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Common Technical and Anatomical Pitfalls in the Evaluation of Multiparametric Prostate Magnetic Resonance Imaging

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Introduction

Multiparametric magnetic resonance imaging (MRI) is the single most versatile imaging assessment of the prostate, which is useful in delineating local soft tissue anatomy and in tumor visualization while providing superior soft tissue resolution. Multiparametric MRI readily detects extracapsular and seminal vesicle invasion, both of which are important staging and prognosticating factors.[1-3] MRI is also helpful in assisting in surgical planning, especially if a neurovascular bundle–sparing technique is considered.[4] As no sequence alone provides sufficient characterization, a multiparametric approach is the current standard. Despite recent technological advancements, radiologists must be aware of the potential pitfalls and diagnostic challenges in interpreting prostate MR images. We discuss a few such pitfalls that are commonly seen in clinical practice.

Acquisition-Related Artifacts

Diffusion-Weighted Imaging

Diffusion-weighted imaging (DWI) is based on the principle of random motion of water molecules in tissue. In cancer, tissues with tightly packed cells, water diffusion tends to be more restricted. T2 "shine-through" artifacts due to the high water content in the peripheral zone can be reduced by calculating the apparent diffusion coefficient (ADC). This allows malignancies to be detected as focal restriction on ADC maps (Fig. 1). DWI sequences with ADC maps are prone to artifacts, especially metal implants such as hip replacement, owing to the relatively low signal-to-noise ratio (Fig. 2). Although correlation between Gleason score and ADC values have been reported,[5-8] there is significant overlap between benign and malignant lesions, thus reducing ADC specificity for malignancy.[9] At our institution, we use multiple *b* values and an additional sequence with a high *b* value up to 2000 s/mm^2 for prostate DWI acquisition. In our experience, and consistent with recent studies,[10-13] high *b* values are associated with improved lesion detection (Fig. 3). However, high *b* values may also lead to contour distortions of the gland on DWI. This is caused by random eddy currents in the human tissue produced by the rapidly changing magnetic fields of DWI echo planar sequences. These eddy currents create irregular magnetic fields that interfere with the external field and degrade the images.[14] Consequently, prostatic capsule, focal lesions, and internal boundaries may appear distorted or obscured on images with high *b* values (Fig. 3D). For an ADC map to be informative, an appropriate windowing level is critical. Figure 4 demonstrates an example of how optimal window accentuates a focal lesion that would be difficult to visualize on suboptimal windows. Determining an optimal window can be a technically complicated process, as it is affected by the various scanning parameters. A prior study[14] has advocated specific values for the window and level settings (window width of 1.650×10^{-6} mm^2/s and level of 1.675×10^{-6} mm^2/s). In our experience, standardized window and level settings are useful to ensure consistent imaging quality, after manual adjustments to account for technical differences between scanners.

Dynamic Contrast Enhancement

In dynamic contrast enhancement (DCE) imaging, a bolus of intravenous contrast agent is injected, followed by a series of rapid T1-weighted (T1W) image acquisitions. Prostate cancer demonstrates increased early enhancement compared with that of the normal tissue because of increased vascularity and vessel permeability and because of tissue factors secreted by the carcinoma.[15,16] Although experience with DCE-MRI is limited, focal early enhancement is suggestive of malignancy. DCE-MRI combined with T2W images has also shown high sensitivity

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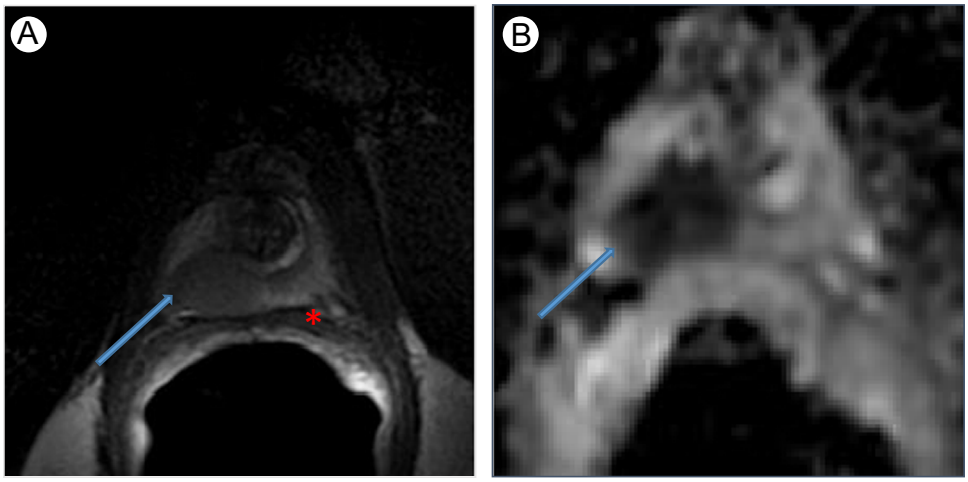

