Structured MRI report in prostate cancer using the PIRADS criterias: the bridge between the imagist and the clinician

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Abstract

Introduction: Multiparametric magnetic resonance imaging (MP MRI) is the most sensitive and specific imaging technique for localizing prostate cancer (PC). A group of prostate MR imaging experts published in 2012 a set of clinical guidelines with the aim to standardize the interpretation and to report the different parametric MR-techniques: the Prostate Imaging and Reporting Archiving Data System (PI-RADS). The purpose of this paper is to summarize the PI-RADS system using MR imaging examples from patients explored in our department.

Materials and method: The PI-RADS scoring criteria are explained for all parameters: T2WI, DWI, DCE and MRIS. Every parameter, is scored independently on a 5-point scale, where score 1 means that the disease is highly unlikely and score 5 indicates clinically significant cancer that is highly likely present. MRSI is considered as an optional parameter by the ESUR guidelines.

Results: Prostate cancer appears in the peripheral zone as a focal area of low signal intensity. In the central gland or involving the anterior fibromuscular stroma, a focal ill-defined area, showing homogenous low signal is suspect for a PC. A focal mass presenting reduced ADC as well as hypersignal intensity on the high *b*-value images is characteristic for PI-RADS 5. When a curve type 2 or 3 is present, in a focal enhancing and asymmetric lesion located at an unusual place the PIRADS score is 4, respectively 5.

Conclusions: The MRI report must contain the following important points: the location of each prostatic lesions, the signs in favor of malignancy and those of extraprostatic extension; the presence of adenopathies and bone metastasis. Always images analysis must be done in a precise clinico-biological context, and the management of the patient with PC must be realizing in a multidisciplinary team.

Keywords: MRI, prostate cancer, PIRADS, structured MR report

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Introduction

All most prostate cancers (PC) are adenocarcinomas. About 30% of men in their 50s have microscopic foci of prostate cancer, but most never progress. Age is the most important risk factor [1]. Rare tumours include: squamous, transitional cell carcinomas, and sarcomas. TNM stage is the most important prognostic variable 5-year disease specific survival for patients with metastasis (M1) is ~30%. The Gleason score is an independent prognostic indicator. 10-year disease survival for clinically localised disease is 87% for well and moderately differentiated tumours, dropping to 34% for poorly differentiated tumours [1]. Prostate specific antigen (PSA) is primarily used in diagnosis and in detection of disease recurrence. High levels correspond to advanced TNM stage at diagnosis [1-3]. Multiparametric (MP) magnetic resonance imaging (MRI) is considered the most sensitive and specific imaging technique for localizing PC [4-13].

Indications of MRI evaluation in prostate cancer are: 1. *Detection* (localisation) and *characterization* using a detection protocol. 2. *Staging*: tumor extension using a staging protocol, that include also a lymph nodes and bone evaluation. 3. *Follow-up of a known prostatic tumor*. 4. *Recurrences* after treatment [5-12].

Objectives

To make and theoretical and illustrated overview concerning the current status of the MRI role in PC evaluation; to present the utility of a structured MRI report taking into account the PIRADS criterias.

Materials and method

Actually the prostate MRI evaluation is a multiparametric diagnostic tool obligatory composed by T2 weighted (W) sequence, DWI and ADC (Apparent Diffusion Coefficient) map interpretation, and dynamic contrast enhanced MR of the prostatic tissue in T1 w image using Gadolinium injection (0,1 ml/kg, injection rate: 2 ml/sec). MRI exam may be done using a 1.5T or 3T magnetic field intensity; the current pelvic phased-array are with 8,16,32 channels; it is possible also to use a endorectal coils; antiperistaltic drugs (Buscopan) are mandatory in the purpose to obtain MR images without movement artifacts. The prostate and seminal vesicles must be covered entirely (slice thickness: 3-4 mm). Imaging, parallel to the prostate long axis, perpendicular to the rectal face of the prostate, or coronal oblique in the seminal vesicles plane are useful to evaluate extraprostatic extension [4-13]. All images presenting in this paper are from patients with elevated PSA and clinical suspicion of PC, explored in our department using the same MR protocol. For a correct and easy analysis, it is very important that the slices used in T2 wi, DWI, DCE T1 after Gd injection have the same plane (centering), slices number, slice thickness, identical interslice space (Fig. 1).

