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St. Paul's Hospital Millennium Medical College**

St. Paul's Hospital Millennium Medical College

Department of Radiology and Medical Radiology Technology

Post-Graduate study program

Correlation of high-grade Prostate Imaging Reporting and Data System version 2.1 findings with histopathology results among patients visited the interventional radiology unit at St. Paul's Hospital Millennium Medical College.

A Research paper to be submitted to St. Paul Hospital Millennium Medical College, Department of Radiology and Medical Radiology Technology in partial fulfillment of the requirements for the specialty certificate in radiology.

By: Abdudin Heru (MD, Radiology Resident)

Addis Ababa, Ethiopia

July 2024



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Advisors:

1. Takele Menna PhD, Associate Professor of Public Health
2. Alemayehu Bedane MD, Body and Neuroradiology sub-specialist

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Acronyms and Abbreviations

ACR: American College of radiology

BPH: Benign prostatic hyperplasia

CSPCA: Clinically significant prostate cancer

EMR: Electronic medical record

MRI: Magnetic resonance imaging

MPMRI: Multi-parametric Magnetic resonance imaging

MRT: Medical Radiology Technology

NPV: Negative predictive value

PI-RADS v2.1: Prostate Imaging Reporting & Data System version 2.1

PhD: Doctor of philosophy

PPV: Positive predictive value

PSA: Prostate-specific antigen

RIS: Radiology information system

SPHMMC: Saint Paul's Hospital Millennium Medical College

SPSS 27: Statistical Package for the Social Science version 27

TRUS: Trans-rectal ultrasonography.

Abstract

Background- Prostate cancer is a common cause of cancer death in men and comes only second after lung cancer. Prostate MRI with the application of PI-RADS v2.1 scoring system helps to stratify patients according to risk and correlate significantly with histopathology results. This study aimed to enhance the diagnostic process of prostate cancer by investigating the correlation between high-grade PI-RADS v2.1 MRI findings and histopathology outcomes following TRUS-guided prostate biopsies.

Objectives: To assess the correlation between high-grade Prostate Imaging Reporting and Data System version 2.1 lesions and their MRI findings with histopathology outcomes obtained from biopsies in patients who visited St. Paul's Hospital Millennium Medical College interventional radiology unit.

Methods: A facility-based retrospective patient's clinical record review study was conducted among patients who were sent to the interventional radiology unit of SPHMMC with high-grade PI-RADS v2.1 MRI reports for TRUS-guided prostate biopsy between January 2023 and April 2024. Data was collected using a structured template, entered into Epi Info v7, and analysed with SPSS v27. Chi-square and Fisher exact tests were used to assess the correlation between high-grade PI-RADS v2.1 scores and their MRI findings with histopathology.

Results: In our study of 105 patients, a statistically significant correlation was found between certain lesion MRI characteristics and the presence of prostate cancer. Specifically, lesions in the peripheral zone with ill-defined margins, larger size, lenticular or crescentic shape, extraprostatic extensions and high-grade PI-RADS v2.1 score were more likely to be malignant (p-value<0.01). In fact, 94.5% of lesions with a PI-RADS v2.1 score of 5 were cancerous, while 51.5% of lesions with a score of 4 showed malignant characteristics.

Conclusion: A significant correlation was observed between high-grade PI-RADS v2.1 scores and the presence of prostate cancer, highlighting the critical role of mpMRI in detecting clinically significant prostate cancer. Integrating mpMRI with clinical and laboratory data can enhance patient care and outcomes. Our institution's performance aligns with published data.

Keywords: High-grade Prostate lesions, Prostate Imaging Reporting & Data System version 2.1, St. Paul's Hospital Millennium Medical College, Interventional radiology

1. Introduction

1.1 Background

Prostate cancer is one of the most common malignancies that affect men throughout the world, because of its prevalence, it requires new and better diagnostic and treatment planning (1). It is estimated that the worldwide prostate cancer incidence will increase almost twofold reaching 2.3 million cases by 2040 (2). In previous periods after detecting enlargement of the prostate gland by ultrasound and subsequent increment in laboratory PSA value, finger-guided biopsies were used as a mainstay of detecting prostatic cancer. However, nowadays the presence of advanced imaging techniques, in particular MRI with Prostate Imaging Reporting and Data System Version 2.1 (PI-RADS v2.1) protocol, changed the diagnostic and management process (3).

There is a significant challenge in the diagnosis of prostate cancer because of the heterogeneous features and the ability of the tumor to have a long-standing benign course or sometimes early aggressive nature. Biopsy is a valuable tool in the diagnosis of prostate cancer, but doing it blindly fails to identify the malignant focus and characterize the disease properly. Because of this significant limitation, the PI-RADS v2.1 scoring system by utilization of mpMRI has turned out to be an encouraging non-invasive tool, giving comprehensive anatomical and as well as pathological information, furthermore, it allows more focused evaluation of suspicious lesions to increase diagnostic yields (1).

The progress from previous PI-RADS versions to the current newer updated version 2.1 shows advancement in the standardization and reproducibility of prostate imaging. The newer version of PI-RADS includes multiparametric MRI imaging, including T2w sequence, diffusion-weighted imaging (DWI), and dynamic contrast-enhanced sequences (DCE). The use of these mpMRI techniques significantly increased the diagnostic ability and accuracy. This progression shows a paramount effort in the medical society to address the significance of prostate cancer, working towards boosting the sensitivity and specificity of lesion identification (4).

Prostate Imaging Reporting & Data System version 2.1 uses different imaging sequences to grade lesions in transitional and peripheral zones. T2 weighted sequence is used as a principal technique in the assessment of lesions in the transitional zone and DWI/ADC map correlation is used in the assessment of peripheral zone lesions. Lesions within prostate glands are considered high and very

high-grade if the PI-RADS v2.1 score is four or five respectively. Lesions with a score of three in the PI-RADS v2.1 category are considered indeterminate and further assessed with the DCE sequence. If the lesion shows focal and earlier than or contemporaneous enhancement of a suspicious lesion (corresponding to T2WI and/or DWI findings) relative to other normal prostatic tissue it will be upgraded to a score of four. Otherwise, it will remain three if no early enhancement or diffuse multifocal enhancement not corresponding to the lesion of suspicion or focal enhancement corresponding to a lesion with features of BPH on T2w sequence. PI-RADS v2.1 score of one is given for normally expected findings within the prostate gland and two is for lesions with benign features (5, 6).

Even if there is improvement and progress from the previous PI-RADS scoring system, the full potential of this newer PI-RADS version 2.1 especially in correlating with post-biopsy histopathologic results is still to be intensively explored. Knowing this correlation is very important in increasing diagnostic accuracy, treatment planning, and finally, improving patient outcomes (7). This research is placed in the very important place between radiology and pathology, aiming to narrow the existing knowledge gap and contribute to the ongoing discourse in precision medicine.

