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Role Of Dynamic Contrast Enhanced And Diffusion Weighted 3 T MRI In Suspected Prostate Cancer

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Abstract

Background : Prostate cancer is one of the most common malignancies in men and preoperative identification of localized prostate cancer for early detection and staging are issues of major concern. Its mortality in India is 2.5/100,000. MRI has the potential to improve the identification of prostate cancer at an early stage.
Aim: To evaluate the role of 3 Tesla Dynamic contrast enhanced and Diffusion weighted imaging in detection of suspected prostate cancer and assessment of its local extent.
Material and methods: 40 patients who were suspected of prostate cancer on the basis patient's symptoms of hematuria, hemospermia, urgency, frequency and nocturia along with digital rectal examination findings of a hard mass and/or serum PSA levels of more than 4 ng/ml underwent multiparametric MR evaluation.
Results: In my study, conventional T2WI role in the detection of pathology revealed a Sensitivity of 85.7%, Specificity of 58.33 %, Positive predictive value of 82.75 %, Negative predictive value of 63.63 % whereas T2 weighted imaging combination with advanced MRI imaging techniques revealed a Sensitivity=92.86%, Specificity =91.67%, Positive predictive value=96.30%, Negative predictive value=84.62%.
Conclusion : Thus the combination of multiple MR parameters is valuable for more accurately evaluating tumour and its spatial extent. This is likely to be due to complementary information provided from diffusion-weighted imaging and dynamic contrast enhanced imaging.
Keywords : Prostate cancer**,** Dynamic contrast enhanced and Diffusion weighted imaging

Introduction

Prostate cancer is a commonly diagnosed tumor in men that represents a broad spectrum of severity, ranging from indolent to highly lethal.[1] The role of imaging sophisticated magnetic resonance (MR) imaging techniques allow insight into such processes as the freedom of water molecule movement, the micro-vascular integrity and hemodynamic characteristics.

The use of serum Prostate Specific Antigen (PSA) has increased the diagnosis of prostate cancer. One problem with current standard of care is that raised PSA has led to random prostate biopsies. Thus MRI may play a role in conjunction with PSA in localizing biopsy site as well as identifying those tumours which can cause death if left untreated.

Only a few MR studies addressing this issue have been conducted at a field strength of 3T. In this study, the role of the most commonly used advanced MR imaging

techniques—perfusion imaging and diffusion-weighted imaging at a field strength of 3 T—in the detection of prostate cancer has been explored.
In the current study, we evaluated the combined role of DWI and DCE in the detection of prostate cancer which yielded high sensitivity and specificity, compared to the conventional MRI, in combination with PSA level and histopathological analysis. High PSA level was the first step for raising suspicion for cancer followed with updated radiological imaging studies.

The term "dynamic" is derived from the multiple serial images that are collected after injection of contrast media. The clinical application of DCE-MRI for prostate cancer is based on data showing that malignant lesions show earlier and faster enhancement & earier contrast agent washout compare with healthy prostate tissues. [2,3]

Material and methods

This was a prospective study in which the diagnostic accuracy of multi-parametric MRI techniques in the detection, assessment and characterization of prostatic cancer. The study was conducted from March 2016 to June 2017 in the department of radiodiagnosis RML-IMS, Lucknow in collaboration with department of surgery and pathology. The institutional ethics committee and the research committee approved the study protocol, and informed consent was obtained from the patients or their care providers.

INCLUSION CRITERIA:

1. Patients of clinically suspected prostate cancer at primary presentation.
2. Patients with raised serum PSA values at presentation
3. Biopsy proven prostate cancer patients not started treatment and with a gap of >= 8 weeks after biopsy procedure.

EXCLUSION CRITERIA:

1. Patients with any metallic implants whereby MRI examination is contraindicated.
2. Patients with Cardiovascular devices (pacemakers, catheter, defibrillators leads)
3. Claustrophobic and agitated patients.
4. Known history of contrast associated adverse effects (moderate to severe chronic kidney disease and proven nephrogenic systemic fibrosis.)