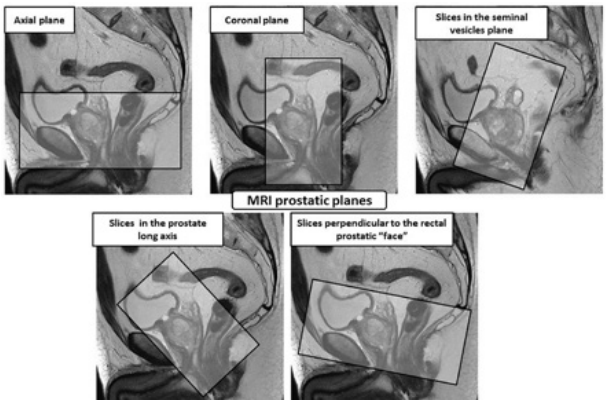


Fig. 1 The standardize MR planes used for the evaluation of prostate cancer

T2-wi FSE (Fast Spin Echo) is optimal to analyze the anatomy of the prostate[1-13], the peripheral zone (PZ) appear in high signal intensity; the central (CZ) and transitional zones (TZ) appear in low signal intensity (compactly arranged smooth muscle and loose glandular tissue); the anterior fibromuscular stroma (AFMS) presents a low signal intensity (Fig. 2).

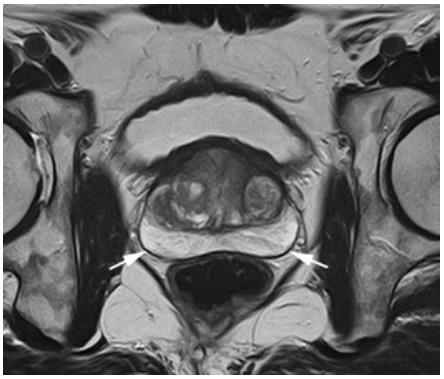


Fig. 2 T2 wi sequence allow to delineate between the PZ the central gland and the capsule (arrows)

The determination of extracapsular extension (ECE) depends on clear visualization of the prostate capsule (Fig. 3).



Fig. 3 Disruption of the prostate capsule by a left prostatic tumor (long white arrows) using a T2wi sequence with Fat Sat

T1-wi SE (Spin Echo) MR images are useful for detecting enlarged pelvic lymph nodes (slices from the pubis symphysis until the aortic bifurcation), bone metastases (Fig. 4) and post biopsy hemorrhage [1-8].

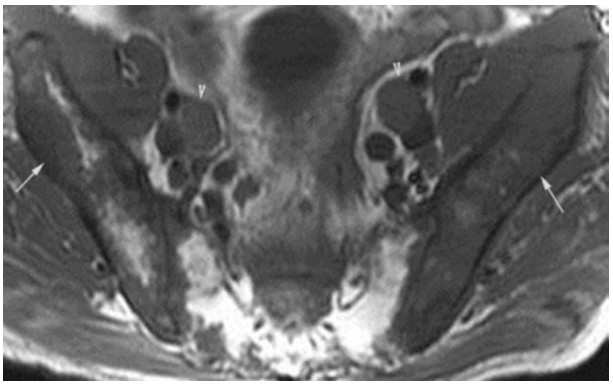


Fig. 4 T1 SE wi sequence permits to visualize the bone metastasis (arrows) and the lymph nodes (arrowhead)

T1 FSPGR (Fast Spoiled Gradient Recalled Echo) Fat Sat (FS) is used to visualize post biopsy prostate hemorrhage focus (Fig. 5).

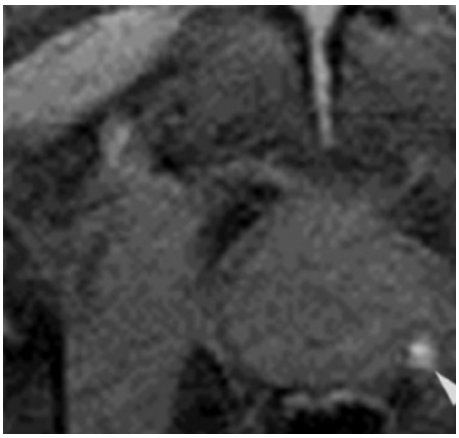


Fig. 5 T1 FSPGR FS is useful to delineate hemorrhagic areas in the prostatic tissue (arrow)

