Significant Prostate Cancer in Patients with PI-RADS Category 3 Lesions: A Single-Center, Retrospective Cohort Study

Burçin TUNÇ [1]*, Mert GENÇTÜRK[2], Adem AKTÜRK[2], Fatih KANTARCI[2]

Purpose: The Prostate Imaging-Reporting and Data System (PI-RADS) category 3 is the most ambiguous lesion with a variable clinically significant prostate cancer (CsPCa) detection rate. Prostate-specific antigen density (PSAD) has been investigated as an adjunctive factor to improve the diagnostic efficiency of PI-RADS categories. This study aimed to investigate the utility of PSAD as an adjunctive factor in predicting CsPCA risk in patients with PI-RADS 3 lesions.

Materials and Methods: The patients with an initial PI-RADS 3 category lesion (n = 142) scheduled for systematic and magnetic resonance imaging-guided prostate biopsy between 2018 and 2022 were retrospectively evaluated. Demographic and clinical variables, including PSAD, were collected. The rate of CsPCa was the primary outcome. The impact of PSAD on the CsPCa detection rate was the secondary outcome.

Results: The median age was 62 years. The rate of CsPCa was 8.5% (n = 12). The patients with CsPCa have significantly lower prostate volüme and higher PSAD levels than those without CsPCa ($p = 0.016$ and $p = 0.012$). The cut-off values of PSAD in predicting CsPCa in all PI-RADS 3 patients and patients with CsPCa and clinically insignificant prostate cancer (n = 26) were ≥ 0.181 ng/ml^2. The sensitivity and specificity values for PSAD ≥ 0.181 ng/ml2 were of 75% (95% CI: 42.8%-94.5%) and 81.5% (95% CI: 73.4%-88.0%) in predicting CsPCa among PI-RADS 3 category.

Conclusion: PSAD values higher than 0.181 ng/ml2 can be used as an adjunctive clinical parameter in predicting CsPCa in patients with PI-RADS 3 lesions and differentiating CsPCa from clinically insignificant prostate cancer cases.

Keywords: prostate cancer; multiparametric prostate MRI; PI-RADS score; PSAD; sensitivity

INTRODUCTION

Multiparametric magnetic resonance imaging (mpMRI) of the prostate gland is the gold standard for diagnosing and evaluating prostate cancer[1-3]. The Prostate Imaging-Reporting and Data System (PI-RADS) categories have been developed to diminish variation in the acquisition, interpretation, and reporting of prostate mpMRI examinations[2,4,5]. Its latest version (v2.1) has been designed to improve detection, localization, characterization, and risk stratification in patients with suspected cancer to treat naïve prostate glands[4,6]. A 5-point scale of the PIRADS v2 is used to describe the lesions indicating the likelihood of clinically significant prostate cancer (CsPCa); as the higher risk with the PI-RADS category 5[2,6,7].

Depending on the institutions and reader expertise, the different PI-RADS categories have variable cancer detection rates[1,5]. Among these categories, PI-RADS 3 lesions are ambiguous, representing a gray zone between chronic inflammation, indolent stromal hyperplasia, clinically insignificant prostate cancer, and invasive pathologies[1,5,8]. Biopsy procedures are not recommended for lesions with a PI-RADS score < 3 due to mpMRI's high negative predictive values of up to 95% [9-11]. The CsPCa rates for PI-RADS category >3 lesions ranged from 62% to 92%, leading to a general recommendation to biopsy these lesions[9,12]. However, PI-RADS 3 category is the most challenging scenario, with 60-85% of unnecessary biopsies and a 60% of clinically insignificant prostate cancer (CisPCa) detection rate [9,13]. Besides, the CsPCA detection rates for these lesions show significant variations[2,14, 15]. Although several guidelines, including the British NICE and the European Association of Urology, recommend performing biopsy procedures for the prostatic PI-RADS 3 lesions, overdiagnosis, and overtreatment choices might be possible[16]. So, there is still a debate about whether a biopsy should be performed for PI-RADS 3 lesions[1,2,5, 15,17,18].