1.2 Statement of problem

Prostate cancer diagnosis and management have created significant challenges for medical care providers throughout the world. Early diagnosis of prostate cancer is important for optimal patient treatment, but diagnostic techniques like prostate-specific antigen (PSA) value and digital rectal examination (DRE) are not entirely reliable for detecting prostate cancer. Even if histopathology is considered the gold standard, it has limitations in providing real-time, non-invasive evaluation (8).

Even if the newer PI-RADS version 2.1 MRI imaging scoring system has been incorporated into standard reporting techniques of prostate lesions worldwide, there is still doubt regarding its ability to identify and characterize high-grade prostate lesions (7, 9). Those high-grade lesions which suggest the presence of aggressive disease in the prostate, require proper characterization and identification of which part of the prostate they are located in order to guide the interventional radiologist to get a biopsy and to further enhance patient outcome (10).

Pathological examination after TRUS-guided prostate biopsy or surgical resection is still a gold standard method for accurately diagnosing prostate cancer and determining pathological Gleason score and extent of the lesion. The presence of discordance between the PI-RADS v2.1 MRI imaging findings and their Gleason's score in the histopathological exam, especially regarding high-grade lesions, emphasizes the importance of studies in the correlation of imaging and histopathology for improving the accuracy and reliability of PIRADS v2.1 in clinical practice (11).

In addition to this, the presence of disagreement between imaging and histopathology requires intensive investigation, since it affects patient selection, treatment planning, and management strategies. Clinicians who get discordant findings from MRI reports and histopathologic exams will face difficulty in the interpretation and integration of diagnostic modalities in prostate cancer management (12).

The presence of these diagnostic uncertainties and clarification between high-grade PI-RADS version 2.1 MRI imaging findings and histopathological Gleason's scores represent a critical investigation imperative. The presence of these studies will not only improve understanding of prostate cancer heterogeneity and disease complexity but also advance the clinical practice guideline, decision-making, and treatment planning, which ultimately improves patient care and outcomes in this time of evidence-based medicine (13).

In our country, Ethiopia there is a significant advancement in prostate cancer management, which is mainly due to the incorporation of Western novel therapeutic modalities and improved oncology approaches. These practices will significantly improve accurate disease characterization and risk assessment. Nevertheless, there is no single published paper regarding the correlation between high-grade PI-RADS v2.1 and histopathology.

To provide this advanced prostate cancer treatment technique, the MRI imaging modality should be able to identify these high-grade lesions accurately. Proving the diagnostic and prognostic capability of MRI PI-RADS v 2.1 report technique in identifying high-grade lesions, not only improves the ability of disease detection and lesion categorization but also helps in the establishment of optimized treatment algorithms and evidence-based oncology strategies (14).

1.3 Rationale of the study

The complex relationship between post-biopsy histopathology results and higher-grade PI-RADS version 2.1 prostatic imaging findings will have a crucial role in the advancement of clinical medicine and future research (15).

Even if a prostate biopsy is essential for a definitive diagnosis, it can result in unnecessary complications and create lots of discomfort for the patients. Identifying those patients with high-grade PI-RADS version 2.1 MRI findings will help to align accurately with histopathology outcomes. This in turn will reduce unnecessary biopsies, and enable a more selective and judicious approach to biopsy recommendations, minimizing patient burden and healthcare costs (16).

This study plans to improve the diagnostic precision of prostate cancer by assessing the correlation between highly suspicious PI-RADS version 2.1 MRI imaging findings and their histopathology results. By improving, the detection of suspicious lesions and characterizing their feature on imaging is important for giving standardized as well as personalized treatment strategies (17).

The categorization of patients based on the newer updated PI-RADS version 2.1 MRI imaging findings and their correlation with histopathology results has a crucial role in standardizing their treatment planning. These treatment strategies include radical prostatectomy and radiotherapy for high-grade/cancerous prostatic findings, targeted therapy for localized ones, and active surveillance for lower-risk groups (3).

Proper diagnostic and management protocol, guided by the use of the newer updated PI-RADS version 2.1 MRI scoring system and their correlation with histopathology will result in cost-effective management of patients with prostatic lesions. By not performing unnecessary biopsies for those patients with lower grade PI-RADS 2.1 version lesions and optimizing proper treatment strategies, there will be significant medical cost reduction without compromising the proper care and patient outcome (18).

In general, the significance of this study extends beyond the limit of clinical practice, addressing crucial parts of patient experience, medical resource usage, and future prostate cancer research advancement.

2. Literature Review

2.1 Introduction

Globally, prostate cancer is one of the most frequently diagnosed cancer in men and ranks as the fifth leading cause of cancer-related deaths. In 2020, there were 1,414,259 new cases of prostate cancer and 375,304 deaths related to the disease worldwide (19, 20).

Fortunately, most prostate cancers tend to grow slowly and are low-grade with relatively low risk and limited aggressiveness (21). Most of the time patients with prostate cancer do not have symptoms early, but in the late period of the disease, they will show easy fatigability due to low hemoglobin, pain within the bone due to metastasis, paraplegia/paraparesis from compression of the spinal cord/nerves and hydronephrosis with renal failure from the distal ureter. There are no clearly identified risk factors for the development of prostate cancer unlike breast cancer but older age, history of prostate cancer in the family, excessive weight, elevated blood pressure, high testosterone level, and race are among commonly suggested factors (22).

2.2 Imaging of prostate cancer

Prostate MRI is the primary imaging modality used for initial prostate cancer detection and diagnosis. It has the ability to detect and stratify suspicious prostate nodules, which will help with localization and staging, assess for the presence of extracapsular extension and it can identify the presence of metastasis to regional and distal lymph nodes that might affect the treatment strategy (23). Despite this, false positive and negative results are frequently reported due to the overlaps between benign findings and prostate cancers. Benign lesions like nodular hyperplasia in transitional zones, inflammation of the gland (prostatitis), and small abscess collections may mimic prostate cancer (24).

2.3 What is PI-RADS?

Prostate Imaging Reporting and Data System Version 2.1 (PI-RADS v2.1) is the product of an international collaboration of the American College of Radiology (ACR), European Society of Uroradiology (ESUR), and AdMetech Foundation. The use of the PI-RADS scoring system is to create international standardized prostate multiparametric magnetic resonance imaging (mpMRI) reporting schemes so that differences in the MRI acquisition techniques and interpretation will be avoided. PI-RADS recommends standardized protocols to determine the minimum acceptable

technical parameters for the MRI of the prostate, it clarifies and universalizes terms to be used in the content of reports, and offers evaluation categories that condense levels of suspicion or risk associated with clinically significant prostate cancer, aiding in the selection of patients for biopsies and treatment planning. The transition from the original version to PI-RADS v2.1 was driven by the need for improved consistency, reproducibility, and clarity in reporting aiming to enhance sensitivity and specificity in detecting clinically significant prostate cancer (1, 10).