Functional MRI. Diffusion (DWI). The diffusion properties of different tissues are related to the amount of interstitial free water and permeability using multiple *b* factor values: 0, 100, 800, 1000, 1500, 2000 s/mm^2 -trace image [5,7-10,14-28]. Higher *b* values (equal or more than 1000 s/mm^2) have been suggested to offer higher prostatic tumor visibility and detection[5,14-24]. Cancer tends to have more restricted diffusion than does normal tissue because of the high cell densities and abundance of intra-/and intercellular membranes [5,14-24]. The cause of lower ADC values in PC may be related to the many tightly packed glandular elements found in cancers that locally replace the fluid containing peripheral zone ducts (Fig. 6). False negative: infiltrative and diffuse prostate ADK, low grade ADK, prostatitis in association with ADK [1-11,19]. Using b values superior to 1500 s/mm^2 is possible to differentiate tumors from prostatitis and stromal BPH, considering that tumors remains intensively bright and that benign tumors doesn't increase the signal using b 1500 compare to DWI with b 1000 s/mm^2 [17,19,21,24]. T2 combined with DWI is able to detect and localize PC better than T2-weighted imaging alone, primarily by providing increased sensitivity while maintaining high specificity in the PZ [2-29].

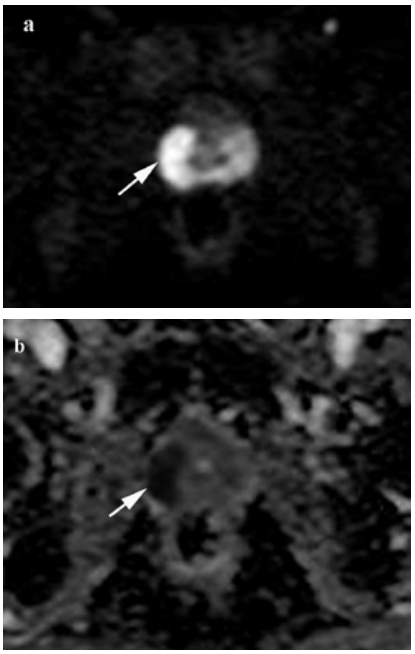


Fig.6. Right prostatic tumor (arrow) with restricted diffusion using a b value of 1000 s/mm (a); in ADC map (b) the tumor appear hypointense

Dynamic Contrast-enhanced (DCE). This technique is based on tumor angiogenesis. In many studies, it has been shown that the values of contrast enhancement parameters: mean transit time, blood flow, permeability surface area, and interstitial volume are

significantly greater in cancerous tissue than in normal tissue [5,18,28,30-38]. DCE has high sensitivity (74–96%), useful for the preliminary detection of tumors (30-38). It is used also for staging and in monitoring therapeutic response of prostate cancer [5,11,18,30]. Ocak et al. determined that a combination of T2W weighted images with DCE-MRI increased cancer detection sensitivity in the PZ by 16% over T2WMRI alone [34].In the transitional zone, BPH nodules strongly enhance but do not wash out as quickly as prostate tumors [5,18]. There are several methods of analyzing DCE data: qualitative, semiquantitative, and quantitative [18]. Qualitative evaluation is based on the visual detection of early focal strong enhancement with rapid washout compared with that of normal tissue (Fig. 7). Semiquantitative analysis is an assessment of the time-signal curve and includes measurement of AUC, time to peak enhancement, and initial slope [18]. Dynamic curves are classified in three categories: persistent- type 1, plateau-type 2, and decline after initial slope- type 3. The type 3, is frequently associated with prostate cancer[5-10,30-38]. In quantitative evaluation, pharmacokinetic modeling is performed using two compartment models that determine *K*trans (forward volume transfer constant) and *k*ep (reverse reflux rate constant between extracellular space and plasma) rate constants [32].

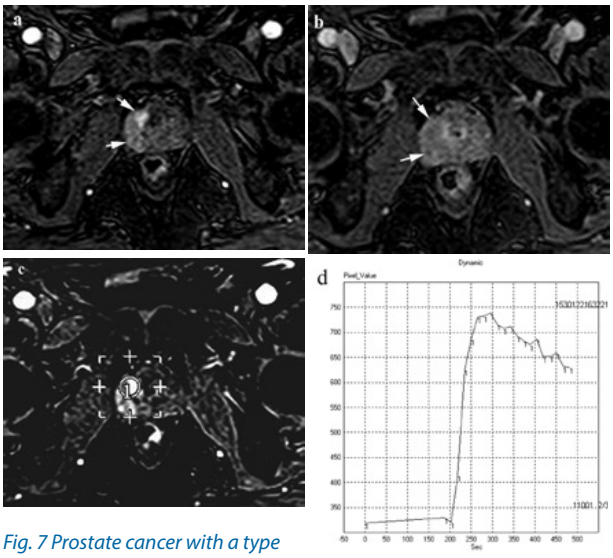


Fig. 7 Prostate cancer with a type 3 of the dynamic curve: (a)-early phase, (b)-late phase, (c) the ROI into the tumoral nodule, (d) the corresponding graph with the wash in and the wash out