Statistical analysis

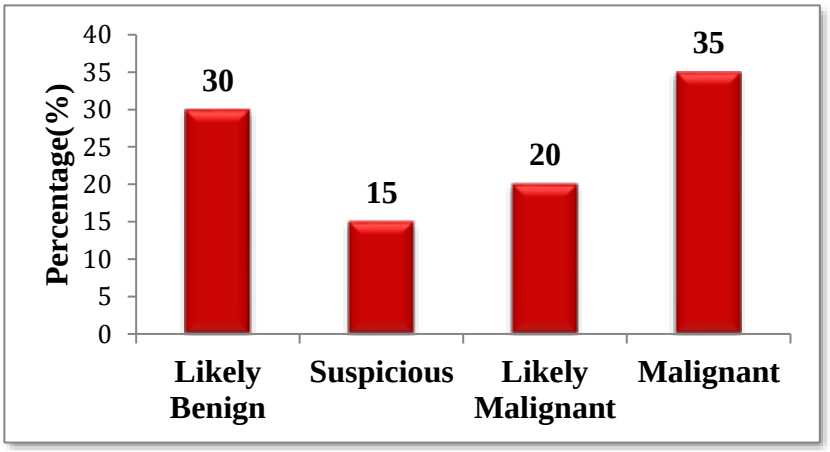
The sensitivity, specificity, PPV and NPV were calculated of the imaging results were calculated from 2x2 contingency table with histopathology taken as gold standard. Statistical analysis was performed using statistical software IBM SPSS, version 23.

Results

A study conducted on 40 subjects showed that the most common shape of prostate gland was a chestnut configuration.

High PSA level was the main including criterion where it ranged from 5.2 to 549 ng/ml. The mean PSA level was 64.65 (±115.94) ng/ml, where the largest group had a PSA level less between 5-40 ng/ml (30 patients).
After laboratory, clinical and imaging evaluation, prostate cancer was detected in 28 patients (70%) and benign was reported in rest 12 patients (30%) including Benign prostatic tissue with prostatitis and no evidence of malignancy.
The majority of the malignant lesions (28 patients) were in the peripheral zone, out of which 10 patients had mixed peripheral and central zone involvement. None of the patients had isolated central gland malignant lesions. Remaining 12 patients had nodules exclusively in central zone which turned out to be benign.

Graph 1 : Percentage distribution of PIRADS in study population.



- PIRADS : Prostate Imaging Reporting And Data System.

Table 1: Association between washout with PIRADS category.

		Wash out on dynamic imaging		
		Yes	No	Total
PIRADS	Likely Benign	0	12	12
		.0%	85.7%	30.0%

Suspicious	4 15.4%	2 14.3%	6 15.0%
Likely Malignant	8 30.8%	0 .0%	8 20.0%
Malignant	14 53.8%	0 .0%	14 35.0%
Total	26 100.0%	14 100.0%	40 100.0%

Table 2: Mean comparison of parameters extracapsular extension, perineural invasion, and seminal vesicle invasion

	Extra-capsular extension		
	Yes (N=20)	**No (N=20)**	
	Mean ± SD	**Mean ± SD**	**P value**
BASELINE PSA (ng/ml)	114.25 ± 149.51	15.05 ± 7.74	0.005*
PROSTATE VOLUME (cc)	44.33 ± 18.17	55.70 ± 37.83	0.233
PSA DENSITY(PSA/prostate volume)	3.04 ± 4.36	0.35 ± .23	0.009*
	Perineural invasion		
	Yes (N=14)	**No (N=26)**	
	Mean ± SD	**Mean ± SD**	**P value**
BASELINE PSA (ng/ml)	149.97 ± 166.52	18.71 ±16.72	<0.001*
PROSTATE VOLUME (cc)	43.75 ±16.27	53.38 ± 34.91	0.337
PSA DENSITY(PSA/prostate volume)	3.97 ± 4.93	0.47 ± 0.51	0.001*
	SVI(*3)		
	Yes (N=14)	**No (N=26)**	
	Mean ± SD	**Mean ± SD**	**P value**
BASELINE PSA (ng/ml)	146.83 ±169.11	20.39 ±16.73	<0.001*
PROSTATE VOLUME (cc)	48.57 ± 19.87	50.79 ± 34.39	0.826