2.4 Imaging findings in prostate cancer

Size of the prostate lesion

The size of suspicious prostate lesions is closely linked to the presence of poorly differentiated cancer and early lymph node metastases. In a study of 139 surgical specimens, prostate cancers ranged in volume from 0.5 to 1 ml, with only 20% of patients diagnosed with clinically significant prostate cancer (25). Other studies showed tumors of approximately 0.5 cm³ had a 10 percent chance of capsular invasion, while those around 4.0 cm³ showed a very high likelihood of seminal vesicle invasion. For tumors measuring about 5.0 cm³, there was also a 10 percent chance of distant metastasis. These findings indicate that tumor volume is a critical factor in predicting the progression of cancer (26).

T2w characteristics

Because it can identify, localize, and stage prostate cancer, including extraprostatic extension and seminal vesicle invasion, T2w is considered a fundamental pulse sequence in mpMRI of the prostate gland. The imaging findings of prostate lesions on T2w can be hypointense, isointense, hyperintense, or complex heterogeneous as compared to normal prostatic tissue. Suspicious areas in the PZ and TZ are usually hypointense or complex heterogeneous as compared to healthy glandular tissue. This feature is non-specific, though, because benign entities in this sequence that mimic cancer include atrophy, bleeding, prostatitis, and alterations that occur after treatment. Since the transitional zone is frequently hypointense on T2WI, cancer is more elusive at this stage. Here, suspicious lesions are distinguished by fuzzy borders, an "erased charcoal" look, and occasionally a spiculated or water-drop appearance (27).

DWI/ADC characteristics

Initially, the mean ADC value was shown to be significantly lower in tumor tissue than in benign areas of the prostate, a finding that was later confirmed by multiple other studies. Various studies analyzed the additional value of DWI-MRI with conventional T2w imaging and found that both sensitivity (71–89%) and specificity (61–91%) increased significantly when DWI-MRI was combined with T2w imaging, compared with the sole use of T2w imaging (sensitivity, 49–88%; specificity, 57–84%) (28).

A meta-analysis evaluated the sole use of DWI-MRI to detect PCa combining the results of 21 studies and found a high-pooled specificity of 90% but a relatively low overall pooled sensitivity of only 60%. While diffusion-weighted MRI (DWI-MRI) is highly sensitive in detecting tumors in the peripheral zone (PZ) of the prostate, it is less effective in the transition zone (TZ), where distinguishing between benign hyperplastic nodules and malignant lesions is challenging. The lower sensitivity in tumor detection in some studies can be attributed to their failure to differentiate between the PZ and TZ of the prostate gland (29).

Dynamic contrast-enhanced (DCE) findings

Dynamic contrast-enhanced (DCE) MRI is a recognized element of multi-parametric MRI for the prostate. The sequence emphasizes the vascularization of cancerous lesions, helping readers confirm suspicious findings seen in T2W and DW MRI and detect subtle lesions not visible in other sequences. However, there is an overlap between benign and malignant tissues in the peripheral and transition zones. Some benign lesions, like benign prostatic hyperplasia (BPH) nodules, exhibit strong early enhancement, while some malignant lesions may lack early enhancement or washout (29).

Once a mainstay of prostate MRI, the use of DCE MRI is today much more controversial. A study involving 70 patients who subsequently had radical prostatectomy revealed that the likelihood of tumor detection was 0.58 when using both DCE MRI and T2W MRI, compared to 0.40 when only T2W MRI was utilized. Though DCE MRI cannot be used alone to identify tumors, the sequence's high-contrast images and improved spatial resolution over DWI can aid readers in increasing the PI-RADS score of lesions equivocal on DWI imaging (30).

Location of the lesions in the prostate gland.

The human prostate is categorized into three zones based on its histological characteristics: the peripheral zone (PZ), the transition zone (TZ), and the central zone (CZ). Prostate cancer incidence, prognosis, and outcomes differ by zones; with tumors in the transitional zone (TZ) generally having more favorable clinical outcomes compared to those in the peripheral zone (PZ) and central zone (CZ). The PZ constitutes the majority of the prostate (70%) covering the posterior and lateral regions of the prostate gland and correspondingly has the highest incidence of prostate cancer (~70%). The TZ, which is located centrally and surrounds the urethra, comprises only 5-10% of the gland and is commonly enlarged in BPH, an abnormal noncancerous proliferation of the prostate gland and up to 25% of prostate cancers are found in this zone (31).

In a study done at Stanford University on surgical pathology and outcomes of 494 patients who underwent RP between 1989 and 2000, TZ cancers were present in 89 of 494 (18%) patients. The rest of the lesions were in the PZ (82%). Compared to peripheral zone (PZ) cancers, transitional zone (TZ) cancers are typically diagnosed as non-palpable (clinical stage T1c), exhibit higher PSA levels, and have greater tumor volume. Despite this, following RP, they are less likely to exhibit involvement of the capsular or seminal vesicles. Improved outcomes were observed in patients with TZ cancers when stratified for high preop PSA and larger cancer volume (32).

Shape and margin

The Prostate Imaging Reporting and Data System version 2.1 (PI-RADSv2.1) guideline includes shape analysis of both transition zone (TZ) and peripheral zone (PZ) observations. In the transitional zone (TZ), cancer is often identified by a lenticular shape, whereas benign prostatic hyperplasia (BPH) typically presents with a round or oval appearance. The feature of the shape of the lesion, whether evaluated subjectively or quantitatively, has been validated to differentiate TZ cancer from BPH. For the PZ, in PI-RADSv2.1, shape features have also been described. Wedge shape or linear shape and band-like or diffuse shape are described as occurring more frequently in benign conditions, such as prostatitis or atrophy, than in round or oval shape, which is more typical of cancer (33).

A study was done to subjectively and quantitatively assess the shape features of prostate tumors compared with pathologic outcomes. According to the results of the consensus evaluation, 63.9% of tumors had an oval or round shape, 22.8% had a crescent shape, and 13.3% had a linear or

wedge shape. Round or oval tumors were higher grade than crescentic tumors and linear or wedge-shaped tumors. In addition, round or oval tumors had higher rates of extraprostatic extension and seminal vesicle invasion than crescentic tumors and linear or wedge-shaped tumors (34).

Benign prostatic hyperplasia nodules can exhibit high cellularity, thus mimicking cancerous lesions on MRI sequences, specifically DWI. Hence, morphologic features on T2W images are more reliable than DWI for TZ assessment, a concept reflected in the PI-RADS v2.1 scoring system. On mpMRI, PCa can also resemble several other benign and pre-malignant conditions, such as granulomatous prostatitis, adenosis, and prostatic intra-epithelial neoplasia. PI-RADS 2.1 classifies a lesion as having a circumscribed or ill-defined margin. Even though prostate cancer can have well-defined margins, most are ill-defined with obscured margins, and most benign lesions including BPH nodules tend to have well-circumscribed margins (35).

