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Original Research Article

Role of transrectal ultrasound and MRI in the diagnosis and localisation of carcinoma prostate - A comparison of diagnostic efficacy of trus versus MRI

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ABSTRACT

Background: In this study, we wanted to correlate the findings of TRUS and MRI with regard to the diagnosis and localization of carcinoma prostate and local staging of carcinoma prostate.
Materials and Methods: Our study included 43 men, with age ranging from 49 to 76 years. They underwent TRUS, MRI and TRUS guided twelve core biopsies after being suspected with prostate cancer based on high PSA values (greater than 4.0 ng /ml) or abnormal DRE findings. This study was conducted from April 2018 -June 2019. Imaging findings were confirmed with histopathology.
Results: TRUS used for the detection of malignancy had sensitivity, specificity, PPV and NPV as 69.70%, 80 %, 92% and 44.44 % respectively. The values were 63.16%, 83.33%, 75.00%, and 74.07% for the sensitivity, specificity, PPV and NPV of TRUS respectively for the detection of ECE. \r\nFor the detection of malignancy, the sensitivity, specificity, PPV and NPV of MRI was 87.88%, 70%, 90.63% and 63.64% respectively and 85.71%, 89.66%, 80.00% and 92.86% for the sensitivity, specificity, PPV and NPV of MRI respectively for detection of SVI.
For detection of extracapsular extension (ECE), MRI had sensitivity, specificity, PPV and NPV of 78.95%, 83.33%, 78.95% and 83.33% respectively.
Conclusions: When compared to TRUS, MRI is more useful in the diagnosis and accurate staging of prostate cancer. MRI can improve the false-negative biopsies resulting due to the inability of TRUS in detection of abnormal areas.

1. Introduction

In most mammals prostate is a compound tubuloalveolar exocrine gland of the male reproductive system. Prostate cancer is one of the commonest malignancies. There is a considerable need for imaging techniques that allow accurate detection and staging of the tumour before treatment because of the high incidence and increasing awareness of prostate cancer along with the ongoing development of new and improved treatment methods.

There are some shortcomings of the Transrectal ultrasound (TRUS) even though it caused considerable excitement when it was first introduced, and hence its use in screening has been limited. TRUS remains a valuable tool to obtain biopsy samples though studies have shown that it may not be able to diagnose 24 to 30% of cancers that have the same echogenicity as surrounding prostate tissue.

On the other hand, the extra prostatic extension and regional metastatic spread of the local disease have been assessed accurately by the MRI. This proves useful in planning biopsy and disease targeting therapies that are currently being developed since the MRI technique can locate the site of intraprostatic disease.

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2. Aims and Objectives

The objectives of our study were to correlate the findings of TRUS and MRI in

1. The local staging of prostate cancer.
2. The diagnosis and localization of carcinoma prostate.

3. Materials and Methods

3.1. Patients

There were 43 men with age range of 49-76 years in this prospective study. They underwent TRUS, MRI and TRUS guided twelve core biopsies after being suspected with prostate cancer based on high PSA values (greater than 4.0 ng /ml) or abnormal DRE findings. The study was conducted from April 2018 to June 2019 in the department of Radiodiagnosis at Medical Trust Hospital, Kochi, Kerala. Before the TRUS-guided twelve core biopsy, all the patients underwent TRUS and MRI. Imaging findings were confirmed with histopathology.

3.2. Transrectal ultrasonography (TRUS) protocol

TRUS was performed on PHILIPS IU-22 using a C9-5ec frequency endocavitatory transducer. A standard sequence of axial images from apex to base was included in the examination. Identification of a suspicious malignant lesion as a focal hypoechoic area with an irregular border in the peripheral zone was done. Bulging or irregularity of the capsule adjacent to a hypoechoic lesion was the criteria used for identifying extracapsular extension (ECE). A hypoechoic lesion that is visibly extended at the base of the prostate into a seminal vesicle or echogenic cancer within the normally fluid-filled seminal vesicle indicates the seminal vesicle invasion (SVI). Solid hypoechoic masses within the seminal vesicles or asymmetry of the seminal vesicles is an indirect indicator of disease extension.

