ORIGINAL RESEARCH

The role of magnetic resonance imaging (MRI) in prostate cancer diagnosis and its correlation with transrectal ultrasound guided "BIOPSY" "(TRUS)"

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ABSTRACT

Aim: The objective of this research is to demonstrate the diagnostic efficacy of magnetic resonance imaging (MRI) using various parameters to assess prostatic tumors, specifically in distinguishing benign from malignant prostatic lesions. **Materials and Method:** Twenty consecutive male patients, with a mean age of 65 years and ages ranging from 50 to 80 years, were enrolled in this prospective study at the outset. These patients were selected based on the presence of various prostatic lesions, a prostate-specific antigen (PSA) level exceeding 4 ng/dL, or a hard nodule detected via digital rectal examination. Magnetic resonance imaging was utilized to evaluate these lesions, and the resulting histopathological data were correlated with the TRUS guided biopsy findings. **Result:** Twenty patients who presented with urological symptoms (dysuria, frequency, and urinary retention) were referred from urological outpatient clinics. The investigation was conducted using ultrasonography, conventional magnetic resonance, diffusion weighted images and MR spectroscopy on the patients; histopathological data were correlated with these findings. Conventional MRI has a moderate sensitivity of 81.8% and a low specificity of 37.3% in detecting prostate cancer, according to this study. By combining dynamic contrast enhanced, diffusion-weighted, and MR spectroscopic imaging with mpMRI, it is possible to distinguish between benign and malignant lesions in the prostate zone with a sensitivity of one hundred percent and a specificity of ninety-six percent. **Conclusion:** For a conclusive diagnosis of prostate cancer, trans-rectal ultrasound biopsy is the benchmark. Nevertheless, TRUS guided biopsy exhibits a notable sampling error, potentially overlooking as many as 30% of malignancies. Furthermore, it may underestimate the Gleason grade, particularly in the case of tumors situated anteriorly. It could potentially result in a heightened incidence of complications. MRI plays a crucial function in enhancing the safety of the diagnostic process. It can also assist in the planning of radiation therapy or surgery, as well as staging. Despite its extensive application in diagnosis due to its exceptional soft tissue resolution, T2W MRI exhibits suboptimal accuracy when it comes to the detection and localization of prostate cancer. Diagnostic efficacy is enhanced when multiparametric MRI techniques—MR spectroscopy, dynamic contrast enhanced imaging, and diffusion weighted imaging—are incorporated into a software application.

INTRODUCTION

The prostate is an exocrine organ that consists of both glandular and non-glandular tissue. With its broad base situated below the bladder and apex situated above the urogenital diaphragm, it encircles the neck of the bladder and urethra.[1,2] Prostate organ diseases cause substantial morbidity and mortality among adult males on a global scale. Prostate diseases that are most commonly encountered include prostatitis, benign prostatic hyperplasia, and prostate cancer.[3]

Prostate cancer is a prevalent malignancy among the geriatric male population and ranks among the primary contributors to mortality associated with cancer.[4] Transrectal ultrasound (TRUS) had surpassed all other prostate imaging modalities by 1990. Its application enhanced comprehension and illustration of intra-glandular anatomy. Screening, diagnosing, and monitoring benign diseases and prostatic cancer, as well as guiding biopsies from suspicious lesions, have been TRUS applications for quite some time.[5]

Currently, the most used method to enhance the timely identification of clinically significant Prostate Carcinoma appears to be the incorporation of multi-parametric MRI (mpMRI) into a screening program.[6] In recent times, mpMRI, an imaging technique that integrates anatomic T2-weighted (T2W), T1W, diffusion-weighted imaging (DWI), and dynamic contrast enhanced MRI (DCE-MRI), has garnered considerable attention.[7] mpMRI's provision of anatomical, biological, and functional dynamic information enhances a multitude of facets pertaining to Prostate carcinoma management. Clinicians must incorporate imaging into their therapeutic decision-making process, in addition to relying on predictive methods and nomograms such as prostate-specific antigen (PSA), digital rectal examination (DRE), and TRUS biopsy results.[7]