Extra-prostatic extension

The overall prevalence of EPE at the time of RP is about 50%, occurring in 10–15% of low-risk cancers and up to 45–50% in high-risk cancers (36).

The management of prostate cancer is significantly influenced by the existence of extraprostatic extension (EPE) on multiparametric MRI (mpMRI). Extraprostatic extension (EPE) is a well-known risk factor for the biochemical recurrence of prostate cancer following radical prostatectomy (RP). MRI/ultrasound fusion-guided targeted biopsy can identify EPE that are missed on standard biopsies. Collectively, these measurements and imaging techniques can augment the detection of EPE and subsequent risk stratification (37).

2.5 Cognitive Magnetic Resonance Imaging-Ultrasound fusion (MR-US fusion)

Several studies have been done to investigate the diagnostic efficiency of cognitive MRI-ultrasound fusion in TRUS-guided prostate biopsy after the lesion is identified on mpMRI. A retrospective study done with 127 biopsy naïve men showed the effectiveness of cognitive MRI-ultrasound fusion in the detection of prostate cancer especially those with high PSA value and PI-RADS scores (38). Another prospective study done for assessment of the efficacy of cognitive targeted TRUS guided biopsy showed a significant increment in diagnostic ability when pre-TRUS biopsy localization was done using mpMRI (39).

2.6 Correlation between MRI PI-RADS scoring and histopathology

A multi-centric study was done in Turkey with 177 patients who underwent preoperative mpMRI and radical prostatectomy for prostate cancer from eight institutions. They tried to assess the correlation of PI-RADS score in preoperative mpMRI with adverse histopathological factors in radical prostatectomy specimens. This study showed a statistically significant correlation between high-grade PI-RADS score and clinically significant prostate cancer. A higher PI-RADS score may help to predict a higher Gleason score, indicating clinically important prostate cancer as well as poor prognostic factors such as extracapsular extension, lymphovascular invasion, and invasion of the seminal vesicles, which could indicate a greater chance of recurrence and the need for further care (4).

A study done in Canada on the correlation of multiparametric prostate MRI using prostate imaging reporting and data system (PI-RADS) version 2.1 with biopsy as a reference standard showed the presence of clinically significant prostate cancer (csPCa) from a biopsy site was highly unlikely in the absence of a corresponding PI-RADS ≥ 3 nodules. For clinically significant prostate cancer (csPCa), they have found the accuracy, sensitivity, specificity, positive predictive value, and negative predictive value of PI-RADS scores of 3 or higher were 89%, 76.5%, 89.7%, 31.7%, and 98.4%, respectively. The detection rates of csPCa for PIRADS 3, 4, and 5 nodules were 6.1%, 33.3%, and 64.4%, respectively. MRI did not identify a nodule in 1.4% of biopsy sites that contained csPCa. The probability of achieving a positive biopsy result for clinically significant prostate cancer (csPCa) was not significantly affected by the fusion biopsy technique, MRI reader, biopsy operator, or zonal location of the prostate lesion (8).

A retrospective single-center study was done in China with the inclusion of 385 patients to assess the efficacy of PI-RADS 2 to avoid unnecessary biopsies and invasive treatment. In a group of 385 patients, the pathological detection rates for prostate cancer with PI-RADS v2 scores ranging from 1 to 5 were 5.0%, 6.3%, 17.0%, 58.3%, and 95.1%, respectively (40).

Two independent reviewers from Germany assessed the cancer detection rate of the PI-RADS v2.1 scoring system by using the histopathological outcome as a reference standard in a meta-analysis with a systematic review. Out of 17 articles that met their criteria, they found out that a PI-RADS score of four had a 59% (with 95 CI 39–78%) cancer detection rate and 85% (73–94%) for a PI-

RADS score of five. A higher category was significantly associated with a higher cancer detection rate (41).

Research conducted in Kenya on the utility of multiparametric magnetic resonance imaging (mpMRI) in predicting clinically significant prostate cancer demonstrated that mpMRI has a high for detection of detection of clinically significant prostate cancer and to differentiate benign from malignancy, validating its use in pre-biopsy evaluation of men at risk of prostate cancer to safely avoid unnecessary prostate biopsy and to guide biopsy of suspicious lesions (42). To our knowledge, the MRI PI-RADS scoring system with histopathology correlation studies has not been published in our country, Ethiopia.

3. Objectives

3.1 General objectives

- To assess the correlation between high-grade Prostate Imaging Reporting and Data System version 2.1 lesions and their MRI findings with histopathology outcomes obtained from biopsy in patients who visited St. Paul's Hospital Millennium Medical College interventional radiology unit.

3.2 Specific objectives

- To identify the correlation between high-grade Prostate Imaging Reporting and Data System Version 2.1 scores (PI-RADS 4 and 5) with clinically significant prostate cancer based on histopathological analysis.
- To determine the correlation between variable multiparametric MRI PI-RADS v2.1 imaging findings of high-grade prostate lesions like size, shape, margin, DWI/ADC characteristics, T2w signal intensity, extraprostatic extension, and DCE pattern with histopathologically proven prostate cancers.

4. Methodology

4.1 Study setting

This study was conducted at St. Paul's Hospital Millennium Medical College (SPHMMC) in Addis Ababa, Ethiopia. It is one of the tertiary referral hospitals in the country and is governed by the Federal Ministry of Health (FMOH). St. Paul's Hospital Millennium Medical College is a teaching hospital for undergraduate and postgraduate medical students enrolled in various programs at the college. The hospital has a total bed capacity of more than 700 beds and, on average, evaluates 1200 emergency and outpatient clients daily. The hospital college provides both academic and service in various clinical disciplines.

The interventional and vascular imaging unit is under the Department of Radiology and Medical Radiology Technology, providing minimally invasive diagnostics and therapeutic care. Among the minimally invasive diagnostic techniques, transrectal ultrasound (TRUS) guided prostate biopsy is one of the commonly performed procedures. TRUS-guided prostate biopsy service is given mainly for patients with MRI PI-RADS v 2.1 score of four and five. On average, a biopsy is done for about 3 to 5 patients per week and 156-260 patients per year. From January 2023 to April 2024, a total of 160 TRUS-guided biopsies was done.

4.2 Study period

This study was conducted from February to June, 2024.

4.3 Study design

A retrospective patient's clinical records review was conducted among adult males with prostate biopsy following high-grade PI-RADS v 2.1 lesions identified on the mpMRI imaging.

4.4 Study Population

- **Source Population:** All adult male patients with MRI PI-RADS v2.1 scores of 4 and 5 who had a TRUS-guided prostate biopsy at the interventional and vascular radiology unit of SPHMMC between January 2023 and April 2024.
- **Study Population:** All adult male patients with MRI PI-RADS v2.1 scores of 4 and 5 who had a TRUS-guided prostate biopsy at the interventional and vascular radiology unit of SPHMMC between January 2023 and April 2024 and fulfilled the inclusion criteria.