Proton magnetic resonance spectroscopic imaging (MRSI) provides informations about specific metabolites within prostatic tissue. The analysis is performed by measuring the resonance peaks of various biochemical metabolite levels – such as citrate, creatine, and choline. Normal prostate tissue contains high levels of citrate. Citrate exhibits a unique peak on MR spectroscopy. In prostate cancer down regulation of the ZIP zinc transporters causes a decrease in zinc levels that decreases citrate levels by inducing oxidation. Choline levels correlate with cell turnover, as seen in prostate cancer. The ratio of choline to citrate is therefore an indicator of malignancy [5,7-9,18,39]. In a multi-institutional study, organized by the American College of Radiology Imaging Network (ACRIN) it was established that MR imaging alone was just as effective as MR imaging with MRSI and did not improve tumor localization in the PZ, where most cancers occur [30].

Results

Tumors appear in the PZ: isointense in T1 wi and hypointense in T2 wi (Fig. 8). Detection of extracapsular extension is based on typical findings: asymmetry into neurovascular bundle; obliteration of the recto-prostatic angle [1-4]; irregular bulging or breech of prostate capsule; invasion of seminal vesicle, bladder or of the rectum (Fig. 9). T2-wi has significant limitations for depicting cancer in the TZ and CZ: cancer and normal tissues have both low signal intensity[1-5]. T2 hyposignal in the peripheral zone may be present also in noncancerous conditions such as in inflammation, biopsy-related hemorrhage (blood products may persist 4–6 weeks or longer after prostate biopsy), post–radiation therapy fibrosis, and changes after hormone deprivation therapy [1-7,26,40]

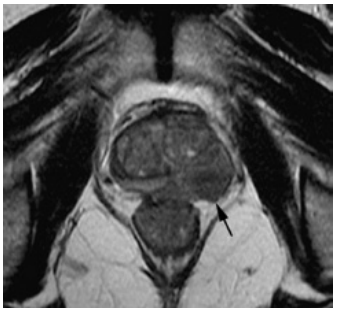


Fig. 8 Tumoral nodule located in the left PZ that appear hypointense, causing small interruption of the prostate capsule (black arrow)

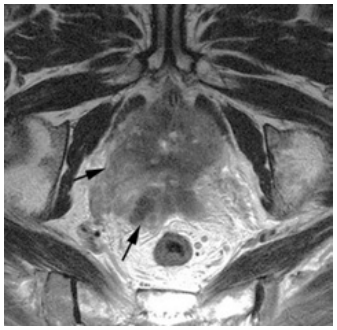


Fig. 9 Voluminous prostatic tumor with important extra-prostatic extension, which invades the seminal vesicles, the mesorectal fascia and the perirectal fat (black arrows)

On DW MRI tumoral nodules in the PZ appears, hyperintense compared to the background due to the restricted water diffusion [16,17]. On ADC maps, cancers are generally characterized by their lower DW MRI but the utility of DWI is limited in depicting extracapsular extension due to its lower spatial resolution but can be useful in DW MRI for the detection of seminal vesicle invasion [5,18,20-23]. Combined anatomic T2W MRI and functional DWMRI improve cancer detection in several studies: sensitivity increased from 50% to 79.6% and specificity increased from 73.2% to 80.8% [2,5,29,30].

Tumors involving the TZ have ADC values lower than normal tissues in the transitional zone corresponding to the increased signal on DW MRI when compared to the background signal. Benign prostatic hypertrophy (BPH) in the TZ of the prostate present a heterogeneous signal intensity pattern depending on the degree in which the stromal or glandular tissues change (Fig. 10). Lesions polymorphism caused more difficulties in the TZ to delineate between tumors and BPH nodules; these two entities can overlap concerning the signal pattern on ADC Maps [5-9,18-20,30]. Anterior prostatic ADK appears like homogeneous area in T2 wi hyposignal, lenticular form, blurred contours, no cyst and without capsule, and with restricted water diffusion (Fig. 11). ADC value in anterior prostate ADK is around 1.30+/-0.16, and the tumor DCE is negative [5-9,23-25,30,38]. ADC values derived from DW MRI have also been reported to inversely predict Gleason scores; low ADC values are associated with higher grade tumor foci [17,18,24,30].