Several clinical and imaging findings as the metric risk factors, including prostate-specific antigen density (PSAD), have been proposed to stratify the risk of prostate cancer and improve the predictive power of mpMRI to detect CsPCa in patients with PI-RADS 3 lesions[1,5,7,19,20,21]. That way, it is possible to manage the selection of the most appropriate subset of patients with PI-RADS 3 lesions to be biopsied. Previous studies reported promising results about the combined use of PSAD in patients with PI-RADS 3 lesions[6,7,20, 21].

[1]Surp Pırgiç Armenian Hospital, İstanbul, TURKEY, Department of Urology.
[2]Surp Pırgiç Armenian Hospital, İstanbul, TURKEY, Department of Radiology.
*Correspondence: Yayla Mah, Cinderesi Cad Elysium Cool A1 Kurtuluş Şişli Istanbul Türkiye.
e-mail: burcintunc@yahoo.com
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Table 1. Demographic and clinical characteristics of the study group (n=142)

		Overall (n=142)	Group 1 (n=130)	Group 2 (n=12)	*p*
Age (year) †		62 (60.0-64.0) [57-67]	62 (60-63) [57-66]	66 (57-72] [61-70]	0.102
Prostate volume (ml) †		54 (49.0-57.0) [42-70]	55 (51-58) [42-71]	42.4 (25.+56) [26-55]	0.016
PSA (ng/ml) †		7.1 (6.2-8.0) [5.1-9.0]	7 (6.2-7.8) [5.2-9.0]	8.15 (4.6-10.0) [4.7-9.8]	0.810
PSAD (ng/ml2) †		0.13 (0.114-0.141] [0.091-0.176]	0.124 (0.113-0.135) [0.092-0.161]	0.195 (0.108-0.267) [0.146-0.249]	0.012
PSAD group ‡	Low	100	97 (81.5)	3 (25.0)	< 0.001
	High	31	22 (18.5)	9 (75.0)	
	Missing	11 (7.7)	11	0	
Diameter (mm) †		10 (10.0-10.0) [6-12]	10 (9-10) [8-12]	10.5 (9-14] [9-13]	0.598
Number of lesions †		1 (1-1] [1-2]	1 (1-1] [1-2]	1.5 (1-2) [1-2]	0.171
Anterior lesion †		26 (18.3)	23 (17.7)	3 (25.0)	0.460

†: median (95% CI) [IQR1-IQR3], ‡: n (%)
CI: confidence interval, IQR: interquartile range.
Group 1: Patients with benign prostatic hyperplasia and clinically insignificant prostate cancer, Group 2: patients with clinically significant prostate cancer, PSA: prostate-specific antigen, PSAD: prostate-specific antigen density.

However, conflicting results with heterogeneous evidence have shown little diagnostic value of PSAD to the PI-RADS classification[22-24]. So, the reliability of PSAD combined with the PI-RADS category remains controversial.

This study aimed to evaluate the CsPCa rates among patients with PI-RADS 3 lesions and investigate the utility of PSAD as an adjunctive factor in predicting CsPCA risk in patients with PI-RADS 3 lesions.

MATERIALS AND METHODS

Study

This study was a retrospective, single-center analysis of all consecutive patients with an initial PI-RADS 3 category lesion scheduled for systematic and mpMRI-guided prostate biopsy procedures in the Urology and Interventional Radiology clinics Surp Pırgic Armenian Hospital, Istanbul, Turkey.

Patients with the PI-RADS categories of at least three were referred to the hospital as the referral center for the prostatic biopsy approaches. The local institutional review board approved the study (Institutional Review Board, Surp Pırgic Armenian Hospital, 30.12.2021-734). The study was conducted following the principles of the Declaration of Helsinki. The written informed consent could not be taken from the patients due to the retrospective design of the study and the unanimity of data.