3.3. Biopsy protocol

The risks and benefits of the biopsy procedure were explained to each patient, and written informed consent was obtained prior to the biopsy. Using 18-G tru-cut biopsy needles loaded on a biopsy gun the biopsies were taken during longitudinal scanning. The twelve core biopsies were taken as follows; from the base, mid lobe and near the apex of the prostate three cores were taken from each side of the lateral area and from the far lateral areas of the prostate at the base, mid lobe and near the apex another 3 cores were taken from each side. Patients were subjected to additional directed 2 biopsies after their hypoechoic areas were visible on ultrasound. To identify the biopsy location all biopsy cores were labelled and the uropathologist evaluated all these specimens.

3.4. MRI Protocol

MRI examination was performed in all patients, before the biopsy. Using 16 channel phased array TORSO coil, MRI imaging was performed on a 1.5 Tesla MR Scanner [PHILIPS MR ACHIEVA]

Table 1: The sequences used and their details

TR	4300 ms
TE	90 ms
Slice	3 mm thickness [slice gap zero]
Matrix	400 X 220
FOV	200/200
No. of slices	19
T 2 Axial	
TR	4300 ms
TE	90 ms
Slice	3 mm thickness [slice gap zero]
Matrix	360 X 170
FOV	180/180
No. of Slices	20
T 2 Coronal	
TR	4300ms
TE	90 ms
Slice thickness	3 mm [slice gap zero]
Matrix	400 X 220
FOV	200/200
No. of Slices	19
T 2 sagittal	
TR	520 ms
TE	15ms
Slice thickness	3 mm [slice gap zero]
Matrix	240 X 180
FOV	180 X 80
No. of Slices	19
T1 Axial	
TR	2500 ms
TE	89ms
No. of Slices	10
Slice thickness	6 mm
Matrix	80 X 61
FOV	160/144
B value	0,50, 2000
Diffusion	
Volume methods	3 slices
Method	PRESS [Point resolved spectroscopy]
TR	1500
TE	120
Spectroscopy	

Intravenous injection of 0.2 mmol per kg body weight of gadolinium at the rate of 2 ml/sec [as a bolus] followed by a 10 ml of saline flush was given and thereafter a dynamic contrast study was obtained.

3.5. MRI image interpretation

The prostate demonstrates homogeneous medium signal intensity on T1-weighted images, which makes it impossible for the tumours to be recognized. Prostate cancer on T2-weighted images appears as area of low signal intensity in the peripheral zone that is easily differentiated from high signal-intensity normal tissue. On diffusion-weighted imaging, the malignancy shows low ADC values as compared to the normal gland. The malignancy shows early wash-in and early wash-out on dynamic post-contrast imaging when compared to the normal gland. On proton spectroscopy, the malignancy shows raised choline: creatinine ratio as compared to the contralateral side. Asymmetry of the neurovascular bundle, obliteration of the recto-prostatic and vesicoprostatic fat plane, an irregular or speculated margin, capsular retraction, tumour envelopment of the neurovascular bundle and a breach of the capsule with evidence of direct tumour extension are the criteria for ECE. Focal low signal intensity within the seminal vesicle, obliteration of the angle between the prostate and the seminal vesicle (best seen on sagittal images), disruption or loss of the normal architecture of the seminal vesicle, and demonstration of direct tumour extension from the base of the prostate into and around the seminal vesicle are some of the features included in SVI.

3.6. Statistical methods

A cross-table was used for correlating the histopathology results, TRUS and MR imaging findings from which sensitivity, specificity, and positive and negative predictive values were calculated.

4. Results

Our study group included 43 patients. 29 (67.44%) patients were in the age group of 61-70 yrs. This suggests that carcinoma of the prostate was the most common in this age group.

