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Research Article

Imaging in Prostatic Carcinoma – An Insight

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Abstract

Prostate cancer is one of the leading causes of cancer death in males. Hence early detection is the key to early management and favorable outcome. Correct staging is required as it determines the treatment protocols especially radiotherapy planning and prognosis. Hence, this article aims to provide an imaging insight in to prostatic carcinoma for easy reference to accurate staging required for treatment planning & determining the prognosis.

INTRODUCTION

Though serum levels of prostatic specific antigen (PSA) may be used as a screening test for prostate carcinoma yet imaging plays a key role in final diagnosis. Imaging of prostate can be achieved with ultrasonography (transrectal - TR and transabdominal - TA), computed tomography (CT scan), magnetic resonance imaging (MRI) and positron emission tomography (PET scan) / PET-CT. However, imaging poses a major challenge as detection rate and staging ability of prostate carcinoma is different with each modality. Other major challenges in image interpretation include:

1. Post-biopsy changes and hemorrhage
2. Prostatitis
3. Hormone production Radiation Atrophy, etc.

DISCUSSION

Grossly, prostate is pyramidal in shape with apex directed inferiorly. Normal size of prostate is approximately 3*3*5cm corresponding approximately up to 25cc. Histologically, prostatic parenchyma is composed of glandular and non-glandular tissues divided in to four distinct zones viz. anterior fibromuscular stroma, central periurethral zone, transitional zone and peripheral zone.

Approximately 70% of prostate carcinoma is located in peripheral zone while rest involves transitional and central zones. Approximately 95% of prostate carcinoma is adeno carcinoma and rest 5% are either small cell carcinoma or mucinous adenocarcinoma or squamous carcinoma.

Ultrasonography (USG)

The commonest and most widely used imaging modality for prostatic anatomy and pathology, however only postero-lateral part can be imaged best with it (Figure 1-3). It is used for assessment of prostatic volume, echo-pattern and tissue stiffness.

Transrectal USG (TRUS) is superior to transabdominal, suprapubic, USG (TAS) for detection of prostatic pathology. On TAS, transverse is superior to longitudinal scan. TRUS is gold standard for all prostatic interventions including prostatic biopsy because of its easy use and real time imaging method.

On TRUS, classical imaging pattern is single or multiple, hypoechoic foci with increased vascularity on color **or** power Doppler imaging. Irregular capsule is a constant feature of prostatic carcinoma [1]. Enlarged prostate with irregular margins, extension in to adjacent part of urinary bladder and nonvisualisation of seminal vesicles are sensitive markers of mitotic disease especially when associated with iliac or para-aortic adenopathy.

CT scans

Are not useful in early detection but are useful in staging and detection of adenopathy / osseous & any other metastases though with lower sensitivity than MRI & PET-CT.

MRI and PET-CT scans

Are not only useful for detection, follow up, local recurrence and distant spread of prostatic carcinoma but also in planning management of local recurrence and distant involvement as the treatment of each of them is different (radiotherapy and chemotherapy respectively). With the advent to robotic assisted pelvic surgery for prostate, local staging by imaging has achieved greater significance.

Role of MRI

Multiparametric MRI is apparently the most accurate

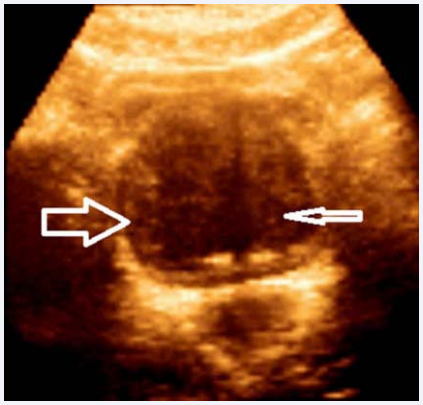

Figure 1 3D transabdominal USG image shows enlarged central / transition zone (thin arrow) compressing the peripheral zone (thick arrow) in a patient of BHP.

