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PICTORIAL REVIEW

An update of pitfalls in prostate mpMRI: a practical approach through the lens of PI-RADS v. 2 guidelines

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Abstract

Objectives The aim of the current report is to provide an update in the imaging interpretation of prostate cancer on multiparametric magnetic resonance imaging (mpMRI), with a special focus on how to discriminate pathological tissue from the most common pitfalls that may be encountered during daily clinical practice using the Prostate Imaging Reporting and Data System (PI-RADS) version 2 guidelines.

Methods All the cases that are shown in this pictorial review comply with the European Society of Urogenital Radiology (ESUR) guidelines for technical mpMRI requirements.

Results Despite the standardised manner to report mpMRI (PI-RADS v. 2), some para-physiologic appearances of the prostate can mimic cancer. As such, it is crucial to be aware of these pitfalls, in order to avoid the under/overestimation of prostate cancer.

Conclusions A detailed knowledge of normal and abnormal findings in mpMRI of the prostate is pivotal for an accurate management of the wide spectrum of clinical scenarios that radiologists may encounter during their daily practice.

Teaching Points

- *Some para-physiologic appearances of the prostate may mimic cancer.*
- *Knowledge of normal and abnormal findings in prostate mpMRI is pivotal.*
- *Any radiologist involved in prostate mpMRI reporting should be aware of pitfalls.*

Keywords Prostate · Prostatic cancer · Magnetic resonance imaging · Diagnosis · Pitfalls

Introduction

High-quality multi-parametric Magnetic Resonance Imaging (mpMRI) has become an important tool in the diagnosis, characterisation and treatment planning of prostate cancer (PCa) [1–3]. Specifically, mpMRI involves T2-weighted anatomical images combined with functional imaging methods such as dynamic Contrast Enhanced Imaging (DCE), Diffusion-Weighted Imaging (DWI) and/or Spectroscopy, if necessary. All these sequences have a limited accuracy, when considered individually, but their association has shown a greater performance in the assessment of PCa [4].

However, inter-reader variability represents a real limitation for prostate mpMRI, and expertise in reporting is crucial to improve cancer detection and staging accuracy. Therefore, it is important to validate the current protocols [5]. In 2012, the European Society of Urogenital Radiology (ESUR) set up an expert panel to develop a standardised system for prostate mpMRI interpretation and reporting, under the name of Prostate Imaging Reporting and Data System (PI-RADS) [6]. In 2015 a revision of this classification led to the publication of PI-RADS v. 2 [7], with the aim to

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Table 1 Wide spectrum of pitfalls and different classifications

Pitfall	Pitfall vs Pitfall
Anatomic	I. PCa in moustache sign
1. Hypertrophic anterior fibromuscular stroma	II. PCa in median posterior change (compressed central zone and BPH proliferation) in reversed teardrop
Benign conditions	III. Ectopic BPH nodule vs abscess
1. *Moustache sign* (small bilateral BPH nodules against the PZ)	
2. *Moustache-like sign* (larger adenoma against the PZ)	
3. *Teardrop sign* (median posterior compressed central zone)	
4. *Teardrop-like sign* (Protruding BPH above the verumontanum)	
5. Ectopic BPH nodule	
6. Haemorrhage	
7. Calcifications	
Overestimation	
1. Periprostatic venous plexus	
2. Neurovascular bundle	
3. Prostatitis	
Mispositioned endorectal coil	

BPH = benign prostatic hyperplasia; PZ = peripheral zone; PCa = prostate cancer

promote a global standardisation of these guidelines, and to reduce the variability in the acquisition, interpretation and reporting of prostate mpMRI. A detailed explanation of PI-RADS v. 2 is beyond the aim of this report, but it is worth summarising the main points of these guidelines: (1) DWI is the dominant sequence in the peripheral zone (PZ); (2) T2-weighted imaging (T2-WI) is the dominant sequence in the transitional zone (TZ); (3) the role of DCE is secondary to DWI in the PZ; and (4) there is an overall 5-point (from 1 to 5) PI-RADS assessment (1: low probability – 5: very high probability of clinically significant cancer).