Out of 43 patients in our study, TRUS identified a hypoechoic lesion in one or both peripheral zones in 25 (58.14 %) patients. Out of 43 patients, 33 (76.74 %) patients were detected to have carcinoma of the prostate on histopathology. Out of 25 patients, in whom TRUS identified a hypoechoic lesion in one or both peripheral zones, 23 were detected to have carcinoma of the prostate on histopathology and 2 were histopathologically negative. Thus the values were 69.70%, 80%, 92% and 44.44% for sensitivity, specificity, PPV and NPV of TRUS for detection of malignancy respectively.

Out of 33 patients, who were having histopathology proven malignancy, 19 patients were detected to have ECE. TRUS detected 16 patients to have ECE, but only 12 patients had ECE and 4 patients were negative for ECE on histopathology reports. Thus TRUS carried a sensitivity of

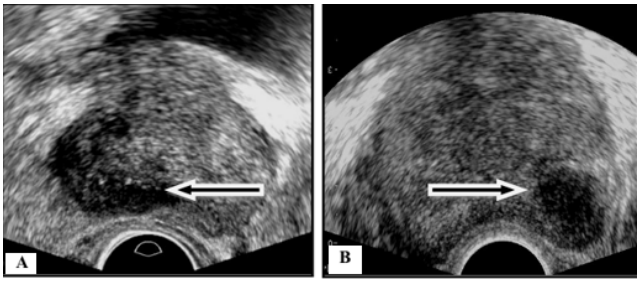

Figure 1: Appearance of malignant lesion on TRUS A. Hypoechoic lesion with irregular borders is seen in right peripheral zone B. Hypoechoic lesion with irregular borders is seen in left peripheral zone.

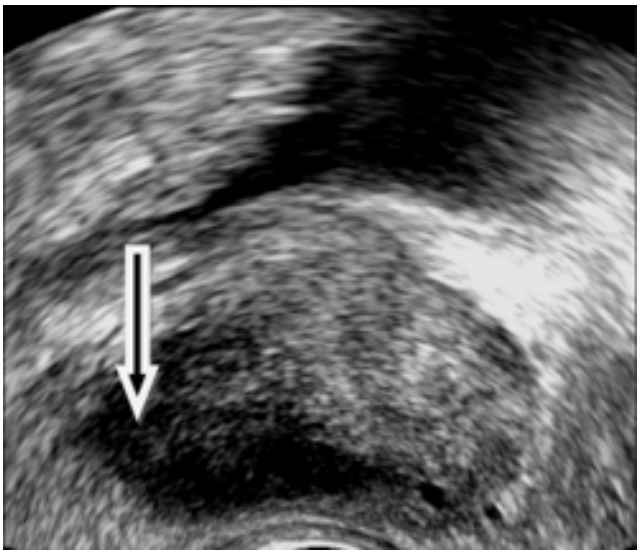

Figure 2: Appearance of ECE on TRUS - Bulging and irregularity of prostatic capsule overlying the right peripheral zone lesion suggestive of ECE

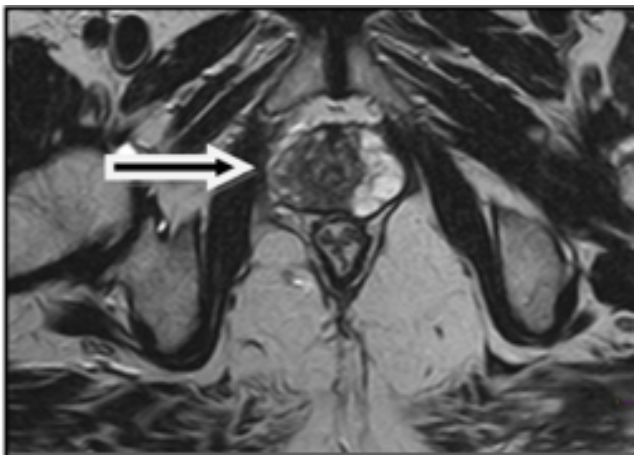

Figure 3: Appearance of malignant lesion on T2 W axial images - Hypointense lesion is seen in right peripheral zone

Table 2:

	PZ lesion		Total
	Positive	**Negative**	
TRUS	25 (58.14%)	18 (41.86%)	43
MRI	32(74.42%)	11 (25.58%)	43
Histopathology	33 (76.74%)	10 (23.26%)	43

Distribution of patients with respect to detection of malignancy on TRUS, MRI and Histopathology.