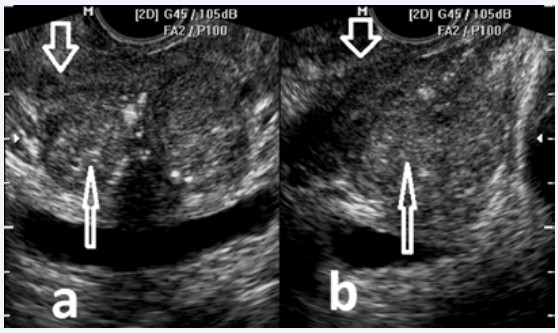

Figure 2 2D transrectal USG images (transverse, a & sagittal, b) show enlarged central / transition zone (thin arrows) compressing the peripheral zone (thick arrows) in a patient of BHP. Periurethral calcifications are also visible.

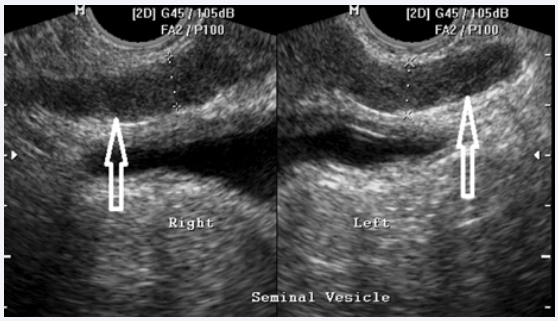

Figure 3 2D transrectal longitudinal USG images show normal-appearing right & left seminal vesicle (arrows).

noninvasive technique for detection of prostatic carcinoma. Commonly utilized MRI protocol for prostatic carcinoma includes high-resolution, axial & coronal 3D-T2 weighted images (T2WI) along with diffusion-weighted images (DWI) at b-values of 0, 500 & 1000 sec/mm^2, magnetic resonance spectroscopy (MRS) and dynamic, contrast-enhanced (DCE) MR imaging. MRS requires endorectal coil in addition to pelvic phase array coil on 1.5 Tesla [T] magnet systems while higher signal-to-noise ratio (SNR) with 3T system obviates the need of endorectal coil (ERC). ERC offers the advantage of optimal capsular delineation and visualisation of neurovascular bundle & rectoprostatic angle reducing overstaging and accurately delineating cancer foci required for intensity-modulated radiation therapy [2,3]

Utility of prostate MRI is higher in patients with abnormal prostate specific antigen (PSA) levels and negative biopsies. Furthermore, it is indispensable for patients with high suspicion of recurrence, for active surveillance, refusal for biopsy, need for MR-guided biopsy and in MRI-US fusion for improving yield of US-guided biopsy [4-9]. MRI delineates the following structures very well viz. distal prostatic urethra, central periurethral zone, peripheral zone, prostatic capsule, levator ani and rectal mucosa. Contrast MRI delineates neurovascular bundles in addition to the above structures. MRI offers no added advantage over CT scan in detection of pelvic adenopathy using 8 mm as short-axis diameter in rounded and 10 mm diameter in ovoid nodes.

T2WI are excellent for demonstrating internal prostatic anatomy as well as in determining grade & cellularity of prostatic carcinoma. It also delineates the prostatic capsule very well (Figure 4-6).

DWI is good for determining the extent of gland formation, cellular density, necrosis and perfusion. Focus of prostatic carcinoma appears hyperintense on high b-values showing corresponding hypointensity on ADC images [10] (Figure 7,8). Presence of post-biopsy hemorrhage reduces the accuracy of

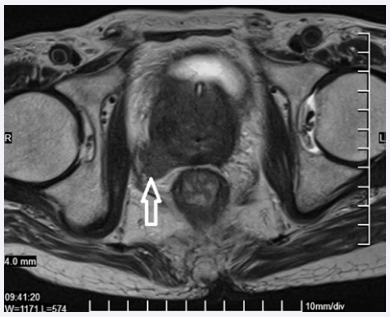

Figure 4 High-resolution transaxial T2W image shows nodule in right peripheral zone of prostate (arrow) with extracapsular extension, involvement of ipsilateral neurovascular bundle & near-complete obliteration of right rectoprostatic angle.