Nonetheless, the interpretation of mpMRI of the prostate can be challenging and new radiological skills are needed, especially when potential pitfalls (i.e., normal anatomic structures, benign conditions of the prostate or artefacts due to technical issues) might be erroneously interpreted as pathological conditions. Moreover, the PI-RADS v. 2 guidelines may be subject to some interpretation variability according to the radiologists' individual experience, lowering the ability to distinguish pitfalls from true malignancy [8]. Awareness of these pitfalls is therefore fundamental.

Currently, there are only three reports (two from the United States and one from Europe) [9–11] addressing the mpMRI pitfalls in PCa. They have all suggested some strategies to assist the radiologists in avoiding misdiagnosis (and consequently mistreatment), but a systematic approach on how to tackle these aspects applying PI-RADS v. 2 has yet to be reported.

Therefore, the purpose of this article is to provide a practical approach for imaging interpretation in PCa, with a special focus on how to apply PI-RADS v. 2 to discriminate pathological conditions from the most common pitfalls that could be encountered during daily clinical practice. Of note, this report is based on a pragmatic consensus among a panel of different international radiologists highly experienced in mpMRI of the prostate (VP, FG, YXK, FC, GV).

PITFALLS and PI-RADS v.2

For the sake of completeness, the cases shown in this pictorial report represent a cohort of men aged 47–79 years, with prior suspicion of PCa based on abnormal digital rectal examination, rise of prostate specific antigen (PSA) and/or family history of PCa. The exams have been acquired on a 3.0 T system (Discovery MR750, GE Healthcare, Waukesha, WI), by using a 32 multi-channel (or 8 multi-channel + endorectal coil) surface phased-array body coil.

Awareness of diagnostic pitfalls is important to avoid both false-positive and false-negative interpretations. A systematic approach to mpMRI of the prostate using PI-RADS v. 2 helps in the identification of PCa, but there still remains a wide spectrum of pitfalls. These can be broadly split into two main groups: (1) pitfalls related to clinical indications and (2) technical and physiological artefacts (Table 1).

Pitfalls related to clinical indications

These pitfalls are related both to the anatomy of the prostate and to certain benign conditions of the gland, which can

mimic the presence of cancer. The typical appearance of PCa in the PZ is a focal hypointense area on T2-WI; however, other benign conditions, such as prostatitis, fibro-muscular bands and post-biopsy haemorrhage can mimic this signal change, leading to potential misdiagnoses.

Anatomic pattern

Hypertrophic anterior fibromuscular stroma

This is related to the presence of muscle cells and connective tissue in the most anterior part of the gland, between the two lobes that constitute the TZ. This condition is characterised by an area of homogeneous, very low signal intensity on T2-WI, usually with lenticular shape (scored as 4/5 or 5/5 according to PI-RADS v. 2). However, hypertrophic anterior fibromuscular stroma does not commonly show enhancement on DCE nor significant restriction on DWI (score 1 or 2), even though low ADC values can be seen sometimes, due to pre-existing low T2-signal areas rather than a true restriction. Therefore, our suggestion is to use all the available planes, including the coronal and sagittal planes. An additional acquisition plan is of utmost importance, as it can confirm the continuity of the hypertrophic anterior fibromuscular stroma with the benign tissue. Such an approach, together with negative DWI and DCE findings, can help to rule out the presence of clinically significant PCa (Fig. 1).

Periprostatic neurovascular bundle

The periprostatic vascular (sometimes venous) plexus courses around the lateral margins of the prostate (i.e., very close to the capsule) and can show a congested appearance, particularly in men with prostatitis.

Sometimes it is difficult to separate the plexus from the PZ on mpMRI, due to focal low T2 signal intensity. This makes the use of PI-RADS v.2 mandatory.

According to PI-RADS v. 2, the plexus can be scored as 3–4/5 on T2-WI, due to its mass-like appearance. Sometimes, this anatomical structure can show a mildly restricted diffusion (3/5) – only on Echo-planar sequence and not on the ADC map, due to the slow speed of blood flow - together with focal enhancement (+), and in continuity with the vessels, raising the suspicion of clinically significant PCa (mimicking T3a stage disease). In order to rule out the presence of a tumour, it is of paramount importance to take into account the appearance of the periprostatic plexus on T2-WI, as well as on delayed subtracted contrast-enhanced images (Fig. 2).

The neurovascular bundle courses along the posterolateral margin of the prostate, near the prostate capsule, at approximately a 5- and 7-o'clock position.

Similar to the periprostatic vascular plexus, the neurovascular bundle, when visible, can mimic the presence of a lesion in the PZ (mimicking T3a disease).