	ECS		Total
	Positive	**Negative**	
TRUS	16 (37.21%)	27 (62.79%)	43
MRI	19 (44.19%)	24 (55.81%)	43
Histopathology	19 (44.19%)	24 (55.81%)	43

Distribution of patients with respect to ECS on TRUS, MRI and Histopathology.

	ECS		Total
	Positive	**Negative**	
MRI	15 (34.88%)	28 (65.12%)	43
Histopathology	14 (32.56%)	29 (67.44%)	43

Distribution of patients with respect to SVI on MRI and histopathology.

Table 3:

TRUS Findings	**Histopathology findings**		**Total**
	Positive	**Negative**	
Positive	23	2	25
Negative	10	8	18
Total	33	10	43

Efficacy of TRUS in the detection of malignancy

MRI findings	**Histopathology findings**		**Total**
	Positive	**Negative**	
Positive	29	3	32
Negative	4	7	11
Total	33	10	43

Efficacy of MRI in the detection of malignancy

MRI findings	**Histopathology findings**		**Total**
	Positive	**Negative**	
Positive	12	4	16
Negative	7	20	27
Total	**19**	**24**	**43**

Efficacy of TRUS in the detection of ECS

MRI findings	**Histopathology findings**		**Total**
	Positive	**Negative**	
Positive	15	4	19
Negative	4	20	24
Total	19	24	43

Efficacy of MRI in the detection of ECS.

MRI findings	**Histopathology findings**		**Total**
	Positive	**Negative**	
Positive	12	3	15
Negative	2	26	28
Total	14	29	43

Efficacy of MRI in the detection of SVI.

Table 4:

Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
69.70%	80.00%	92.00%	44.44%
Sensitivity, Specificity, PPV and NPV of TRUS in the detection of Malignancy			
Sensitivity	**Specificity**	**Positive Predictive Value**	**Negative Predictive Value**
87.88%	70.00%	90.63%	63.64%
Sensitivity, Specificity, PPV and NPV of MRI in the detection of Malignancy			
Sensitivity	**Specificity**	**Positive Predictive Value**	**Negative Predictive Value**
63.16%	83.33%	75.00%	74.07%
Sensitivity, Specificity, PPV and NPV of TRUS in the detection of ECS			
Sensitivity	**Specificity**	**Positive Predictive Value**	**Negative Predictive Value**
78.95%	83.33%	78.95%	83.33%
Sensitivity, Specificity, PPV and NPV of MRI in the detection of ECS			
Sensitivity	**Specificity**	**Positive Predictive Value**	**Negative Predictive Value**
85.71%	89.66%	80.00%	92.86%
Sensitivity, Specificity, PPV and NPV of MRI in the detection of SVI			