Patients

All patients who underwent the systematic and mpMRI-based targeted biopsy approaches between 2018 and 2022 were evaluated in the study. All biopsy procedures were performed transrectally. We did not include the patients with prior prostate cancer therapy, 5-α reductase inhibitors treatment within three months of the biopsy, and previous prostate biopsy. Three hundred eight patients underwent prostatic biopsy approaches. The radiological diagnoses of PI-RADS categories 4 (n = 130, 42.2%) and 5 (n = 36, 11.7%) were excluded. In the end, 142 patients (46.1%) with PI-RADS 3 category lesions were included in the study.

Interventions

As a general policy, we initially performed a mpMRI-based targeted biopsy in all patients, followed by a systematic biopsy. This institution performed the mpMRI images with a 3.0 Tesla MRI (SignaTM Pioneer AirTM, GE Healthcare, United States). The mpMRI images with good imaging quality obtained in the other imaging centers were loaded into the radiology information system. One experienced radiologist (MG) with more than ten years of experience in prostate mpMRI studies reviewed the images.

Any lesion with the highest PI-RADS score was regarded as the dominant lesion in the case of multiple lesions with different scores. The biopsy procedures were performed according to previously defined principles[25,26]. A 12-core systematic ultrasound-guided prostate biopsy and 3 to 10-core mpMRI-guided targeted biopsy (median 5) procedures were performed by a urologist (BT) with at least ten years of experience with performing standard biopsies and the radiologist (MG) with more than ten years of experience in performing mpMRI-guided targeted biopsy procedures. The median number of positive core biopsies for the systematic and mpMRI-based targeted approaches were six and three. A cytopathologist with more than eleven years of experience performed the histopathological evaluation of the biopsy specimens.

Variables

Data about the demographic and clinical variables, including serum prostate-specific antigen (PSA), prostate volume (ml), PSA density (PSAD) (ng/ml2), number and the maximum diameter of prostatic lesion or lesions, the Gleason scores of each positive core, anteriorly located lesions, and the histopathological diagnoses were collected using the hospital information system and the medical files of the patients. According to the 2014 International Society of Urological Pathology (ISUP) grade, the grades were specified in the final pathology report[26]. Prostate cancer with a Gleason score of 6 was defined as CisPCa. The scores greater than six were considered CsPCa.

Groups

Based on the ISUP grades, the patients with benign prostatic hyperplasia or CisPCa were grouped as Group 1. Group 2 included the patients with CsPCa.

Statistical analysis

The rate of CsPCa detection rate was the primary outcome. The secondary outcome was to analyze the impact of PSAD on the cancer detection rate.

Descriptive statistics were given as a median with an interquartile range of 25% (IQR1) and an interquartile range of 75% (IQR3) for continuous variables depending on their distribution. We added the median difference estimates with 95% confidence intervals (Cis). Numbers and percentages were used for categorical

Table 2. The diagnostic efficacy of PSAD-based model in diagnosing CsPCa in patients with PI-RADS 3 lesions.

		CsPCa	
		Positive (n=12)	**Negative (n=119)**
PSAD groups	High (n=31)	9	22
	Low (n=100)	3	97

CsPCa: clinically significant prostate cancer, PSAD: prostate-specific antigen density.

variables. The normality of the numerical variables was checked by the Kolmogorov-Smirnov and Shapiro-Wilk tests and by Q-Q plots and histograms.

The Pearson Chi-Square test compared differences between categorical variables in a 2x2 table setup when the cell numbers were five or more. In the RxC table setup, the Fisher's Exact test was used when the cell numbers were less than 5.

The Mann-Whitney *U* test compared two independent groups where numerical variables were without normal distribution.

The receiver operating characteristic (ROC) curves were constructed, and areas under the curve (AUCs) were estimated. Sensitivity, specificity, positive and negative predictive values (PPV and NPV), and accuracy of the PSAD based-model were calculated to analyze the optimal sensitivity of prostate cancer. For sensitivity and specificity calculations, we added 95% CI values. The SPSS 20.0 software (Chicago, Illinois, US) was used for statistical analysis. In all statistical analyses, the significance level (*p*-value) was set at 0.05.