Biopsy guided by transrectal ultrasound (TRUS) is a standardized but untargeted technique. Due to the constraints of the currently accessible diagnostic instruments, considerable effort is being devoted to enhancing the precision of prostate cancer detection. Potential for increasing the diagnostic accuracy of MRI for prostate cancer detection has been demonstrated by developments in MRI techniques. A multi-parametric MRI approach, which integrates functional data with anatomic T2-weighted imaging, has emerged as a highly promising methodology in the field of prostate cancer detection in recent times.[8,9] Functional magnetic resonance imaging (MRI) techniques can be utilized to reveal altered cellularity, metabolic information, and noninvasive characterization of tissue and tumor vascularity.[10] While these techniques have yet to be extensively integrated into routine clinical practice, they are progressively being referenced in guidelines pertaining to prostate cancer.[11]

The objective of this research is to demonstrate the diagnostic efficacy of magnetic resonance imaging (MRI) using various parameters to distinguish benign from malignant prostatic lesions.

MATERIALS AND METHODS

Twenty consecutive male patients, with a mean age of 65 years and ages ranging from 50 to 80 years, were enrolled in this prospective study at the outset. These patients were selected based on the presence of various prostatic lesions, a prostate-specific antigen (PSA) level exceeding 4 ng/dL, or a hard nodule detected via digital rectal examination. Magnetic resonance imaging was utilized to evaluate these lesions, and the resulting histopathological data were correlated with the TRUS guided biopsy findings.

Inclusion criteria

- Men at least 40 years or overat risk of prostate lesions.
- Fit to undergo all protocolprocedures.
- Elevated PSA.

Exclusion criteria

- Previous history of prostate surgery.
- General contraindications to MRI asmetal implant, pacemaker implant, claustrophobia
- Renal impairment estimated GFR<50.
- Generalcontraindications to TRUS as piles and acute painful perianal disorders

Medical history

Urinary symptoms such as urgency, hesitancy, dysuria, or urinary frequency, nocturnal symptoms include urge incontinence or overflow, terminal dribbling, complete urinary retention, body pains, and occasionally fever, as well as complications during sexual activity.

Investigations

- Abdominal sonography.
- TRUS color Doppler.
- Prostate—specifc antigen (PSA).
- Histopathology of TRUS guided prostatic biopsy.

Methods

As a diagnostic method for various prostatic pathologies, TRUS will be administered to all patients by Samsung HS 50. Using a 16-channel standard pelvic-phased array coil and a 16-channel 1.5 T MR scanner (GE HDXT), every MRI procedure and multi-voxel spectroscopic analysis were performed. In each patient, the seminal vesicles and entire prostate were observed.

Patient preparation

It must be standard practice to reassure the patient from the entrance to the scanning chamber, which includes having a thorough understanding of the entire procedure.

Parameters of prostate imaging in this study

T2W sequence: We began with an Axial T2-weighted turbo spin-echo sequence consisting of 24 slices, a TR of 3000, a TE of 90, an ACQ matrix of 260×259. Subsequently, sagittal T2-weighted turbo spin-echo sequences were executed (TR 4990, TE 120, ACQ matrix 268×233, 20 slices, slice thickness 1.5 mm). Slicing depth of 3.5, followed by 24 slices, a cronal T2-weighted turbo spin-echo sequence was executed (TR 438, TE 10, ACQ matrix 260×252).

T1W sequence:Twenty-four slices in an axial T1-weighted turbo spin-echo sequence (TR 438, TE 10, ACQ matrix 260250, slice thickness 3.5).

The prostate is subsequently imaged utilizing **DW sequences** and three orthogonal difusion gradients (TR 1294, TE 85, ACQ matrix 88×84, slice thickness 5 mm, and 20 slice) with b values of 0, 250, 500, 1000, and 2000s/mm2 on a multi-shot echoplanner.

3D HMR Spectroscopy: For the quantitative detection of choline, citrate, and creatinine, multi-voxel H-MR spectroscopy imaging is followed by the implementation of an automatic shimming algorithm

and manual post-shimming to optimize field homogeneity, followed by frequency selective fat and water suppression utilizing a prostate-adjusted box. The following are represented: TR 1132 and 1500, TE 110 and 120, SPIR1500, ACQ matrix 4×5, segments 55×55×55, and 5 slice.

Statistical analysis

When applicable, statistical measures such as range, mean, standard deviation, frequencies (number of cases), and percentages were utilized to characterize the data. For multi-parametric MRI, the sensitivity, specificity, accuracy, positive predictive value, and negative predictive value of conventional T2WI, diffusion weighted imaging, and MR spectroscopy were calculated independently for each parameter. To determine the difference between variables, the Mann–Whitney test was applied. $P < 0.05$ was established as the level of statistical significance, and all reported P values were two-sided.