- **Study Units:** Medical records of adult male patients with MRI PI-RADS v2.1 scores of 4 and 5 who underwent TRUS-guided prostate biopsies at the interventional and vascular radiology unit from January 2023 to April 2024.

4.5 Eligibility criteria

Inclusion Criteria:

- All adult males who had prostate MRI and TRUS-guided prostate biopsy results in SPHMMC during the study period.
- Only patients with prostate MRI have proper multiparametric sequence and quality.

Exclusion criteria:

- Patients who had a history of prostatectomy and sent for TRUS-guided prostate biopsy for assessment of tumor recurrence.

4.6 Sample Size determination

The total number of patients who visited the interventional radiology unit for TRUS-guided prostate biopsy between January 2023 and April 2024 was 160. Since only those patients with PI-RADS v2.1 scores of four and five are expected to be referred for image-guided biopsy, all were included in this study. Therefore, the sample size for our study was 160 patients.

4.7 Variables

Independent variable:

- Age
- Location of the lesion
- T2w signal intensity
- Shape
- Margin
- Size of the lesion
- DWI/ADC characteristics
- DCE enhancement pattern
- Extraprostatic extension

Dependent variable:

- Histopathology results (Benign/prostate cancer)

4.8 Operational definitions of variables

PI-RADS (Prostate Imaging–Reporting and Data System)

- It is a structured reporting scheme for mpMRI in the evaluation of suspected prostate cancer in the treatment of a naive prostate gland. PI-RADS version 2.1, released in 2019, was developed by an international team that included the American College of Radiology (ACR), the European Society of Urogenital Radiology (ESUR), and the AdMeTech Foundation (1, 10).

High-grade prostate Lesions

- Prostatic lesions will be considered high and very high-grade if the MRI PI-RADS v2.1 score is four and five respectively (10).

Diffusion-weighted imaging (DWI)/ Apparent diffusion coefficient (ADC) of prostate lesions

- Diffusion restriction is present when a lesion with a high DWI signal corresponds to a low signal on the ADC map, which is highly correlated to malignant cells. The exact ADC value of the lesion is inversely correlated to the likelihood of a malignant lesion (28)

Dynamic contrast-enhanced (DCE) MRI

- Lesions that show focal and earlier or contemporaneous enhancement of a suspicious lesion (corresponding to T2WI and/or DWI findings) relative to other normal prostatic tissue will be considered positive DCE. If no early enhancement or diffuse multifocal enhancement not corresponding to the lesion of suspicion or focal enhancement corresponding to a lesion with features of BPH on T2w is noted, it will be considered negative (10, 11).

T2 weighted Sequence (T2w)

- High-resolution T2W FSE sequences are obtained in the axial and sagittal plane. T2W images show anatomical information on normal and abnormal prostatic tissue. The

appearance of a lesion on T2w sequence ranges from hypointense, hyperintense, isointense, and mixed heterogeneous signals (10).

4.9 Data Collection Procedure

The multiparametric prostate MRI reports approved by consultant radiologists were accessed from the radiology information system (RIS) by using the patient medical record number. Post-biopsy histopathology results were collected from the pathology department and patients' electronic medical records. All included patients underwent prostate MRI with Siemens 1.5T MRI by a professional medical radiology technologist. The following MRI sequences were the minimum requirement used for mpMRI protocol, which is necessary for scoring of PI-RADS v2.1; Axial T2w, diffusion-weighted imaging (DWI) with b value of 1400, apparent diffusion coefficient (ADC) and dynamic contrast-enhanced sequences (DCE). Only images with optimal quality were used in this study. Data was collected by the principal investigator from June 10 to June 20, 2024. The collected data was again revised by the principal investigator and clinical advisor. A structured data collecting template containing MRI PI-RADS v2.1 descriptors, final PIRADS v2.1 category, and histopathologic results was used for obtaining the necessary data.

4.10 Data management and Analysis

The collected data was coded and entered into Epi info version 7, cleaned, stored, and transferred to Statistical Package for Social Sciences, version 27 (SPSS v27). Descriptive statistics using measures of frequency are used to summarize categorical variables. This analyzed information is presented by using simple frequencies, summary measures, tables, and figures in the result sections below. A chi-square test and Fisher exact test were run to determine the presence of a significant difference between the PI-RADS v2.1 imaging descriptors and the presence of prostate cancer on histopathological results. A statistically significant difference was detected for variables with a P-value of ≤ 0.05 .

4.11 Data quality control

Data quality was assured through appropriate and detailed patient record revision using checklists from the data collection template. The collected data were checked for completeness, clarity, and accuracy by the principal investigator before any attempt to enter code and analyze it

4.12 Ethical clearance

Ethical clearance was obtained from SPHMMC's research review board. Since this is a record review of anonymity, privacy and confidentiality were strictly respected. No, risk or benefit goes forth to individuals of the record.

4.13 Dissemination of Results.

This final finding of the study will be submitted to the Department of Radiology and Medical Radiology Technology in the form of a written document. The result will also be orally presented for partial fulfillment of final year post-graduate courses in radiology to the department and all other interested bodies. Publications will be made in Peer-reviewed reputable journals.

5. Result

5.1 Study population characteristics

Out of the 160 patients who had a TRUS-guided prostate biopsy between January 2023 and April 2024, 105 were eligible for inclusion. Participants ages ranged from 46 to 92 years, with the majority (67.6%) being between 61 and 80 years old. The majority of patients had a prostate volume ranging from 51 to 100cc, a PSA value between 20 and 50ng/ml, and a PSA density greater than 0.21. Table 1 presents general information collected for the 105 patients, including age, prostate volume, PSA value, and PSA density.

Table 1. Socio-demographic and general information of participants along with mean and median value after objective normality test with p-value was done (**n=105**)

Variables	Range	Frequency(proportion)	Mean (SD)
Age (yr.)	41-60	24(22.9)	67.85 (9.58)
	61-80	71(67.6)	
	>= 81	10(9.5)	
			Median (IQR)
Prostate volume (cm ³)	<=50	26(24.8)	68 (50, 96)
	51-100	56(53.3)	
	101-150	13(12.4)	
	>=151cm ³	10(9.5)	
PSA value(ng/dl)	4-10-20	9(8.6)	34.7 (18, 62.6)
	10-20	20(19)	
	20-50	44(41.9)	
	>50	32(30.5)	
PSA density	<=0.1	5(4.8)	0.46 (0.26, 0.7)
	0.11-0.15	7(6.7)	
	0.151-0.2	10(9.5)	
	>=0.21	83(79)	

Among the 105 multiparametric prostatic MRI findings with PI-RADS v2.1 scores of 4 and 5, 78 (74.3%) were found in the peripheral zone (PZ), while the remaining 27 (25.7%) were located in the transition zone (TZ). Of the 78 lesions in the PZ, 73 (93.5%) were prostate cancer, with the rest being benign pathologies. In contrast, only 12 (44.4%) of the 27 lesions in the TZ were malignant (Table 2).