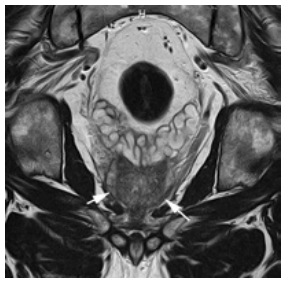


Fig. 10 Benign prostatic hypertrophy: heterogeneous signal intensity pattern in the central gland by the alternation of stromal and glandular tissues

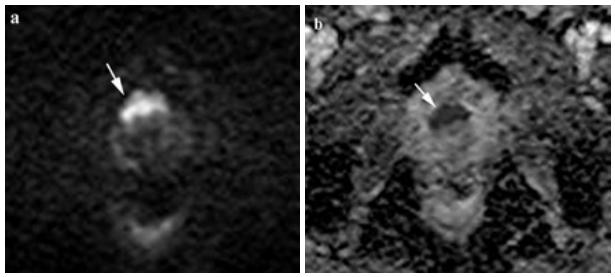


Fig. 11 Anterior prostatic ADK: DWI (a) and ADC map (b): nodular area located into the AFMS with restricted diffusion (arrow)

Discussions

Prostate Imaging Reporting and Data System and was published in February 2012 by ESUR in the aim to standardize reporting in MRI of the prostate, to improve the reproductibility of radiologists reports, and the communication with referring physicians [5,40,41]. MP MRI of the prostate represent in our days the most sensitive and specific technique for detect and localizing prostate cancer (Fig. 12).

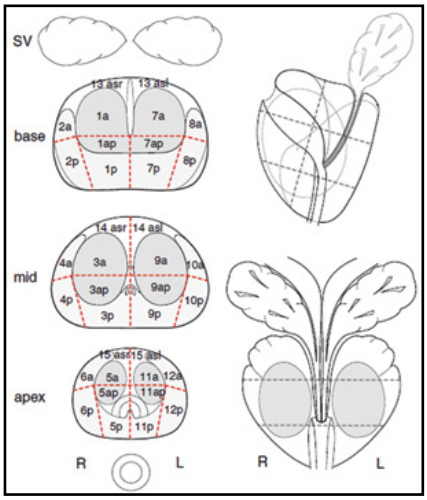


Fig. 12. Regions of interest: Twelve anterior (a), twelve posterior (p) glandular regions at base, mid and apex. Three anterior stroma (AS) divided in right and left regions (41,42)

According to a group of prostate MRI experts from ESUR, MP MRI should consist of high resolution T2-wi and two functional techniques: dynamic contrast-enhanced MRI, diffusion weighted or proton MR spectroscopy (H-MRS). T2WI (Table nr. 1 and Table nr 2), DWI (Table nr.3), and DCE (Table nr. 4), is scored independently on a 5-point scale started from the typically benign lesion (score 1) until the score 5 typically malign. T2wi in association with DWI and DCE permits the highest accuracy in patients with higher grade of prostate cancer [5,18,30,32-37].T2 wi, DWI and DCE are more accurate for the PZ than for the transitional zone to detect prostate cancer [9-11,18].DCE increase prostate cancer detection in the peripheral zone (36). DWI is considered the leading sequence in the TZ [11,15].

Table nr. 1. PI-RADS scoring system for T2WI—PZ (5,8,18)

PI-RADS score	Criteria
1	Uniform high signal intensity
2	Linear, wedge-shaped, or geographic areas of lower signal intensity, usually not well demarcated
3	Intermediate appearances not in categories 1/2 or 4/5
4	Discrete, homogeneous low signal focus/mass confined to the prostate
5	Discrete, homogeneous low signal intensity focus with extracapsular extension/invasive behavior or mass effect on the capsule (bulging), or broad (>1.5 cm) contact with the surface

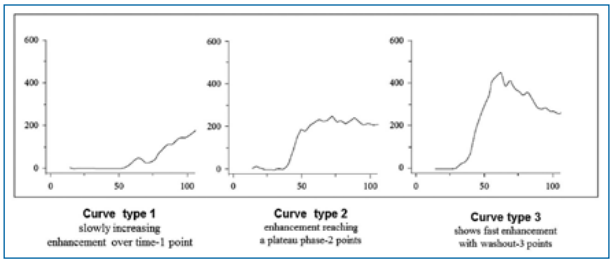
Table nr. 2. PI-RADS scoring system for T2WI-transition zone (5,8,18)

