Multiparametric MR imaging of the Prostate

Interpretation Including Prostate Imaging Reporting and Data System Version 2

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KEYWORDS

• Prostate cancer • Multiparametric MR imaging • PI-RADS

KEY POINTS

- The key sequences of a prostate mp-MRI scan are high-resolution T2-weighted, high b-value diffusion-weighted, and dynamic contrast-enhanced imaging.
- PI-RADS standardizes interpretation of mp-MRI, resulting in moderate-to-high accuracy for the diagnosis of clinically significant prostate cancer.
- A quantitative approach to functional imaging of the prostate has the potential to further improve diagnostic accuracy of mp-MRI and to provide insights into tumor aggressiveness and prognosis.

INTRODUCTION

Radiologists in the United States are experiencing a significant growth of volume of prostate MR imaging studies.[1] This mirrors an increasing interest from the urology community in the application of this technique for the management of patients with, or at risk for, prostate cancer, particularly for biopsy guidance. The technological developments experienced in the last two decades culminated in a mp-MRI approach that combines anatomic and functional imaging. However, the greater complexity of this technique, along with an increasing demand, brought new challenges to imaging interpretation.

The Prostate Imaging Reporting and Data System (PI-RADS), first proposed in 2011 by the European Society of Uroradiology, is an effort to address these challenges through a standardized approach to the interpretation of prostate mp-MRI.[2] The second version of PI-RADS (PI-RADS v2) was released in 2015 with many simplifications and improvements.[3]

The first part of this article is focused on interpretation of the pulse sequences recommended in the PI-RADS v2 guidelines, including useful tips based on the authors' experiences at two large academic institutions. In the second part, we review advanced quantitative imaging tools and discuss future directions.

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INTERPRETATION OF MULTIPARAMETRIC MR IMAGING: PULSE SEQUENCES INCLUDED IN PROSTATE IMAGING REPORTING AND DATA SYSTEM VERSION 2

An mp-MRI of the prostate is an examination comprised of multiple pulse sequences, including anatomic and functional images. The key pulse sequences recommended in the PI-RADS v2 guidelines are three-plane high-resolution axial T2-weighted images (T2WI), high b-value axial diffusion-weighted images (DWI), apparent diffusion coefficient (ADC) map, and axial dynamic contrast-enhanced (DCE) images.[3] The high-resolution coronal and sagittal T2WI help to better define the morphology and spatial relationship of a finding already identified on the axial images. A practical approach to review this large data set is to organize the key pulse sequences and display them simultaneously on the viewing monitors, allowing the radiologist to link and quickly correlate the findings detected on anatomic and functional images. According to the PI-RADS v2 guidelines, each prostatic finding should be assigned a score between 1 and 5 based on its appearance on T2WI, DWI, and DCE MR imaging. A score of 5 indicates very high probability of clinically significant prostate cancer, defined as Gleason score greater than or equal to 7, and/or volume greater than or equal to 0.5 mL, and/or extraprostatic extension (EPE).[3]

Anatomic Imaging

T2-weighted images: peripheral zone

Multiplanar high-resolution T2WI is the hallmark sequence for anatomic evaluation of the prostate. In contrast to the normal peripheral zone (PZ), which has high signal intensity (SI) on T2WI because of its large water content, most tumors exhibit low SI.[4] Moreover, tumors with higher Gleason scores tend to have lower SI than less aggressive cancers.[5,6] This is because tumor grade increase represents a progressive loss of the normal glandular anatomy and continuing dedifferentiation and clustering of cancer cells.[7] Three other important anatomic features depicted on T2WI are shape, borders, and size of lesions. Prostate cancer tends to present as a focal round or crescent abnormality on imaging, whereas benign lesions are more often indistinct or have a linear or triangular shape.[8] Although there is an overlap between the features of benign and low-to-intermediate grade prostate cancers, tumors with high Gleason score are usually more noticeable lesions.[6] Lastly, lesion size has been positively correlated with chance of malignancy and Gleason score, that is, larger lesions are more likely to represent high-grade prostate cancer than smaller ones.[8,9] Furthermore, there is also a positive correlation between tumor size and the probability of EPE and seminal vesicle invasion.[9]

It is not surprising, therefore, that the T2WI PI-RADS v2 categories are based on these four features (**Table 1**).[3] Lesions with high probability of representing a clinically significant prostate cancer are focal masslike, circumscribed, and have homogeneous moderately low SI (score 4 or 5) (**Fig. 1**). The distinction between a score 4 and 5 is based on the presence of definite EPE or size, where the lesions greater than or equal to 1.5 cm are assigned a score 5. On the other end of the spectrum are lesions that are likely benign (score 2). Those lesions are linear, wedge-shaped, or present as areas of mildly low SI with indistinct borders (**Fig. 2**). Lesions that have moderately low SI, but are heterogeneous or noncircumscribed are considered indeterminate and receive a score of 3 (**Fig. 3**). T2WI is only moderately accurate for the detection of cancer, although its performance improves when the goal is to identify high-grade disease. Mucinous adenocarcinomas of the prostate, for example, may have a predominantly high SI resulting in false-negative based on T2WI score.[10] However, many nontumoral lesions, such as inflammation, fibrosis, and hemorrhage, can mimic cancer on T2WI.[11]

T2-weighted images: transition zone

The accurate identification and characterization of prostate cancer within the transition zone (TZ) likely represents the greatest challenge of mp-MRI interpretation. The difficulty arises with the development of benign prostatic hyperplasia (BPH), which affects virtually all middle age or older men, the same population at risk for prostate cancer. BPH affects glandular and stromal tissues and it is characterized by the growth of multiple nodules and intervening hyperplastic stroma, depicted on T2WI as a large, distorted, and markedly heterogeneous TZ, an appearance described as "organized chaos."[12] Differentiating the intertwined hyperplastic stroma or stroma-rich nodule from cancer is problematic because both entities present with low SI on T2WI, and the random appearance of BPH allows prostate cancer to blend within the nodular TZ.[12,13] Hence, detection of these tumors requires a careful analysis of the lesion morphology on high-resolution T2WI (see **Table 1**). Well circumscribed and encapsulated nodules with low or heterogeneous T2 SI are typically benign (PI-RADS v2 score 2) (**Fig. 4**). High-grade tumors, however, characteristically present as lenticular or indistinct foci of homogenous moderately low SI (PI-RADS v2 score 4 or 5)