RESULTS

Table 1: Age and clinical presentation among the studied cases

Characteristics	Mean±SD	Range
Age (years)	65±8.9	50.0−80.0
	N	%
Retention	13	65
Dysuria	11	55
Hematuria	8	40
Frequency	6	30
Hematosperia	3	15
Bone pain	1	5

The Study comprised a sample of 20 male patients, ranging in age from 50 to 80 years (Mean±SD 65±8.9), and presenting with diverse urological symptoms.

Table 2: Conventional MRI compared with histopathology results

Histopathology	MRI findings	No	Percent (%)
Cyst	Cystic lesion (high T2, low T1)	2	100
BPH	Enlarged transitional zone with normal peripheral zone	3	100
Malignant	Enlarged transitional zone with abnormal SI at peripheral zone (BPH+cancer) Abnormal SI at peripheral zone and transitional zone (sarcoma Total	8 2 10	 100
Infarction	Enlarged transitional zone with abnormal SI at peripheral & transitional zones	1	100
Atrophy	Normal transitional zone with abnormal SI at peripheral zone	2	100
Granulomatous prostatitis	Enlarged transitional zone with abnormal SI at peripheral & transitional zones	1	100

The results of comparing conventional MRI to histopathology are presented in Table 2. Ten cases are malignant, eight have an enlarged transitional zone accompanied by abnormal SI in the peripheral zone, and two have abnormal SI in both the transitional zone and peripheral zone (sarcoma).

Table 3 Showing biopsy results compared to DWI result

DWI	Biopsy			
	Adenocarcinoma	BPH	Mets	Lymphoma
Restricted	10	1	2	0
Facilitated	2	3	0	2
Total	12	4	2	2

Table 3 showing biopsy results compared to DWI results.

Table 4 Agreement between biopsy (reference) and MRI T2W findings

MRI T2W	Biopsy		Total
	Malignant	Benign	
Lesion	12(60%)	3(15%)	15(75%)
No lesion	2(10%)	3(15%)	5(25%)
Total	14(70%)	6(30%)	20(100%)

Fourteen cases were pathologically proved by Biopsy among the studied cases as malignant lesions, their percent 70% another 6 cases were proved by biopsy as benign lesion 30%.

DISCUSSION

Prostate cancer ranks second in developed countries in terms of cancer-related fatalities and is the most prevalent malignancy among males. Other varieties of prostate cancer are aggressive and can spread rapidly, whereas the majority of these diseases progress slowly and may require little to no treatment. Early prostate cancer detection increases the likelihood of effective treatment outcomes. Consequently, early detection of prostate cancer continues to be a challenge despite its critical importance.[12]

The objective of our research was to assess the diagnostic precision of magnetic resonance imaging (MRI) methods in distinguishing and defining various prostatic lesions when compared to TRUS. Additionally, we sought to emphasize the significance of advanced MRI techniques in precisely identifying, localizing, and staging prostate cancer.

The patients comprised a mean age of 65±8.9 years, ranging from a minimum of 50 years to a maximum of 80 years. Additionally, it indicates that the average PSA level was 64.2–34.4 ng/dL, with a minimum of 7 ng/dL and a maximum of 123 ng/dL. However, the study by Yuen JSP et al.[13] revealed that the mean age of their patients was 49 years. As of now, the majority of studies examining the accuracy of anatomic T2-weighted imaging in conjunction with one or more functional techniques for the detection of prostate cancer have reported a range of sensitivity and specificity values. A systematic review and meta-analysis comparing the diagnostic accuracy of T2-weighted imaging alone and T2-weighted imaging combined with DWI was recently published.[14]

By contrast-enhanced MRI, we discovered that only eleven cases (or 55 percent) possessed an enhanced curve. A positive curve indicates malignancy in seven cases, a nonspecific curve in two cases (35 percent), and a negative curve in two cases (10 percent). A study conducted in Singapore examined 24 males and yielded comparable results, with a cancer detection rate of 59.2%.[13]Preliminary findings on MRI-guided transgluteal biopsies in a cohort of 25 individuals with a median PSA of 11.8 ng/ml were reported by Zangos et al. [15] Their detection rate for malignancy was 40% (10 of 25). However, it is important to note that (1) the examination of the men was not conducted in succession, which introduces the possibility of selection bias, and (2) not all participants had previous negative TRUS-guided biopsies; thus, a subset of men underwent their biopsy for the first time. A transgluteal approach is also not regarded as the most advanced method for prostate biopsy due to its invasive characteristics. An initial experience with MRI-guided transrectal prostate biopsies utilizing a closed MR unit at 1.5 Tesla was documented by Beyersdorf et al. [16] in 2005. The study involved 12 consecutive patients, with a median prostate-specific antigen (PSA) of 10 ng/ml (range: 6–60). The presence of cancer was identified in five out of twelve males.