When difficult to discriminate from PZ, the neurovascular bundle can be scored as 4/5 on T2-WI according to PI-RADS v. 2, due to the very low signal intensity on this sequence. However, the neurovascular bundle can show restriction on DWI (4–5/5) due to signal from myelinated fibres and is characterised by a mild, enhancement pattern (+), tangent to the capsule. In this case the application of PI-RADS v. 2, and the knowledge of anatomy on DWI and DCE sequences is decisive to rule out the presence of PCa (Fig. 3).

In case of a tumour located adjacent to the periprostatic neurovascular bundle, the distinction might not be easy due to the absence of the adipose plane between them. At this regard, DCE sequences can be of help due to the different behaviour after contrast injection (early vs late/mild enhancement). Additionally, the coronal plane can help to localise the neurovascular bundle and the continuity of the capsule in another plan.

Moreover, mpMRI is increasingly being used in the decision-making pathway of PCa, to support the choice of a nerve-sparing approach when possible. In this regard, the use of diffusion-tensor imaging from mpMRI holds promise for the future [10].

Benign conditions

Bilateral benign prostatic hyperplasia proliferation (moustache sign)

The presence of median symmetric, bilateral areas of low signal intensity on T2-WI at the base/middle of the prostate on either side of the ejaculatory ducts can mimic cancer. This set of appearances has been called the "*moustache sign*", and can be ascribed to two main conditions. The first is the compression of the central zone by small nodules of benign prostatic hyperplasia (BPH) against the PZ, and this typically occurs in the posterior portion of the prostate, at the base or mid-gland level (*moustache sign*) (Fig. 4). The second finding is related to the protrusion of a much larger adenoma in the PZ, and this also occurs in the posterior portion of the prostate, at the base (*moustache-sign like*) (Fig. 5).

On the contrary, foci of PCa generally show a more heterogeneous appearance, with ill-defined margins.

Histologically, the low signal intensity reflects respectively the compressed central gland, with hypertrophic tissue, and the different glandular pattern of BPH, with increased cellularity. In both cases, this sign typically appears as a symmetrical oval shape, with sharp margins and a homogeneous, low signal intensity.

These regions can also be characterised by restricted diffusion and homogeneous/positive enhancement. Protrusion of