Table 2-Location of the lesions within the prostate gland and their histopathological outcomes (n=105)

Location	Frequency(proportion)	Histopathology outcomes	
		Malignancy	Benign
Peripheral zone	78(74.3)	73(93.5)	5(6.5)
Transitional zone	27(25.7)	12(44.4%)	15(55.6)

5.2 Outcome measurement

Among the 105 patients who underwent TRUS-guided prostate biopsy between January 2023 and April 2024, prostate cancer was detected in 81% (95% CI 72.1-87.9) of cases. The remaining 19% (95% CI 12.1-27.9) had benign conditions such as benign prostatic nodules and prostatitis (**Figure 1**).

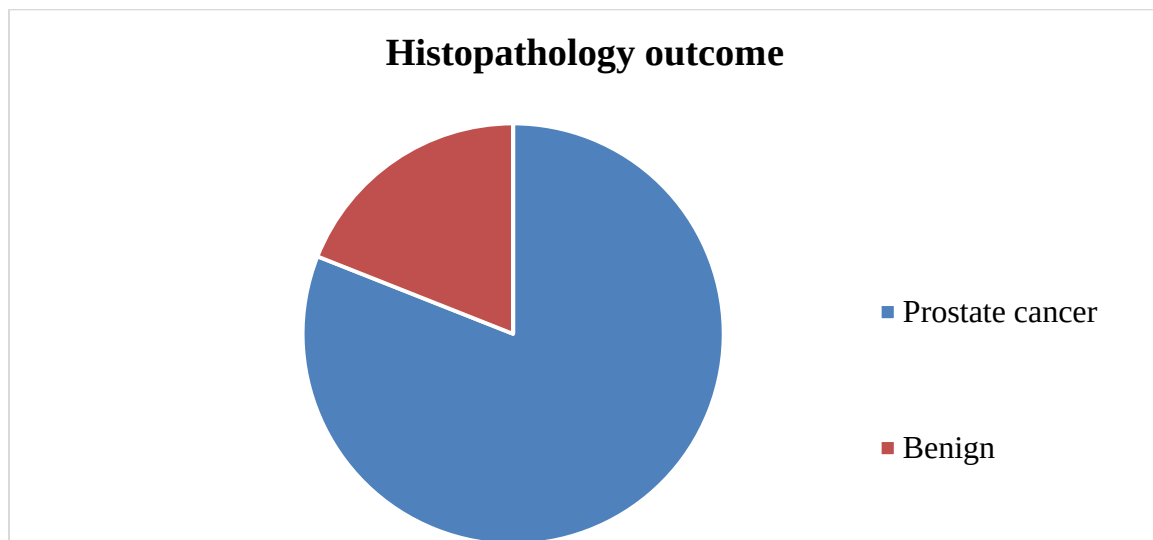


Figure 1. Pie chart showing the proportion of histopathology outcome

Out of all patients, 72 (68.6%) had a PI-RADS v2.1 score of 5, and the remaining 33 (31.4%) had a score of 4 (Table 3).

Table 3. Overall assigned PI-RADS v2.1 categories

PI-RADS v2.1 category	Frequency	Percentage (%)
5	72	68.6
4	33	31.4
Total	105	100

Among those with a score of 5, 68 (94.5%) were diagnosed with prostate cancer, while the remaining 4 (5.5%) had benign findings. Of the 33 patients with a score of 4, 17 (51.5%) had prostate cancer, and the remaining 16 (48.5%) had benign findings (**Table 4**).

The 20 benign prostate lesions identified included 12 cases (60%) of prostatitis and 8 cases (40%) of nodular hyperplasia. Nodular hyperplasia was only found in the transition zone, whereas prostatitis was present in both zones, with 58% of the cases occurring in the peripheral zone.

Table 4. Comparison between high-grade PI-RADS version2.1 scores and post-biopsy histopathology outcome (n=105)

Final PI-RADS version 2.1score Vs Histopathology Results Cross-tabulation	Histopathology results			
		Prostate cancer	Benign	Total
Final PI-RADS v2.1 score	4	17(51.5%)	16(48.5%)	33
	5	68(94.5%)	4(5.5%)	72
Total		85	20	105

5.3 Correlation between MRI imaging findings of high-grade prostate lesions and histopathological results.

Based on the result of the Chi-square and Fisher exact test, significant correlations were found between the presence of prostate cancer and among different PI-RADS v2.1 imaging descriptors, including location of the lesion within the prostate gland, its shape, appearance on DWI/ADC maps, DCE characteristics, the presence of extra-prostatic extension, the size and margin of the lesion, and the overall PI-RADS v2.1 score.

The majority of lesions located in peripheral zones were prostate cancer as compared to those seen in the transitional zone (93.5% vs. 44.4%, p-value <0.01). Similarly, lesions with lenticular shapes had a higher chance of being prostate cancer as compared to those with wedge-shaped morphology (p-value of <0.01).

Lesions with extra-prostatic extension had a very high likelihood of being prostate cancer, as all identified cases were confirmed as prostate cancer (p-value = 0.02).

The size of the prostate lesions also significantly correlated with the presence of prostate cancer, as lesions 1.5 cm or larger were more frequently identified as prostate cancer (94.6% vs. 46.6%, p-value < 0.01).

In the Chi-square test for correlation between the margin of the lesion and prostate cancer assumption failure was detected, so the Fisher exact test was applied and revealed lesions with an ill-defined margin were more likely to be prostate cancer as compared to those with a well-circumscribed border (83.3% (cancer) vs. 14.9% (benign), p-value = 0.006).

The final score of PI-RADS v2.1 results was also correlated with the presence of prostate cancer. Lesions with a score of five had a significantly higher chance of being prostate cancer than those with a score of four (94.5% vs. 51.5%, p-value <0.01).

Similarly, lesions with diffusion restriction and positive DCE had a greater chance of being prostate cancer as compared to those with facilitated diffusion and negative DCE (both with a p-value of <0.05) (Table 4).

In the Chi-square test for correlation between T2w sequence and prostate cancer assumption failure was also detected, so the Fisher exact test was applied. Lesions with hypointense signal intensity did not show a significant correlation compared to those with other signal intensities (p-value =

0.39). This lack of correlation is attributed to the fact that many benign lesions also exhibited hypointense signal intensity.

