal examination
DTI = Diffuse tensor imaging; DWI = Diffusion-weighted imaging
ESUR = European Society of Urogenital Radiology; IQR = Interquartile range
LR = Likelihood ratio; MRI = Magnetic Resonance Imaging; mpMRI = multiparametric MRI
PCa = Prostatic cancer; PI-RADS = Prostate Imaging Reporting and Data System
PSA = Prostatic Specific Antigen; PZ = Peripheral zone; SD = Standard deviation
T1W = T1-weighted; T2W = T2-weighted; TRUS = Transrectal ultrasound
TZ = Transition Zone; YD = Test yield

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