RESULTS

The median age of the patients with PI-RADS category 3 was 62 years (57-67 years). There were 12 patients (8.5%) with CsPCa in the study group. The ISUP grades were 3+4 and 4+3 in 11 and one patient. The CisPCa detection rate was 18.3% (n = 26). The diagnoses of CSPCa and CisPCa (n=38) were obtained in 21 (55.3%) and three patients (7.9%) via the systematic and mpMRI-based targeted biopsy approach. In 14 patients (36.8%), both approaches were positive for the diagnosis.

The number of patients was 130 and 12 in Groups 1 and 2. **Table 1** compares the demographic and clinical parameters of the groups. The prostate gland volume was significantly lower in Group 2 than in Group 1 ($p = 0.016$). We detected a significant difference in PSAD levels between the groups ($p = 0.012$). The PSAD levels in Group 2 were significantly higher than in Group 1 (median 0.195 ng/ml2 vs. 0.12 ng/ml^2). The groups were similar considering age, PSA level, the diameter and number of the lesions, and the proportion of anteriorly located lesions ($p = 0.102$, $p = 0.810$, $p = 0.598$, $p = 0.171$, and $p = 0.460$, respectively) (**Table 1**).

The receiver operating characteristics curve analysis revealed that the cut-off value for PSAD in detecting CsPCa was 0.181 ng/ml2 (AUC=0.719, 95% CI: 0.537-0.900, $p = 0.013$) (**Figure 1**). The grouping based on the cut-off value of PSAD also revealed a significant difference between the groups ($p < 0.001$).

The diagnostic efficacy of the PSAD-based model in diagnosing CsPCa in patients with PI-RADS 3 lesions is summarized in **Table 2**. There were nine and 97 true positive and negative cases. The cut-off PSAD level $\geq$ 0.181 ng/ml^2 had sensitivity and specificity values of 75% (95% CI: 42.8%-94.5%) and 81.5% (95% CI: 73.4%-88.0%) in predicting CsPCa among the patients