Table 5. mpMRI PIRADS v2.1 findings (T2w, margin, Shape, DWI/ADC map, DCE, extra-prostatic extension, size and location) of the lesion, final P-IRADS score and comparison between prostate cancer Vs benign histopathology outcome (n = 105)

Variables	Histopathological outcome			P-value
	Prostate cancer=n (%)	Benign=n (%)	Total=n (%)	
Margin of the lesion				
Well-circumscribed	5(45.5)	6(54.5)	11(10.5)	0.006
Ill-defined	80(83.3)	14(14.9)	94(89.5)	
Shape of the lesion				
Lenticular	55(98.2)	1(1.8)	56(53.3)	<0.01
Wedge	7(63.6)	4(36.4)	11(10.5)	
Round/oval	23(60.5)	15(39.5)	38(36.2)	
DWI/ADC maps				
Restricted	85(83.3)	17(16.7)	102(97.1)	0.006
Facilitated	0(0)	3(100)	3(2.9)	
DCE findings				
Positive	66(97)	2(3)	68(64.8)	<0.01
Negative	19(51.3)	18(48.7)	37(35.2)	
Extra-prostatic extension				
Yes	29 (100)	0(0)	29(27.6)	0.02
No	56(73.6)	20(26.4)	76(72.4)	
Size of the lesion				
1.49cm and less	14(46.6)	16(53.4)	30(28.6)	<0.01
1.5 and more	71(94.6)	4(5.4)	75(71.4)	
Location of the lesion				
Transitional zone	12(44.4)	15(55.6)	27(25.7)	<0.01
Peripheral zone	73(93.5)	5(6.5)	78(74.3)	
T2w findings				
Hypointense	67(82)	14(18)	81(77%)	0.39
Mixed/Heterogeneous	18(75)	6(25)	24(23%)	
PI-RADS v2.1 final score				
4	17(51.5)	16(48.5)	33(31.5)	<0.01
5	68(94.5)	4(5.5)	72(68.5)	

6. Discussion

PI-RADS is an abbreviation for Prostate Imaging Reporting and Data System. It is an MRI-based scoring system used to standardize the interpretation and reporting of prostate lesions. PI-RADS helps clinical radiologists in categorizing and stratifying lesions detected during prostate MRI scans, helping to determine the likelihood that a lesion is clinically significant and potentially indicative of prostate cancer. PIRADS v2.1 is the latest updated version of the PI-RADS, which refines and enhances the scoring criteria and guidelines for interpreting prostate MRI images. This version includes adjustments to improve accuracy and reliability in detecting clinically significant prostate lesions.

Our study evaluated the correlation of high-grade prostate lesions with histopathological analysis and identified prostate cancer in 51.5% of cases that received a PI-RADS v2.1 score of 4 and 94.5% of cases in PI-RADS v2.1 score of 5. Compared to studies done in China, Germany, and Canada, the prostate cancer detection rate of PI-RADS v2.1 for a score of 4 in our setup had comparable results. On the contrary, for PI-RADS v2.1, a score of 5 our setup had a slightly higher cancer detection rate (8, 40, 41). This higher detection rate of prostate cancer in patients with a PI-RADS v2.1 score of 5 in our study is likely attributed to the fact that patients in our setup often present with advanced stages of the disease. This highlights the importance of early detection and screening for prostate cancer.

In assessment of the distribution of prostate cancer lesions within the prostate gland, specifically comparing the peripheral zone (PZ) and transition zone (TZ). The results showed that 74.3% of prostate cancer lesions were located in the PZ, while 25.7% were found in the TZ. This outcome is consistent with a previous study on prostate cancer zonal assessment, which reported similar findings (PZ: 70%, TZ: 30%) (31). However, as compared to a meta-analysis conducted at Stanford University they found a higher percentage of lesions in the PZ (82%) compared to our study (74.3%) (32).

Our study also investigated the correlation between prostate lesion size and the likelihood of prostate cancer. The findings revealed that lesions with the largest dimension size of 1.5cm or larger were significantly associated with a histopathological diagnosis of prostate cancer. This result is consistent with previous studies that have also explored the link between prostate lesion size and cancer risk (25, 26). The consistency across studies suggests that larger lesions are more

likely to be malignant, highlighting the importance of lesion size as a predictor of prostate cancer. The significance of this association has important implications for clinical practice, suggesting that lesion size should be considered a crucial factor in determining the need for further evaluation and potential biopsy.

Out of 85 cases of prostate cancer identified, the majority of lesions (64.7%) exhibited a lenticular or crescentic shape, while 27% were round or oval. The remaining lesions were wedge-shaped. When compared to a Canadian study that focused exclusively on lesion shapes in the peripheral zone (PZ), significant differences were observed. Their study reported a higher proportion of round or oval lesions (63.9%) and a lower proportion of lenticular or crescentic lesions (22.8%) (34). This discrepancy may be attributed to the difference in scope between the two studies, as their study only included lesions from the PZ, whereas the current study included lesions from all zones of the prostate gland. This highlights the importance of considering lesion location and shape in prostate cancer diagnosis and suggests that lesion morphology may vary depending on the location within the prostate gland.

This study examined the benign histopathological outcomes in the prostate gland, revealing that prostatitis was the most common finding in the peripheral zone (PZ), while nodular hyperplasia was the predominant finding in the transition zone (TZ). Notably, these benign entities have been recognized as mimickers of prostate cancer in previous studies, highlighting the importance of accurate diagnosis and differentiation (24). Prostatitis, inflammation of the prostate gland, and nodular hyperplasia, a non-cancerous enlargement of the prostate, can exhibit similar symptoms and imaging features to prostate cancer, making it challenging to distinguish between these entities. Therefore, a thorough understanding of their histopathological characteristics is essential for accurate diagnosis and appropriate patient management. The study's findings underscore the importance of careful evaluation and consideration of these benign entities in the diagnostic workup of prostate cancer.

This study also assessed the correlation between high-grade PI-RADS v2.1 imaging findings with histopathologically confirmed prostate cancer after a TRUS-guided biopsy was done at the interventional unit. The chi-square test result of this study shows a significant difference in the presence of benign versus prostate cancer among PI-RADS v2.1 score of 4 and 5 (51.5% for a score of 4 Vs 94.5 for a score of 5). This result is comparable with multiple studies done in the

past (4, 42). Similarly, the comparison between different PI-RADS v2.1 descriptors and the presence of benign versus prostate cancer were assessed. The result showed that lesions in the peripheral zone with ill-defined margins, larger size, and extraprostatic extensions were significantly associated with the presence of prostate cancer. This is also demonstrated by other studies done in multiple countries (26, 31, 32, 35, 36).

7. Strengths and limitations of the study

Strength

- To the best of our knowledge, there is no study conducted in Ethiopia that assessed correlations between PI-RADS MRI scoring and histopathology results.

Limitations

- The effect of the evaluation of MRI reports by different radiologists may be considerable as there may be a certain degree of interobserver variability.
- This retrospective clinical review study was constrained by data limitations, including inaccuracies, incomplete records, and missing details, which reduced the participant pool.