PSA DENSITY(PSA/prostate volume)	3.84 ±5.02	.54 ±0.51	0.002*

Table 3: Association b/w histopathological findings & extracapsular extension, perineural invasion, seminal vesical involvement

	Extra-capsular extension		Perineural invasion		Seminal vesical involvement		Total
	Yes	No	Yes	No	Yes	No	
Adenocarcinoma	20 (100%)	8 (40%)	14 (100%)	14 (53.8%)	14 (100%)	14 (53.8%)	28 (70%)
Benign	0 (100%)	12 (60%)	0 (100%)	12 (46.2%)	0 (0%)	12 (46.2%)	12 (30%)
Total	20 (100%)	20 (100%)	14 (100%)	26 (100%)	14 (100%)	26 (100%)	40 (100%)

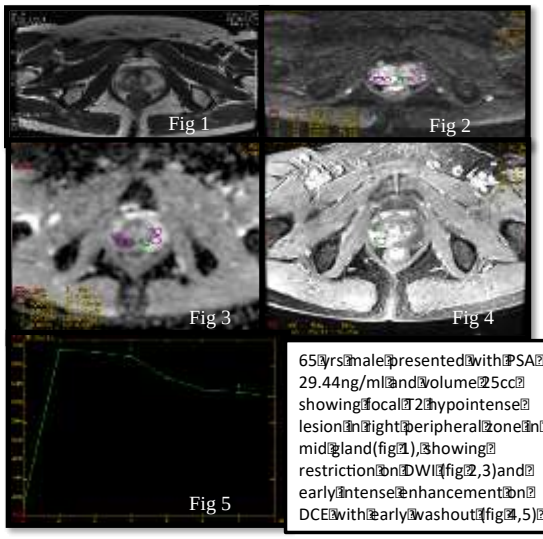
Table 4: Sensitivity, Specificity, PPV, NPV

	Histopathology yes	Histopathology no
Conventional T2 yes	24	05
Conventional T2 no	04	07

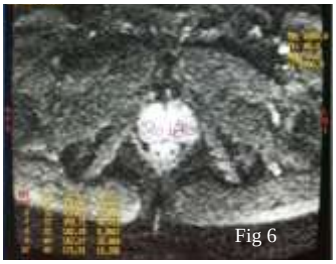
Sensitivity =85.7%
Specificity =58.33%
PPV=82.75%
NPV=63.63%

	Histopathology yes	Histopathology no
Conventional + advanced MRI yes	26	01
Conventional + advanced MRI no	02	11

Sensitivity=92.86%
Specificity =91.67%
PPV=96.30%
NPV=84.62%



65 yrs male presented with PSA 29.44ng/ml and volume 25cc showing focal T2 hypointense lesion in right peripheral zone in mid gland(fig 1), showing restriction on DWI (fig 2,3) and early intense enhancement on DCE with early washout (fig 4,5)



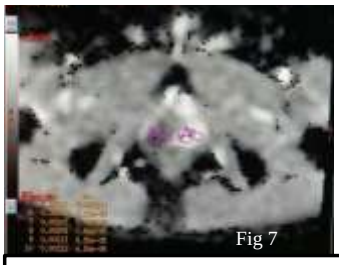


Figure (6 and 7) Method of determining ADC of DWI images with ADC maps, atleast three different ROIs of area 30-40 mm^2 each were placed in different regions of tumour, with lowest ADC considered. An ADC of 0.000784 in ROI 3 was considered lowest in this example.