Table 5: Lymphadenopathy and skeletal metastasis

Finding	No. of Patients
Lymphadenopathy	03
Skeletal Metastasis	04

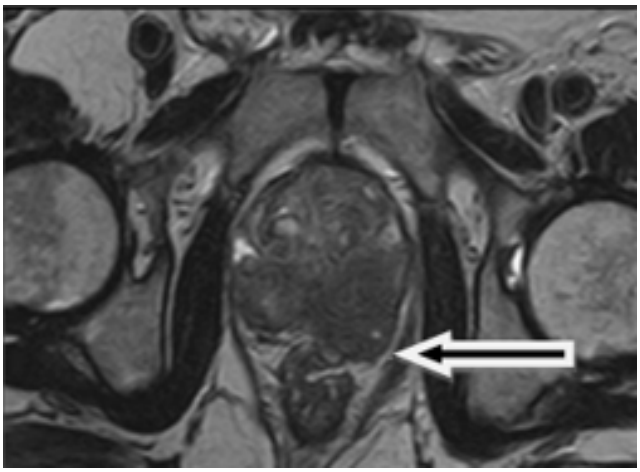

Figure 4: T2 W axial image showing -Appearance of extracapsular extension on MRI

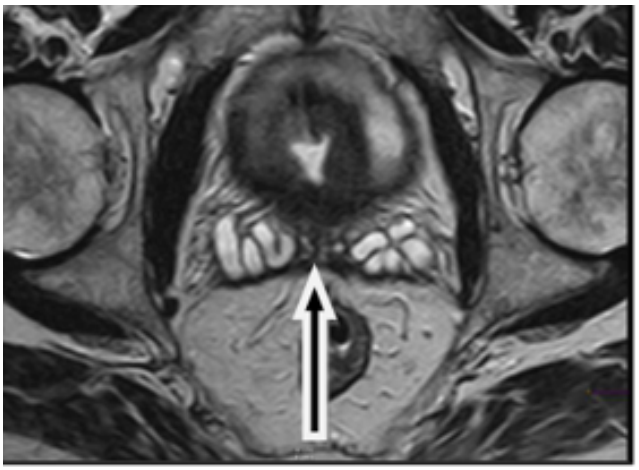

Figure 5: T 2 W axial-Appearance of seminal vesicle invasion on MRI

63.16 %, specificity of 83.33 %, PPV of 75.00 % and, NPV was 74.07 % in the detection of ECE.

Out of 43 patients in our study, MRI identified a malignant lesion in one or both peripheral zones in 32 (74.42 %) patients. Out of 43 patients, 33 (76.74%) patients were detected to have carcinoma of the prostate on histopathology. Out of 32 patients, in whom MRI identified a malignant lesion in one or both peripheral zones, 29 were detected to have carcinoma of the prostate on histopathology and 3 were histopathologically negative. Thus there was a sensitivity of 87.88 %, specificity of 70 %, PPV of 90.63 % and NPV 63.64 % of TRUS for detection of malignancy.

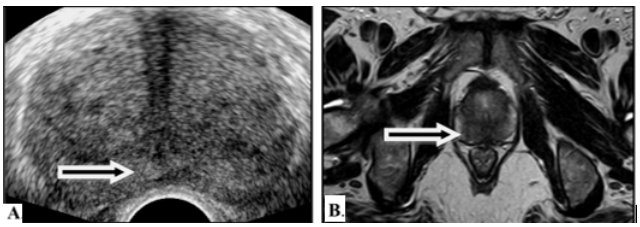

Figure 6: A: TRUS not showing any lesion; **B:** MRI showing the lesion

Out of 33 patients, who were having histopathology proven malignancy, 14 patients were detected to have SVI on histopathology. MRI detected 15 patients to have SVI, but only 12 patients had SVI and 3 patients were negative for SVI on histopathology reports. Thus sensitivity, specificity, PPV, NPV of MRI for detection of SVI were 85.71%, 89.66%, 80.00% and 92.86% respectively.

For detection of the malignant lesion in the peripheral zones of the prostate, TRUS had sensitivity, specificity, PPV and NPV of 69.70%, 80%, 92% and 44.44% respectively. While MRI had sensitivity, specificity, PPV and NPV of 87.88%, 70%, 90.63% and 63.64% respectively.

In addition, MRI detected lymphadenopathy in three patients and skeletal metastasis in four patients. These were additional findings that we could detect with MRI as compared to TRUS.

5. Discussion

5.1. Trans rectal ultrasound (TRUS)

A suspicious malignant lesion was identified as a focal hypoechoic area with an irregular border in the peripheral zone in our study. Pulsed wave Doppler showed increased vascularity in these suspicious malignant lesions. Our results are in agreement with the results of Colombo T et al[1] who found a "sensitivity of TRUS for detection of malignancy to be 66.1%."; also with J Tang, S Li, J Xu et al[2] who found a "sensitivity of 76.0% and specificity of 89.4%"; as well as with J C Presti, H Hricak et al[3] who "found sensitivity (70%) and specificity (58%)"; H Ito, K Kamoi et al[4] also found similar results with "sensitivity and specificity of 68% and 94%" and Maria Inês Novis, Ronaldo Hueb Baroni et al[5] who found sensitivity to be 70.4%. However, M Watanabe, M Saitoh et al[6] found "a sensitivity of TRUS to be 80%"; and R Malik, V K Pandya et al[7] found "sensitivity and specificity of TRUS as 86.96 percent and 71.43 percent respectively for diagnosis of prostate cancer"; which is slightly higher as compared to our study. Also, Sheila Sheth et al[8] found a sensitivity of TRUS in the detection of malignant lesions as 55% and the specificity as 37% which were lower as compared to our study. A study by M K Terris, F S Freiha et al[9] found a "sensitivity of 53.3% and a specificity of 75%"; also N Hayashi, J Kawamura et al[10] found a "sensitivity of TRUS" to be 57% and Dirk Beyersdorff et al[11] found the "sensitivity to be 33%" which were lower as compared to our study.