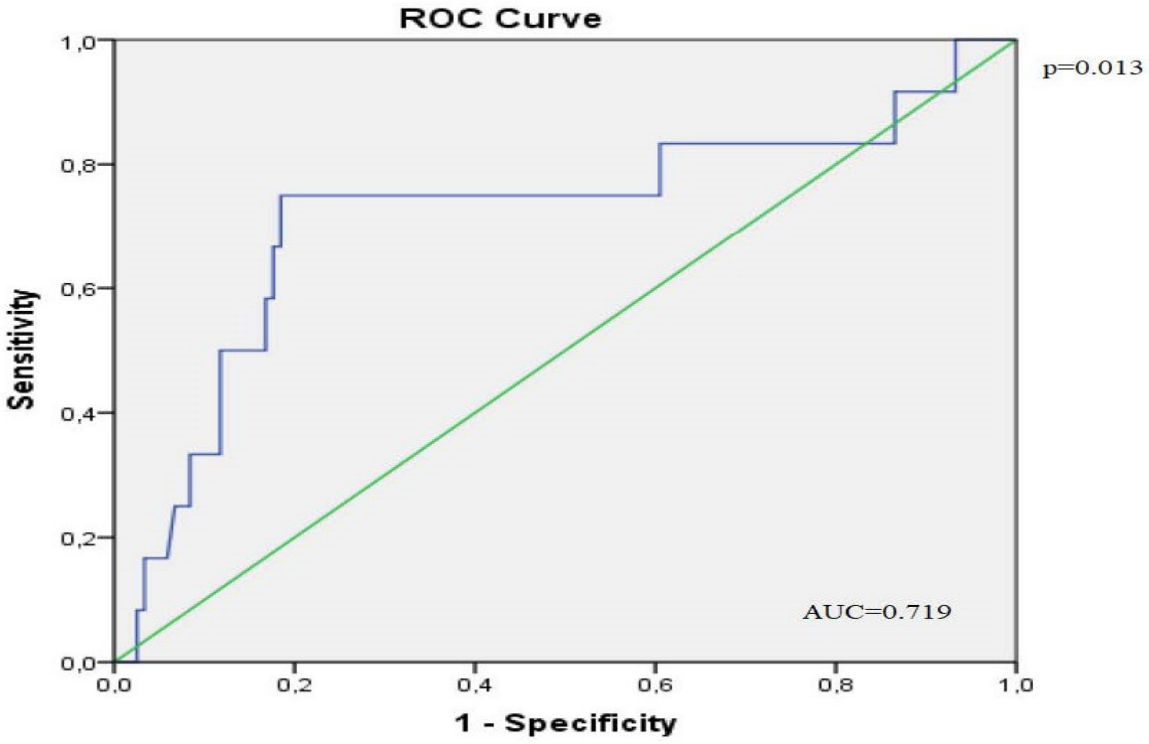

Figure 1. The receiver operating characteristics curve analysis of PSAD in detecting CsPCa in the overall study group (n=142).

Table 3. Accuracy analysis of high PSAD levels in diagnosing CsPCa in patients with PI-RADS 3 lesions.

	TP (n)	FP (n)	FN (n)	TN (n)	Sensitivity (%) [95% CI]	Specificity (%) [95% CI]	PPV (%)	NPV (%)	Accuracy (%)
High PSAD (≥0.181 ng/ml^2)	9	22	3	97	75 [42.8%-94.5%]	81.5 [73.4%-88.0%]	29	97	80.9

PSAD: Prostate-specific antigen density, CsPCa: clinically significant prostate cancer, TP: true positive, FP: false positive, FN: false negative, TN: true negative, PPV: positive predictive value, NPV: negative predictive value.

in the PI-RADS 3 category. The NPV, PPV, and overall diagnostic accuracy of the PSAD-based model were 97%, 29%, and 80.9% (**Table 3**). Using PSAD to tailor the management to diagnose prostate cancer revealed that there would be three patients with the under-diagnosis of CsPCa (25%). The overdiagnosis rate was 18.5% (22 cases out of 119). However, it would avoid 97 prostate biopsy procedures (81.5%) to increase the detection rate of CsPCa from 8.5% to 29.0% (nine cases out of 31 biopsy procedures) (**Table 2**).

The comparison of the patients with CisPCa and CsPCa is given in Table 4. The patients were similar in age and lesional characteristics, including the diameter and number of the lesions and the proportion of anteriorly located lesions (p = 545, p = 0.411, p = 0.505, and p = 0.656, respectively). Although PSA levels were higher in patients with CsPCa than those with CisPCa, the difference was insignificant (p = 0.609). In patients with CsPCa, we detected significantly smaller prostate volumes and higher PSAD values than those with CisPCa (p = 0.021 and p = 0.010).

The receiver operating characteristics curve analysis revealed that the cut-off value for PSAD in detecting CsPCa among all patients with a diagnosis of prostate cancer (n = 38) was 0.181 ng/ml2 (AUC=0.763, 95% CI: 0.568-0.958, p = 0.012) (**Figure 2**). The grouping based on the cut-off value of PSAD also revealed a significant difference between the groups (p < 0.001) (**Table 3**). The PSAD level ≥ 0.181 had sensitivity and specificity values of 75% and 87.0% in predicting CsPCa among patients with prostate cancer (n = 38).

DISCUSSION

This study showed that the rate of CsPCa in patients with PI-RADS 3 lesions was 8.5%. Our findings revealed the higher accuracy rates of the PSAD-based model in discriminating CsPCa pathology in patients with PIRADS-3 lesions and differentiating between CsPCa and CisPCa pathology in the same patient group. Based on these findings, we recommend using PSAD levels to decide on the diagnostic interventions for patients with PI-RADS 3 lesions.