In this study, the sensitivity of MRI diagnosis was assessed with 15 cases yielding true positives at a rate of 50%, 8 cases producing false negatives at a rate of 26.7%, and 7 cases producing false positives at a rate of 23.3%.[17,18] Our findings corroborate the conclusions drawn in systematic reviews that evaluate the diagnostic precision of MP-MRI. The evaluations reported 58–96% sensitivities, 63–98% negative predictive values, and 23–87% specificities. Due to the single-center design of the studies, which each induced distinct target conditions using distinct reference standards, the ranges were extensive. Retrospective analysis, non-blinding of imaging findings (incorporation and reporting biases), and MP-MRI comparison with erroneous (TRUS-biopsy) or inappropriate (radical prostatectomy) reference tests hampered the majority of studies. An additional prospective study was conducted to compare MP-MRI and TPM-biopsy, with interim results followed by final results.[18]

This study examines the sensitivity of the TRUS diagnosis, which yielded the following results: 6 cases (20%) were true positives, 8 cases (26.7%) were true negatives, 9 cases (30%) were false positives, and 7 cases (23.3%) were false negatives. Futterer JJ et al[17] reported that in terms of both sensitivity (98% vs 48%) and negative predictive value (89% vs 74%), MP-MRI was more precise than TRUS-biopsy. In their research, TRUS-biopsy demonstrated increased specificity (41% vs. 96%) and positive predictive value (51% vs. 90%).Ohori et al. [19] discovered that the combination of digital rectal examination and transrectal ultrasound to predict extracapsular tumor extension had a sensitivity of 91% and a positive predictive value of 79%. Additionally, Maričić et al. [20] documented that the initial period sensitivity of transrectal sonography was 62.57%, while the negative predictive value was 87.72%. Specificity was 94.2%, accuracy was 86.2%, and positive predictive value was 80.45%.

Djavan et al. [21] conducted the inaugural investigation of its kind wherein they analyzed the correlation between the number of prior negative TRUS-guided biopsies and the detection rates of prostate cancer. The quantity of prior negative TRUS-guided biopsies had no significant impact on the detection of prostate cancer using MRI-guided biopsy. The detection rate for TRUS-guided biopsies exhibits a negative correlation with the number of biopsies conducted. Specifically, the first, second, and third biopsies have been documented to have detection rates of 10%, 5%, and 4%, respectively.

In comparison to conventional biopsy techniques, MRI-US fusion targeted biopsies detect 17% fewer

low-risk malignancies and 33.3% more clinically significant cancers (median: 9.2 vs. 23.6%) with fewer cores (median: 37.1% vs. 23.6%).[22,23]This is further supported by a recent meta-analysis which found that MRI-TBx detected significant prostate cancer at a higher rate than TRUS-Bx, which had a sensitivity of 91% and a lower rate of detecting insignificant prostate cancer.[24]

CONCLUSIONS

The trans-rectal ultrasound (TRUS)-biopsy is presently regarded as the clinical gold standard for the conclusive diagnosis of prostate cancer. Nevertheless, this form of TRUS-guided biopsy exhibits a notable sampling error, potentially overlooking as many as 30% of malignancies. Furthermore, it may underestimate the Gleason grade, particularly in tumors situated anteriorly. It could potentially result in a heightened incidence of complications. MRI plays a crucial function in enhancing the safety of the diagnostic process. It can also assist in the planning of radiation therapy or surgery, as well as staging. Despite its extensive application in diagnosis due to its exceptional soft tissue resolution, T2W MRI exhibits suboptimal accuracy when it comes to the detection and localization of prostate cancer. The diagnostic efficacy is enhanced through the integration of dynamic contrast enhanced (DCE MRI), diffusion weighted imaging (DWI), multi-parametric MRI (mp MRI), and MR spectroscopy (MRS) into a single program.

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