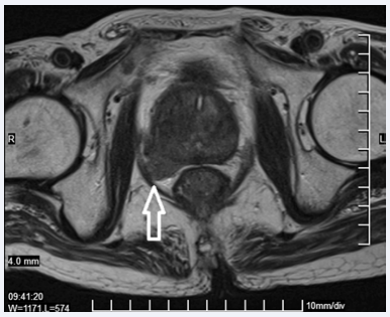

Figure 5 High-resolution transaxial T2W image shows nodule in right peripheral zone of prostate (arrow) with extracapsular extension, involvement of ipsilateral neurovascular bundle & near-complete obliteration of right rectoprostatic angle reaching up to the right-sided levator ani.

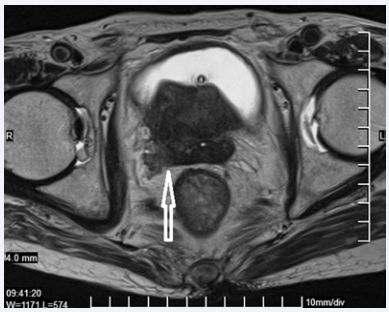

Figure 6 High-resolution transaxial T2W image shows nodule in right peripheral zone of prostate with extracapsular extension, involvement of ipsilateral neurovascular bundle & extension in to seminal vesicles.

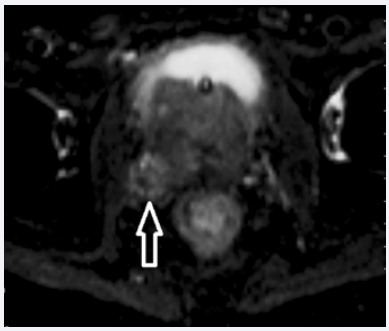

Figure 7 High-resolution transaxial DW image shows hyperintensity corresponding to nodule in right peripheral zone of prostate (arrow) corresponding to nodule in figure 4.

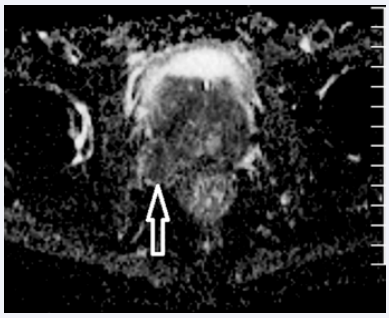

Figure 8 High-resolution transaxial ADC image shows hypointensity corresponding to nodule in right peripheral zone of prostate (arrow) corresponding to nodule in figures 4 and 7.

DWI & ADC images for detection of prostatic carcinoma hence a gap of 4-6 weeks has been recommended between biopsy and MRI prostate for detection of prostatic carcinoma. Though DWI improves detection of pelvic adenopathy yet it does not improve the overall accuracy. DWI is very sensitive in detection of bone lesions. In fact, whole body DWI is superior to bone scintigraphy in detection of bony lesions in prostatic carcinoma [11]. DWI & ADC have very important role in monitoring the effect of hormonal & radiation therapy in patients of prostatic carcinoma. Also detection of local recurrence is facilitated by DWI in combination with T2WI. Post surgical inflammation is characterized by higher ADC values than those seen in local recurrence.

In spite of all the advantages of DWI in prostatic carcinoma, it is not free from limitations. Lower ADC may be noted in acute prostatitis, benign hyperplasia with dense fibro muscular stroma, presence of hemorrhage, susceptibility artefacts produced by rectal gas / visceral movement while higher ADC may be noted in well-defined tumors with high glandular component.

MRS detects cell membrane turnover and replacement of normal glandular tissue. MRS show significant decrease in citrate & polyamine and increase in choline resulting in higher choline / citrate and choline + creatinine / citrate ratios [12].