The overall detection rate of CsPCa shows variations from 4% to 43% in patients with PI-RADS 3 lesions [1-3, 9,13-15,17,18,27-29]. The rate of CsPCa was 8.5% in our study, which is within the reported ranges in the literature. Pepe et al.[29] reported a rate of 25.4% for CsPCa in patients with PI-RADS 3 lesions. The rate for CsCPa in the prostatic lesions with a PI-RADS score of less than 3 was 8.7% in this study. Besides the heterogeneity in the patient groups and the reader-dependent characteristic of the mpMRI technique, the variable experiences of the radiologists with different learning curve practices in prostate MRI interpretation might also impact this great range[3,30]. The true incidence of CsPCA might also differ in surgical specimens[9,14]. An overestimation is a possibility in prostate biopsies. As an institutional policy, we combined mpMRI-targeted and standard biopsy procedures to diagnose CsPCa. In that way, our study's findings may be more reliable considering the under or over-estimation problems.

The cut-off analysis for PSAD has been performed in different studies that included patients with PI-RADS 3 lesions. Other studies investigated reproducing an optimal threshold for all PI-RADS lesions[27,31-37]. In these studies, different accuracy rates have been reported[15,35]. The minimum and maximum values of PSAD levels ranged from 0.07 to 1.5 ng/ml^2[3,7,9,15,17,37]. However, the cut-off value of 1.5 ng/ml^2 for PSAD has been studied more frequently than the other PSAD values [7,34,38]. Frisbie et al.[34] stratified the different cut-offs of PSAD to determine PI-RADS risk behavior. They thought that a PSAD of 0.1 ng/ml^2 could be more helpful in obtaining increased clinical utility. Roscigno et al.[31] stratified the patients according to two different PSAD cut-off values as ≥ 0.2 ng/ml^2 and < 0.1 ng/ml^2. So, we may think that an optimal threshold has not been reproduced yet[15]. The present study found that PSAD higher than 0.181 ng/ml2 was significantly associated with CsPCa. Besides, this PSAD value was a valuable threshold in differentiating CsPCa from CisPCa for PI-RADS 3

Table 4. Demographic and clinical characteristics of the patients with CisPCA and CsPCa.

		Patients with CisPCa (n=26)	Patients with CsPCa (n=12)	*p*
Age (year) †		64 (61-68) [60-68]	66 (57-72) [61-70]	0.545
Prostate volume (ml) †		55 (48-74) [45-74]	43 (25-56) [26-55]	0.021
PSA (ng/ml) †		6.4 (5.2-8.8) [5.0-8.2]	8.2 (4.6-10) [4.7-9.8]	0.609
PSAD (ng/ml2) †		0.124 (0.084-0.147) [0.080-0.149]	0.195 (0.108-0.297) [0.146-0.249]	0.010
PSAD group ‡	Low	20 (87.0)	3 (25.0)	<0.001
	High	3 (13.0)	9 (75.0)	
Diameter (mm) †		10 (8-12) [7-12]	11 (9-14) [9-11]	0.411
Number of lesions †		1 (1-2) [1-2]	1.5 (1-2) [1-2]	0.505
Anterior lesion†		4 (15.4)	3 (25.0)	0.656

†: median (95% CI) [IQR1-IQR3], ‡: n (%)

CI: confidence interval, IQR: interquartile range.

Group 1: Patients with benign prostatic hyperplasia and clinically insignificant prostate cancer, Group 2: patients with clinically significant prostate cancer, PSA: prostate-specific antigen, PSAD, prostate-specific antigen density.