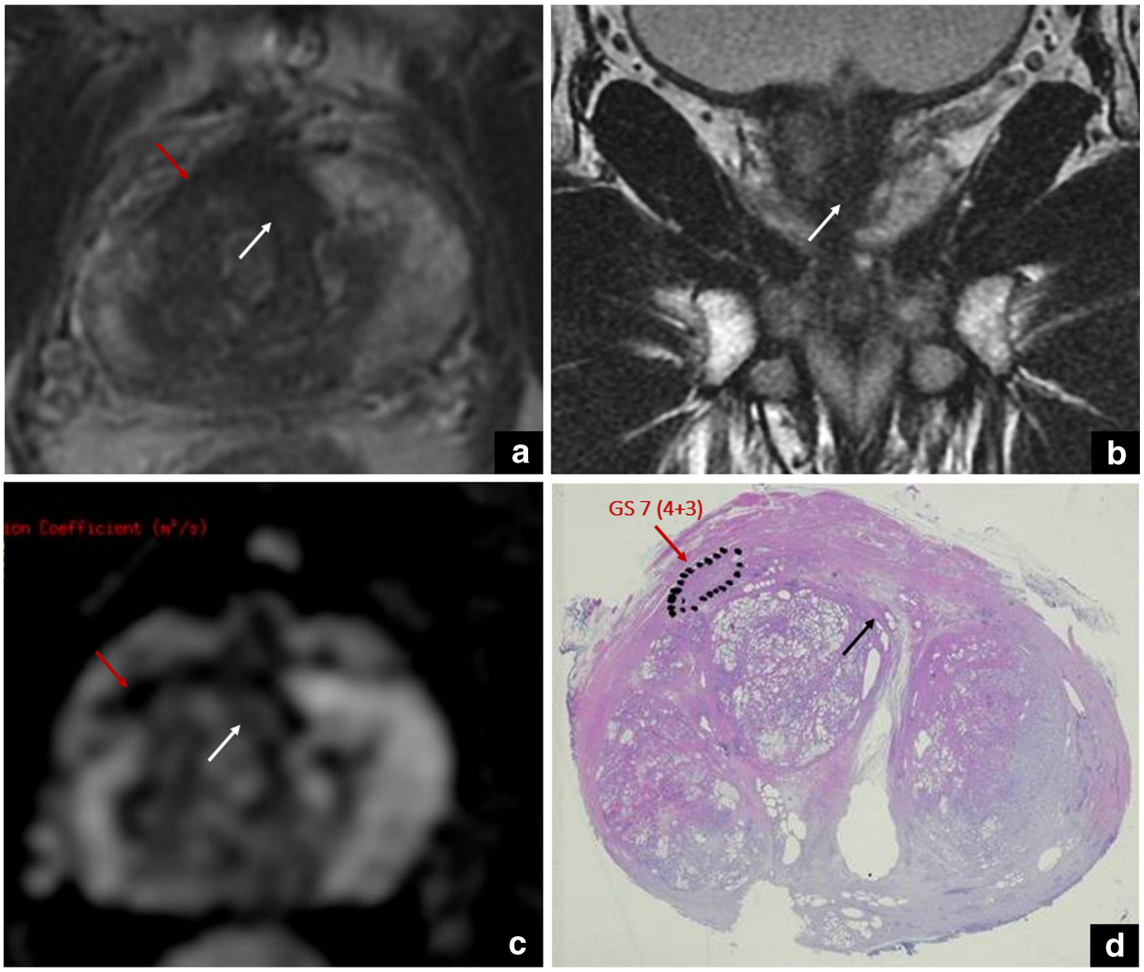

Fig. 1 Hypertrophic anterior fibromuscular stroma vs cancer. Axial (**a**) and coronal (**b**) T2-weighted images that show an area of homogeneous low signal intensity with a lenticular shape (white arrows), and not significant restriction in the ADC map (**c**). The red arrows show a small focus of prostate cancer in the anterior right gland (**a**), corresponding to an area of restricted diffusion in the ADC map (**c**). These findings were confirmed at final histology, after radical prostatectomy (GS = Gleason score 4 + 3) (**d**)

BPH nodules shows homogeneous enhancement, whereas the compressed central zone usually does not.

According to PI-RADS v. 2, a potential score for this pitfall could be 3–4/5 for T2-WI, 4/5 for DWI (in case of marked restriction of diffusion) and early enhancement (+) on DCE; such scenario would orient towards the presence of clinically significant PCa and might suggest biopsy. However, if we apply PI-RADS v. 2 after carefully considering other distinguishing features (e.g., the use of the coronal T2 weighted sequence, the presence of sharp margins and a symmetrical

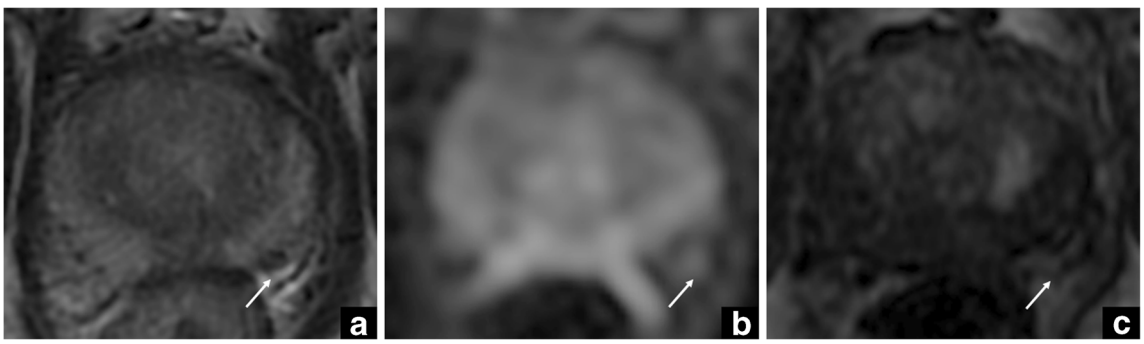

Fig. 2 Periprostatic bundle. The arrow in the axial T2-weighted image (**a**) shows an area of intermediate to low-signal intensity in the right peripheral zone. This corresponds to mild, restricted diffusion on the echo-planar diffusion-weighted sequence (**b**), due to the slow speed of blood flow and focal enhancement on DCE imaging (**c**)