DCE MRI delineates blood flow and vascular permeability. Relative peak enhancement is the most accurate perfusion parameter for prostate cancer detection in peripheral and central zones with wash-in time being more accurate than T2W images in peripheral zone [13,14]. Prostatic carcinoma enhances earlier & intensely with rapid wash-out relative to the prostatic parenchyma (Figure 9). Benign hyperplasic nodules show intense enhancement with relative persistence; latter being in contrast to prostatic carcinoma [15].

PET-CT has been reported to have a sensitivity, specificity, positive predictive value and negative predictive value of 66%, 96%, 82 % and 92% respectively in high risk cases of prostatic carcinoma [16]. It is also useful in detecting local recurrence and or nodal / osseous metastases even in patients with low PSA levels [17].

Staging of prostate carcinoma – TNM classification

Primary tumor

T1 - clinically non-apparent & non-palpable and non-detectable tumor on imaging

T2 – tumor localized within prostate

T3 – tumor locally invasive beyond the capsule (imaging signs include asymmetric capsular bulge with irregular margins, obliteration of rectoprostatic angle, asymmetry & encasement of neurovascular bundle and invasion of seminal vesicles [18]).

T3a represents extra-capsular extension

T3b represents seminal vesicle invasion

T4 – tumor locally invasive and involving adjacent structures like rectum, bladder, levator ani, external sphincter, pelvic wall.

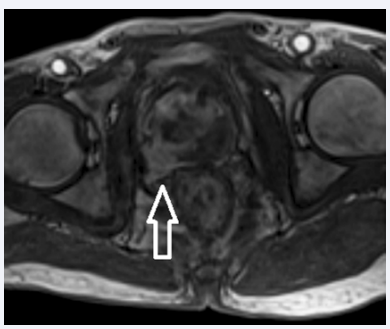

Figure 9 Dynamic, contrast-enhanced, transaxial T1-weighted image shows intense and early enhancement of nodule in right peripheral zone of prostate (arrow) corresponding to nodule in figures 4, 7 & 8.

Regional Node involvement

N0 – No involvement

N1 – Involvement present

Metastases

M0 – No metastases

M1 – Metastases present

M1a – Non-regional node involvement

M1b – Bone involvement

M1c – Any site other than bone

Scoring system for likelihood of significant prostate cancer - LIKERT or LIKE-5 grade scoring system or PIRADS (Prostate Imaging Reporting and Data System):

Score 1

Clinically significant disease, highly unlikely to be present – normal, uniform high signal intensity peripheral zone – transitional zone containing well-defined, marginated, stromal and glandular hyperplasia / adenoma.

Score 2

Clinically significant cancer, unlikely to be present – linear, wedge-shaped / geographic, not well-demarcated, non-focal areas of low signal intensity - transitional zone containing smooth margin rounded low signal intensity lesion, lenticular-shaped, band-like, low signal intensity in midline / around central adenoma

Score 3

Presence of clinically significant cancer is equivocal – appearance other than 1 & 2 and 4 & 5 categories.

Score 4

Clinically significant cancer, likely to be present – well-defined, low signal intensity lesion within prostate - transitional zone containing lenticular-shaped, anterior low signal intensity lesion without capsular invasion

Score 5

Clinically significant disease, highly likely to be present - invasive, low signal intensity lesion (extracapsular and seminal vesicle invasion, mass effect on capsule including bulging) - lenticular or rounded lesion with bulge / irregularity / retraction of anterior prostate capsule, irregular, infiltrating mass destroying transitional zone architecture invading adjacent peripheral zone / seminal vesicle / urinary bladder.

Clinically significant cancer means tumor that cause significant risk on individual health which depends upon aggressiveness of tumor and life expectancy and criteria's are tumor volume > 0.5ml + / Gleason pattern 4 or 5 + / Extra capsular disease.

CONCLUSION

To summarize, multimodality imaging especially multiparametric MRI imaging goes a long way in not only detection & staging of prostatic carcinoma but also in monitoring treatment, determining prognosis and detecting local recurrence.

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