Discussion

In the current study, conventional T2WI role in the detection of pathology revealed a Sensitivity of 85.7%, Specificity of 58.33 %, Positive predictive value of 82.75%, Negative predictive value of 63.63 % whereas T2 weighted imaging combination with advanced MRI imaging techniques revealed a Sensitivity=92.86%, Specificity =91.67%, Positive predictive value=96.30%, Negative predictive value=84.62%.

We performed DWI technique without breath holding, using a multi-channel phased array surface coil only. On the other hand, Kim et al.[4] reported that endorectal coil provides a superior signal-to-noise ratio (SNR) but causes reduced patient compliance and increased susceptibility effects, whereas, the pelvic phased-array coil results in a relatively inferior SNR, which may be overcome by increasing the number of averages used in imaging, however, this compensatory strategy results in a longer image acquisition time. Also, Turkeby et al.[5] added that endorectal coils provide large gains in signal with reductions in noise, most noticeably at 1.5 T; however, endorectal coils are uncomfortable and expensive.

The considered criterion for the diagnosis of cancer prostate in our study was hyperintense lesion on DWI on suppressed background with corresponding low ADC value. Ren et al.[6]and Koh et al.[7] reported that in Prostate cancer, higher signal

intensity on DWI and lower ADC compared with BPH nodule and normal tissue is explained with the replacement of normal tissue (composed of water rich acinar structures) by densely packed malignant epithelial cells within small amount of stroma, associated with increased nucleus-to-cytoplasm ratio, resulting in extremely reduced motility of water molecules.

Dynamic contrast enhanced (DCE) MRI has the ability to track the enhancement of tissue and therefore provide a measure of angiogenesis, on which tumor growth is dependent . In DCE MRI, tumors are highlighted by their strong enhancement compared to the normal background tissue. Tumor enhancement appears earlier and washes out more quickly in comparison to normal tissue. This reflects the process of angiogenesis—whereby new vessels are formed with higher vascular permeability to deliver more nutrients to the growing tumor, thus aiding in its growth.

On DWI, 25 of them, proved to be carcinomas, showed restricted diffusion (seen as hyperintense on the highest used *b* value image, hypointense on the ADC map) with a corresponding low measured ADC value ranging from $0.485–1.040 \times 10^{-3}$ mm^2/s. The mean ADC value was $0.73 (\pm 0.14) \times 10^{-3}$ mm^2/s. The remaining three cases of the hypointense lesions seen on the T2WI, did not show restriction as hyperintense signals on the DWI and relatively hypointensity in ADC map and the measured ADC value was borderline at 1.2×10^{-3} mm^2/s.

Dynamic contrast enhanced MRI adds specificity because the lesions that enhance and wash out rapidly are likely to be prostate cancer. Engelbrecht et al[8]–reported that optimal parameter for discrimination of prostate cancer in peripheral zone and central gland was relative peak enhancement. Noworolski et al[9] showed significantly higher peak enhancement , faster enhancement slopes and faster wash out slopes in abnormal as compared with normal peripheral zone. Barentsz et al[10] showed that fast dynamic MRI of prostate cancer resulted in early enhancement , steeper slope, higher maximal signal intensity, and washout in comparision to normal tissue. Our study had findings similar to prior reports and shows modest benefit of adding DCE to prostate imaging protocols.

Conclusion

The combination of multiple MR parameters is valuable for more accurately evaluating tumour and its spatial extent. This is likely to be due to complementary information provided from diffusion-weighted imaging and dynamic contrast enhanced imaging. A visual map that combines low ADC, early and intense enhancement, small time to peak with early wash out may be useful in correctly identifying the tumour. It helps not only in identifying and characterization of tumour but also in assessing its local extent. This multi-parametric MR approach will provide physicians treating patients with prostate cancers with additional diagnostic information.

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