8. Conclusion

This study investigated correlation between high-grade PI-RADS v2.1 findings and histopathological results in patients undergoing TRUS-guided prostate biopsy at Saint Paul Hospital Millennium Medical College interventional radiology unit. The study found that various MRI characteristics, as defined by the PI-RADS v2.1 guidelines, such as the presence of dynamic contrast enhancement (DCE), larger size, peripheral zone (PZ) location, ill-defined margin, diffusion restriction, and extra-prostatic extensions, are significantly associated with positive histopathology results from biopsies. These findings have important implications for enhancing the non-invasive evaluation and classification of prostate cancer risk, which may lead to more informed biopsy decision-making and improved patient outcomes.

Our study's analysis revealed a significant correlation between PI-RADS v2.1 scores of 4 and 5 and the presence of malignancy, aligning with established literature and guidelines. Our institution's performance in utilizing PI-RADS v2.1 scoring demonstrated comparable results to existing standards. The application of multiparametric prostate MRI with PI-RADS v2.1 classification emerged as a robust predictor of malignancy, highlighting its potential as a valuable tool in the diagnostic workup of prostate cancer.

9. Recommendations

The PI-RADS v2.1 scoring system offers valuable predictive insights for the diagnosis of prostate cancer. Clinician should routinely integrate the PI-RADS v2.1 scoring system with clinical and laboratory data, such as PSA levels and DRE exams, to improve the accuracy of prostate cancer diagnosis and management decisions.

Further research is recommended to explore factors that could affect the predictive accuracy of the PI-RADS v2.1 system, including the use of advanced MRI techniques or biomarkers.

Given the growing availability of MRI machines in various regional and zonal cities, implementing the PI-RADS v2.1 scoring system for prostate cancer stratification is advisable. Radiologist should adopt PI-RADS v2.1 universally to create a consistent framework for evaluating prostate MRI scans. This will facilitate uniform reporting and interpretation across different regions and institutions.

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ANNEX I: Information sheet

Title of the study- Correlation of high-grade Prostate Imaging Reporting & Data System version 2.1 findings with histopathology results among patients visited interventional radiology unit at SPHMMC.

I have permission to do this research from St. Paul's Hospital Millennium Medical College Research Ethics Committee. The study uses a retrospective chart review study. Structured template is prepared below for data collection.

The objective of the study: To assess the correlation between histopathology results obtained from biopsy and high-grade Prostate Imaging Reporting and Data System Version 2.1 MRI imaging finding in patients visited SPHMMC interventional radiology unit.

Benefit: There will be no benefits for the patient included in the study. However, the information obtained from patient medical record will be very helpful in assessing, analyzing, and improving the diagnostic accuracy of prostate cancer.

Harm: Patients whose medical record are included for data collection will not be harmed in any way.

Confidentiality: I would like to assure you that privacy of patient medical file will be strictly maintained throughout the study. If a report of the results be published, no personal information will appear included.

Persons to contact: If you have any concerns or questions regarding the research, you can contact the principal investigator at any time. Tel: 0921903350, Email-heruabdudin@gmail.com

Annex II- Data Collection Template

Name of data collector _____

Signature _____

Date _____

Patient demographic data

MRN	
Age (yrs.)	

Instructions-please follow these instructions while collecting data from medical records.

- For the variables in number, 1-3 please state the specific number.
- For PI-RADS v2.1 descriptors form number 4 to 9, please mark the finding by using ✓ symbol.
- Please write in full the type of procedure done and the histology outcome of the patient
- For the outcome variable in number 14, please mark the finding by using ✓ symbol.

General information's		Data
1. Prostate volume (in cm ³)		
2. Total Prostate-specific antigen value (in ng/dl)		
3. Prostate density		
PI-RADS v2.1 descriptors		
4. Location of the lesion	Transitional zone	
	Peripheral zone	
5. Shape	Lenticular	
	Wedge	
	Round/oval	
6. Margin	Well circumscribed	
	Not well circumscribed	
7.T2w characteristics	Hypointense	
	Isointense	
	Hyperintense	
	Heterogeneous/complex signal	
8. DWI/ADC maps	Facilitated diffusion	
	Intermediate diffusion	
	Restricted diffusion	
9. Enhanced MRI (DCE) characteristic	Positive DCE according to ACR	
	Negative DCE according to ACR	
10.Extra-prostatic extension	Any invasion of adjacent structures (Yes/No)	

11. Size of the suspicious lesion			
12. Final PI-RADS version 2.1 score	4	5	
13. Procedure done	TRUS guided biopsy		
14. Histopathology result	Prostate cancer	Benign	
15. If histopathology result is benign, please choose the diagnosis	1. Prostatitis 2. Benign prostatic nodule/BPH 3. Prostatic abscess 4. others		
16. Outcome	Concordant		
	Discordant		

Name of the supervisor: _____ Sign. _____ Date _____

NB-PI-RADS v2.1 descriptor variables in the above data collection templates are adopted from 2019 ACR–ESUR–AdMeTech white paper on PI-RADS v2.1 (Link-
<https://www.acr.org/Clinical-Resources/Reporting-and-Data-Systems/PI-RADS>).

Annex-3 Reference for PIRADS v2.1 scoring

Peripheral Zone PI-RADS V 2.1 Transition Zone			
ADC / DWI		T2W	
1 Normal	PI-RADS 1	Normal appearing TZ (rare) or round, completely encapsulated nodule	1
2 ADC: Linear/wedge shaped hypointense and/or DWI: linear/wedge shaped hyperintense	PI-RADS 2	Mostly encapsulated nodule or Homogeneous circumscribed nodule without capsule or Homogeneous mildly hypointense area between nodules. DWI ≤ 3	2
3 ADC: Focal hypointense and/or DWI: focal hyperintense May be markedly hypointense on ADC or markedly hyperintense on high b-value DWI, but not both. DCE -	PI-RADS 3	Same as above but DWI ≥ 4	2
3 Same as above but DCE +	PI-RADS 4	Heterogeneous signal intensity with obscured margins. Includes others that do not qualify as 2, 4, or 5. DWI ≤ 4	3
4 ADC: Focal markedly hypointense DWI: markedly hyperintense Diameter < 1.5cm		Same as above but DWI = 5	3
4 ADC: Focal markedly hypointense DWI: markedly hyperintense Diameter < 1.5cm	PI-RADS 4	Lenticular or non-circumscribed, homogeneous, moderately hypointense, < 1.5cm. any DWI	4
5 Same as 4, but ≥ 1.5cm or extraprostatic extension	PI-RADS 5	Same as 4, but ≥ 1.5cm or extraprostatic extension. any DWI	5

<https://radiologyassistant.nl/abdomen/prostate/prostate-cancer-pi-rads-v2-1>.