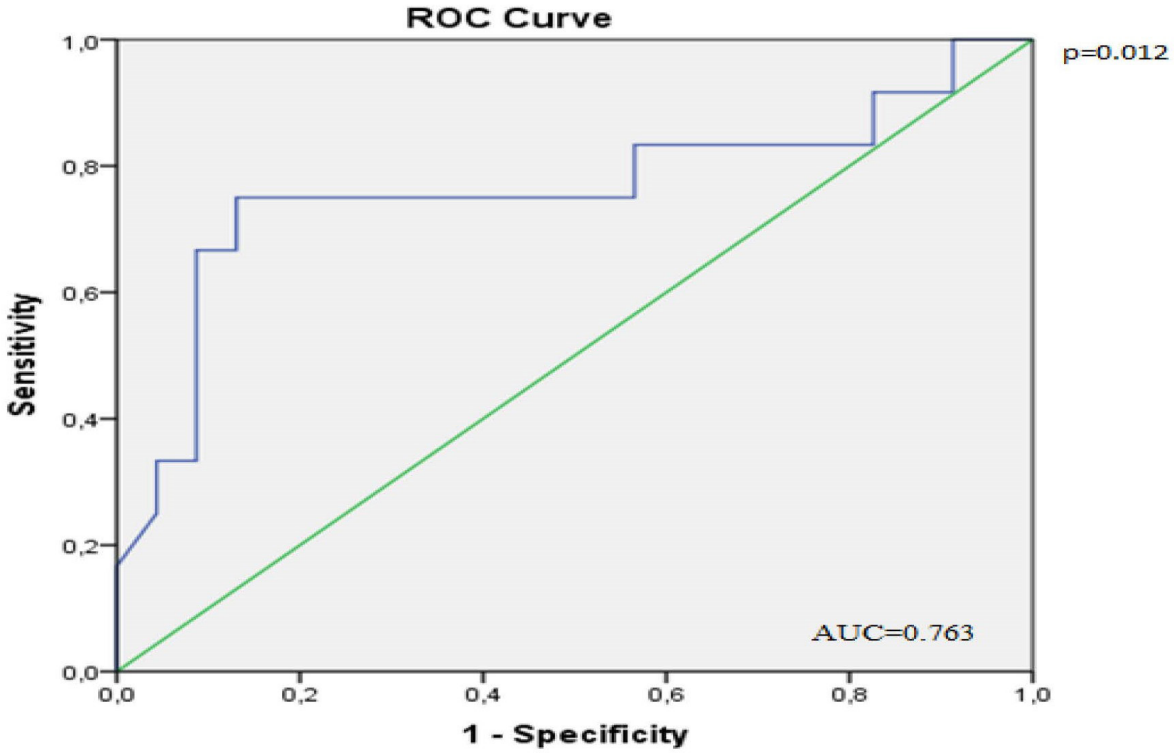

Figure 2. The receiver operating characteristics curve analysis of PSAD in detecting CsPCa in all patients with a diagnosis of prostate cancer (n=38).

lesions. Several authors reported that many biopsies would be avoided using PSAD as a cofactor for the PI-RADS system[9]. We also showed that a threshold value of PSAD would be essential in preventing unnecessary biopsy procedures consistent with others [34]. So, PSAD should be considered an adjunctive/complementary factor for indeterminate prostatic lesions like PI-RADS 3. The PSAD has also been used in predicting the degree of the upgrade of the Gleason scores under active surveillance[1,35]. They reported that PSAD significantly increased in CsPCa patients during the follow-up period[39]. Roscigno et al.[40] analyzed the role of mpMRI and several clinical parameters, including PSAD, in predicting disease reclassification of patients on active surveillance. They showed that a 0.1 unit increase in PSAD was an independent risk factor in predicting grade 2 prostate cancer during confirmatory or follow-up biopsy. A risk stratification based on PIRADS and PSAD values was recommended to avoid unnecessary biopsies during active surveillance. Others thought PSAD is a valuable clinical parameter for pending cases to decide whether to trigger or postpone biopsy [41]. The impact of PI-RADS 3 diagnosis on the long-term outcomes of the underlying prostatic pathology has been studied. Boschheidgen et al.[1] showed that a PI-RADS upgrade occurs in patients diagnosed with prostate cancer after 12-24 months. They also reported a downgrade in the PI-RADS category for the PI-RADS 3 lesions without prostate cancer diagnosis after 25-36 months. Therefore, they did not recommend early follow-up imaging for patients with PI-RADS 3 lesions [1]. Although we did not perform a long-term analysis of our patient group, there are several clinically practical issues for PSAD during the diagnosis and follow-up of such patients.