There was a bulging or irregularity of the capsule adjacent to a hypoechoic lesion in the extracapsular extension (ECE) of the malignancy. Our study results are similar to the results of J Rørvik, O J Halvorsen et al[12] wherein "for the detection of extracapsular tumour growth by TRUS of prostatic cancer, the sensitivity, specificity, positive and negative predictive values were found to be 68%, 63%, 85% and 38%, respectively". J M Vapnek, H Hricak, et al[13] found "PPV of 81% for TRUS in the detection of ECE", which is similar to our study. M Sanchez-Chapado, J C Angulo et al[14] found "the accuracy of TRUS for detection of ECE to be around 60%". However P L Vijverberg, M C Giessen et al[15] found "sensitivity and specificity of TRUS to be 43% and 91% respectively", for detection of ECE; Colombo T, Schips L, Augustin H, et al[1] found "sensitivity, specificity, positive predictive values as 41.2%, 81.8% and 36.8% respectively"; J C Presti, H Hricak et al[3] found, "sensitivity (48%), specificity (71%), positive predictive value (50%), and negative predictive value (69%)"; Maria Inês Novis, Ronaldo Hueb Baroni et al[5] found "sensitivity, specificity, PPV and NPV values as 33.3%, 92%, 14.3% and 97.2% for transrectal ultrasound in the detection of ECE". All these studies show the sensitivity of TRUS to be lower as compared to our study.

5.2. Magnetic resonance imaging

For non-invasive, anatomic and metabolic evaluation of prostate cancer, MRI is emerging as the most sensitive tool. When cancer is suspected despite negative transrectal US and biopsy findings, MR imaging can be used for prostate cancer detection. It can also help in local and distant staging. Because of the excellent demonstration of zonal anatomy and the relationship of the prostate gland to surrounding structures in the pelvic cavity, MRI is considered to be a good modality for imaging carcinoma prostate, especially for its local staging. For both treatment selection and treatment planning, pre-treatment knowledge of ECE is important. To complement T2-weighted MRI in improving prostate cancer localization techniques such as MR spectroscopy (MRS), diffusion-weighted MRI (DWI), and dynamic contrast-enhanced MRI (DCE-MRI), have been investigated.

Results similar to ours were found in the following studies; Dirk Beyersdorff et al[11] found a "sensitivity of 83% and a PPV of 50%"; H Ito, K Kamoi, et al[4] found "sensitivity and specificity of 87% and 74% respectively". However, Maria Inês Novis, Ronaldo Hueb Baroni et al[5] found "sensitivity, specificity, PPV and NPV of 71.5%, 58.9%, 76.6%, and 52.4% respectively" which were lower as compared to our study. J C Presti, H Hricak et al[3] found "sensitivity (97%), specificity (58%), positive predictive value (95%) and negative predictive values (70%)" which were higher as compared to our study.