Figure 1 A scan of a 45-year-old man with Gleason score of 6 (3 + 3) adenocarcinoma of the prostate. (A) Axial T2W image at the level of apex, which shows nonspecific low signal in the right peripheral zone apex (arrow). There is moderate bulging of the prostatic capsule on the right and effacement of rectoprostatic angle (*). (B) The ADC map demonstrates focal restriction in the right apex (arrow), correlating with the low-signal area on T2W images. (Color version of figure is available online.)

and specificity rates (90% and 88%, respectively) for lesions more than 0.5 cm.[17,18] In our experience, DCE-MRI is an important sequence as part of a multiparametric examination. However, it has limited value on its own, as some nonmalignant lesions such as prostatitis could also demonstrate early focal enhancement (Fig. 5).

Interpretive Errors

Errors in Detection When a Reader Fails to Perceive an Abnormality

Occasionally, prostate tumors may have unusual or uncommon imaging presentations, leading to diagnostic dilemma or false-negative interpretations.

Subcapsular Crescentic Tumors

Small subcapsular tumors can be diagnostically challenging, as they tend to be crescentic and may be difficult to differentiate from the crescentic capsule on T2W images. It has been previously hypothesized[19] that peripheral zone tumors may initially exhibit subcapsular spread during early growth. Subcapsular tumors are important to identify for optimal surgical planning, given the propensity for extraprostatic extension. As demonstrated in Figure 6, such a tumor may be indistinct on T2W images from the adjacent capsule. The flattening of the capsule by an endorectal coil, if used, may also hinder identification. DWI and DCE imaging facilitate detection by more clearly showing small subcapsular signal abnormalities. In this example (Fig. 6B), the lesion was revealed on the ADC map.

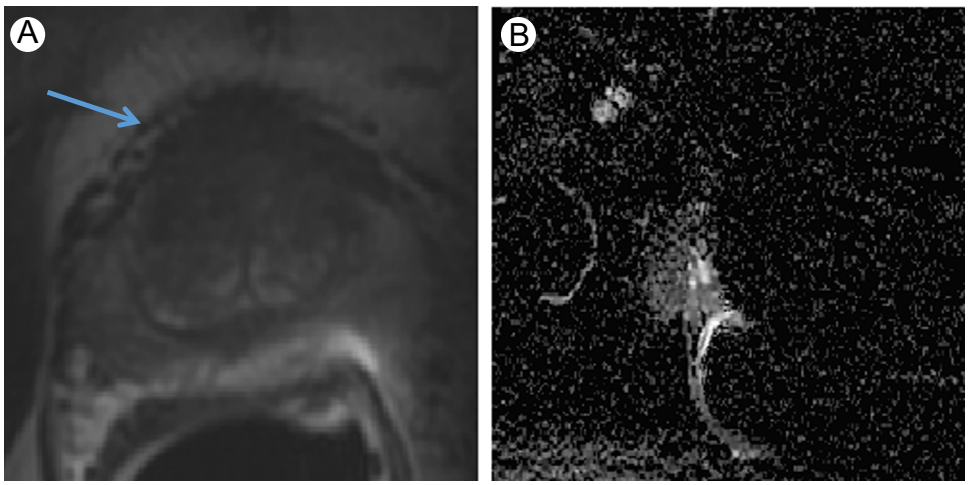

Figure 2 A scan of a 58-year-old man with targeted biopsy-confirmed far-anterior prostate adenocarcinoma of Gleason score of 7 (4 + 3). This patient also has a left hip prosthesis. (A) An axial T2W image at the level of the midgland, demonstrating an ill-defined far anterior lesion with capsular bulge (arrow). (B) An ADC map at the same level, demonstrating extensive metal artifact. Except for a small area in the right peripheral zone, the ADC map is uninterpretable, and the anterior lesion seen on the T2W image cannot be evaluated. (Color version of figure is available online.)