PI-RADS score	Criteria
1	Heterogeneous transition zone adenoma with well-defined margins: "organized chaos"
2	Areas of more homogeneous low signal intensity, however well-marginated, originating from the transition zone/ BPH
3	Intermediate appearances not in categories 1/2 or 4/5
4	Areas of homogeneous low signal intensity, ill defined: "erased charcoal drawing sign"
5	Same as 4, but involving the anterior fibromuscular stroma sometimes extending into the anterior horn of the peripheral zone, usually lenticular or water-drop- shaped

Table nr. 3. PI-RADS scoring system for DWI (5,8,18)

PI-RADS score	Criteria
1	No reduction in ADC compared to normal glandular tissue. No increase in signal intensity on any high b-value images
2	Diffuse hypersignal intensity on high b-value images with low ADC; no focal features, linear, triangular, or geographical features, allowed
3	Intermediate appearances not in categories 1/2 or 4/5
4	Focal area(s) of reduced ADC but isointense signal intensity on high b-value images
5	Focal area/mass of hypersignal intensity on the high *b*-value images* with reduced ADC

Table nr. 4. PI-RADS scoring system for DCE (5,18)



When a curve type 2 or 3 is present, it is necessary to verify if the specific lesion is a focal enhancing lesion. If yes = +1 point to PI-RADS. If the the lesion is asymmetric or is located at an unusual place= +1 point to PI-RADS [5,8,18,30].

Loco-regional extension is also scored regarding the extracapsular extension and the involving of seminal vesicles, of the urinary bladder neck, and of the distal sphincter (table nr.5).

Table nr. 5. Loco-regional prostate cancer extension (5)

Criteria	Findings	Score
Extracapsular extension	-Abutment -Irregularity -Neurovascular bundle thickening -Bulge, loss of capsule -Measurable extracapsular disease	1 3 4 4 5
Seminal vesicle	-Expansion -Low T2 signal -Filling in of angle -Enhancement and impaired diffusion	1 2 3 4
Distal sphincter	-Adjacent tumor -Effacement of low signal sphincter muscle -Abnormal enhancement extending into the sphincter	3 3 4
Bladder neck	-Adjacent tumor -Loss of low T2 signal in bladder muscle -Abnormal enhancement extending into bladder neck	2 3 4

The dominant parameter for cancer suspicious lesions in the peripheral zone is DWI, for transition zone lesions it is T2WI, and for lesions suspicious for PCa recurrence it is DCE [5,17,18,30,32,40,41].

The overall PI-RADS score may be classifying using the sum-score (Table nr.6) according to the algorithm proposed by Röthke et al. [41].

Table nr. 6. Calculation of the overall PI-RADS score according to the ESUR panel definitions compared to the sum-score (41)

Overall PI-RADS	Definition of the ESUR panel	Sum-score of T2W, DWI, and DCE
Score 1	Clinically significant disease highly unlikely to be present	3,4
Score 2	Clinically significant cancer is unlikely to be present	5,6
Score 3	Clinically significant cancer is equivocal	7-9
Score 4	Clinically significant cancer is likely to be present	10-12
Score 5	Clinically significant is highly likely to be present	13-15

Conclusions

Always prostatic images analysis must be done in a precise clinico-biological context. The MRI report must contain the following important points: if the prostate MR exam is normal or with abnormalities; the dimensions/volume of the prostate; to locate and describe each intraprostatic lesion (see Fig.12); to specify the signs in favor of malignancy and those of extraprostatic extension; to note the presence of adenopathies (Table nr.7) and bone metastasis; to identify others lesions. The management of the patient with prostate cancer is preferable to be realizing in a multidisciplinary team.

Table nr. 7. The MRI report must contain

Score	Significance	Lesion description -significance			Extraprostatic extension of a lesion-significance	
		T2	DWI	DCE		
1	Non suspect	very unlikely to contain a clinically significant lesion			very unlikely extension	- Prostate dimensions - Adenopathies - Bone metastasis - Others lesions
2	Unlikely suspect	unlikely to contain a clinically significant lesion			unlikely extension (without direct and indirect signs)	
3	Equivocal	we cannot rule on the presence of a significant lesion			equivocal aspects (uncertain direct and indirect signs)	
4	Suspect	likely to contain a significant lesion			likely extraprostatic extension (direct sign)	
5	Very suspect	very likely to contain a significant lesion			certain extension (certain direct sign)	

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