The extracapsular extension (ECE) of the malignancy was detected as asymmetry of neurovascular bundle, obliteration of the rectoprostatic and vesicoprostatic fat plane, capsular retraction, tumour envelopment of the neurovascular bundle, an irregular or speculated margin and a breach of the capsule with evidence of direct tumour extension. P Torricelli, M Iadanza et al[16] found "85.7% sensitivity and 73.6% specificity"; Ronil V Chandra, Stefan Heinze et al[17] found "sensitivity and specificity for an

extracapsular extension to be 69 % and 82% respectively"; J M Vapnek, H Hricak, et al[13] found PPV of 77% in the detection of ECE; M Sanchez-Chapado, J C Angulo et al found NPV of 85%; all these studies show the results which are almost similar to our results. However, Maria Inês Novis, Ronaldo Hueb Baroni et al[5] found "sensitivity, specificity, PPV and NPV values for detecting extracapsular extension to be 50.0%, 77.6%, 13.7% and 95.6% respectively" which were on the lower side as compared to our study. J L Pariente, F Jacob et al[18] found "the positive predictive value of MRI to be 90% for the capsular invasion"; and J C Presti, H Hricak et al[3] found "sensitivity (91%), specificity (71%), positive predictive value (51%), and negative predictive value (90%)" which were on the higher side as compared to our study results in detection of ECE.

The SVI was detected as the obliteration of the angle between the prostate and the seminal vesicle (best seen on sagittal images), focal low signal intensity within the seminal vesicle, disruption or loss of the normal architecture of the seminal vesicle, and demonstration of direct tumour extension from the base of the prostate into and around the seminal vesicle. J L Pariente, F Jacob et al[18] found the "specificity of 92%" and P Torricelli, M Iadanza et al[16] found "91.6% sensitivity, 89.2% specificity in detection of SVI"; these results are matching with the results of our study. Ronil V Chandra, Stefan Heinze et al[17] found lower sensitivity i.e., 60 % but the specificity of 100% which was more as compared to our study. J M Vapnek, H Hricak, et al[13] found lower PPV i.e., 40% and equal NPV of 90%. Maria Inês Novis, Ronaldo Hueb Baroni et al[5] found lower sensitivity i.e., 40.0%, but almost equal specificity i.e., 83.1%, and almost similar NPV of 94.7%.

5.3. TRUS vs. MRI

The previous studies have referred to MRI as a more sensitive and specific modality for diagnosis and staging of carcinoma prostate and our results are in agreement with them.

5.4. Limitations and advantages of our study

More percentage of positive cases as compared to other studies may affect sensitivity and specificity. The pelvic phased-array coil has been used by us in comparison to the endorectal coil used in some of the studies. The advantages of our study include the use of colour Doppler in addition to conventional ultrasonography; which helped to improve the detection of a malignant lesion. We have also used DWI, dynamic contrast-enhanced sequences and proton spectroscopy as and when necessary, which helped to improve the detection of malignancy. By using pelvic phased-array coil we were able to detect skeletal metastasis and lymphadenopathy, which upgraded staging and helped in treatment planning.

6. Conclusions

Primarily used for biopsy guidance, Transrectal ultrasound (TRUS) is a standard imaging tool in prostate cancer, but when compared to MRI it is not much sense in differentiating normal prostate gland from cancer tissue, resulting in biopsies not specifically targeted to areas most likely to be malignant. But when the colour Doppler technique is used in conjunction with conventional TRUS, it slightly improves detection rates for malignancy. TRUS is also less sensitive in the detection of seminal vesicle invasion (SVI) and extracapsular extension (ECE) in comparison to MRI.

The sensitivity and specificity of MRI in the diagnosis of carcinoma prostate have been improved significantly by using imaging techniques like dynamic contrast-enhanced imaging (DCE), diffusion-weighted imaging and spectroscopy in conjunction with conventional MRI along with improvements in MRI technologies. In addition, MRI is more accurate in the detection of seminal vesicle invasion (SVI) and extracapsular extension (ECE). MRI is also helpful in the detection of lymphadenopathy and skeletal metastasis.

MRI is a more useful modality in the diagnosis and accurate staging of prostate malignancy as compared to TRUS. MRI can improve the false-negative biopsies resulting due to the inability of TRUS in the detection of abnormal areas by showing the exact area of abnormality.

Thus we feel that MRI is the modality that improves detection and upgrades staging of carcinoma prostate and plays an important role in the management of patients.

7. Source of Funding

None.

8. Conflict of Interest

None.

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