Previous studies analyzed several clinical predictors for CsPCA identification in patients with PI-RADS 3 lesions. Age, diameter, prostatic volume, and PSA are independent predictors[3,5,7,18]. Alan et al.[7] stratified the PI-RADS 3 lesions according to lesion diameter (<1 cm vs. >1 cm) and PSAD levels (< 0.15 ng/ml^2 vs. $\geq$ 0.15 ng/ml2). They found no missing patients with CsPCa if he has a lesion larger than 1 cm and a PSAD level higher than 0.15 ng/ml^2. Nevertheless, the lesion diameter in predicting CsPCa has been questioned in several studies. Different threshold measurements for the lesion diameter range from 0.5 cm to 1.5 ng/ml2. It is generally believed that PI-RADS 3 lesions < 0.5 cm were not likely to represent clinically significant disease[3]. In this study, we could not detect significant differences in age, tumor diameter, and PSA levels between patients with and without CsPCa. However, the prostatic volume in patients with CsPCa was significantly lower. The findings of several studies in which smaller prostate volume was associated with prostate cancer supported our findings[3,18,32]. Although using PSAD in patients with larger prostate glands may be less sensitive for further analysis, we recommend that the clinical parameters be considered as a possible adjunctive factor to tailor the management and follow-up of the patients with suspicious prostatic lesions.

The utility of clinical-radiomic models has also been investigated in different patient groups for prostate cancer[2,5,19]. The term "radiomics" has gained popularity over the last decades. It is a technique in which the medical images of the patients are extracted and analyzed regarding their quantitative characteristics[5]. The mpMRI-based radiomic features and the Gleason grading have been used simultaneously in distinguishing CsPCa[2,5]. Li et al.[2] incorporated radiomics features

and PSAD for discriminating CsPCa from non-CiPCa among PI-RADS 3 lesions. In this study, we did not evaluate such imaging characteristics considering the quality of the images. Some images were obtained in other centers, and transferring may negatively impact the image quality.

The diagnostic efficacy of 68Ga-prostate-specific membrane antigen (PSMA) positron emission tomography/computed tomography has been studied in patients with CsPCa. The expression of prostate-specific membrane antigen in most primary and metastatic prostate cancer cases led to its increased popularity in clinical practice [42]. Besides, Pepe et al.[43] reported reasonable accuracy rates compared to mpMRI-targeted biopsy. They thought such new technologies might improve the detection rate of prostate cancer via a systematic biopsy approach.

The retrospective design was the major limitation of our study. Our study was a retrospective analysis of the patients with PI-RADS 3 lesions in a single institution. The majority of the patients were referred to a mpMRI targeted biopsy facility. Therefore, the gold standard pathological report for the prostatectomy specimens in patients who underwent surgical treatment and the follow-up data needed to be included. This factor might be the other limiting factor.

CONCLUSIONS

Considering PSAD values higher than 0.181 ng/ml2 as a clinical parameter in managing patients with PI-RADS 3 lesions leads to the higher diagnostic accuracy of mpMRI-based diagnosis. In that way, it is more apparent in deciding which patients with PI-RADS 3 lesions require biopsy. The number of unnecessary prostate biopsies can be reduced safely in patients with PI-RADS 3 lesions. Further studies are warranted to determine the PSAD cut-offs by PI-RADS scores without over and under-diagnosing prostate cancer.

CONFLICTS OF INTEREST

All authors have completed the ICMJE uniform disclosure form. The authors have no conflicts of interest to declare.

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