Prostate Magnetic Resonance Imaging: Challenges of Implementation

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Prostate cancer is among the most common causes of cancer and cancer deaths in men. Screening methods and optimal treatments have become controversial in recent years. Prostate magnetic resonance imaging (MRI) is gaining popularity as a tool to assist diagnosis, risk assessment, and staging. However, implementation into clinical practice can be difficult, with many challenges associated with image acquisition, postprocessing, interpretation, reporting, and radiologic-pathologic correlation. Although state-of-the-art technology is available at select sites for targeting tissue biopsy and interpreting multiparametric prostate MRI, many institutions struggle with adapting this new technology into an efficient multidisciplinary model of patient care. This article reviews several of the challenges that radiologists should be aware of when integrating prostate MRI into their clinical practice.

Introduction

Prostate cancer is a common cause of cancer and cancer deaths among men in the United States, with an estimated 233,000 new cases and 29,480 deaths each year.[1] In recent decades, screening and diagnosis of prostate cancer relied on serum prostate-specific antigen (PSA) and digital rectal examination, followed by targeted or saturation biopsy for positive screens. However, PSA screening has become controversial. Recent randomized trials evaluating the utility of PSA screening have shown increased diagnosis of prostate cancer in screened populations, leading to increased interventions but no difference in prostate cancer mortality or all-cause mortality.[2,3] The lack of survival benefit and added morbidity associated with intervention ultimately led to a grade D recommendation[4] against routine PSA screening by the U.S. Preventive Services Task Force (USPSTF).

Beyond screening, the optimal treatment of localized prostate cancer is controversial with studies demonstrating little or no mortality benefit when comparing radical prostatectomy with observation.[5-7] The inability to prospectively identify and differentiate high-risk tumors from indolent tumors, many times, leads to overtreatment and the psychological stress associated with a cancer diagnosis for patients.[8]

In the wake of the USPSTF recommendation against routine PSA screening and the mounting evidence against radical prostatectomy for men with low-risk tumors, there has been renewed interest in observational management. In particular, there is increasing enthusiasm for active surveillance (AS) of prostate cancer. AS defines monitoring and treatment triggers aimed at minimizing interventions for indolent cancers.[9] Optimal monitoring and treatment algorithms for AS are not yet well defined within the urology community. Gleason score on repeat biopsies, serial PSA monitoring, and patient preferences play a key role in determining treatment strategy. Multiparametric prostate magnetic resonance imaging (MPP-MRI) is increasingly being used to document tumor burden in patients and offers a potentially powerful tool to help identify patients who are appropriate for AS.[9-11]

There are many arguments in favor of adding MPP-MRI to the AS algorithm. Initial studies show that MPP-MRI can more accurately classify patients to AS when combined with clinical classification schemes (eg, the D'Amico, Epstein, and Cancer of the Prostate Risk Assessment systems).[10] MPP-MRI may identify tumors and allow for targeted biopsies, which is

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TABLE 1. Potential benefits of MPP-MRI in AS

Improve negative predictive value of tumor burden assessment
Improve accuracy of tumor grade determination
Reduce unnecessary biopsies
Contribute to accurate assignment of patients to AS
Provide a tool to follow up patients noninvasively once diagnosis is established

important to accurately assess tumor grade given that saturation biopsies randomly sample less than 0.5% of the gland. Early retrospective studies have shown that MPP-MRI may result in removal of up to 29% of patients from AS after confirmatory repeat biopsy. Likewise, MPP-MRI may provide a high negative predictive value for large or high-grade tumors, allowing patients to stay on AS with more confidence.[11] Table 1 summarizes the potential roles of MPP-MRI in AS.

In light of the possible clinical utility of MPP-MRI, the volume of imaging requests have gone up in many centers, and radiologists must be familiar with the performance and interpretation of these studies. MPP-MRI can be challenging for many reasons, including issues related to technical acquisition, post-processing, interpretation, reporting, and radiologic-pathologic correlation. This article provides an overview of the role of MPP-MRI in AS as well as the challenges associated with its implementation.

Challenges in Acquisition

There is no uniformly agreed protocol in the community. In a survey of predominantly academic centers, there was a near-even split between acquiring images using an endorectal coil at 1.5 T, a pelvic phased-array coil at 3 T, and an endorectal coil at 3 T.[12] Nearly all centers performed diffusion-weighted imaging (DWI) in addition to acquiring T2-weighted images (T2WIs), and more than half of centers used dynamic contrast enhancement (DCE) in addition to T2WI and DWI. Only 21% of surveyed centers used MR spectroscopy, all of which were academic centers. Guidelines and consensus statements for prostate MRI acquisition and reporting have been proposed in Europe[13-15] but not yet by a North American society. These guidelines and a thorough review of the literature by Hoeks et al[16] suggest that MPP-MRI be performed with a minimum of DWI and DCE in addition to T2WI. We therefore focus our discussion on these 3 techniques. The challenges of prostate MRI protocol design are discussed later with reference to supportive literature where available. We also discuss our approach and solutions to challenges at our own institution. Table 2 shows typical sequence parameters. Table 3 shows some of the more common challenges encountered with the various sequences as well as potential solutions to these challenges.

Field Strength and Coil Selection

Most academic centers use an endorectal coil when imaging at 1.5 T, and most of the literature supports reasonable accuracy for staging with this coil selection.[12,16] The performances of endorectal coils and phased-array coils in the same patient population at 1.5 T was prospectively compared by 2 studies.[17,18] In 1 study, 81 patients underwent prostate MRI using both phased-array coil and an integrated endorectal-pelvic phased-array coil system during the same examination. The endorectal coil images showed significantly improved prospective diagnostic accuracy (from 59%-83%) and more importantly specificity (from 62%-98%) of extracapsular extension detected

TABLE 2. Nominal MR parameters

Protocols	T2WI	DWI	DCE
Sequence type	Turbo spin echo	Echo planar imaging	Spoiled 3D gradient echo
Options	Phase encoding in left-right direction which helps reduce motion artifact from rectal peristalsis	Spectral fat saturation, partial Fourier acquisition, b = 0, 500, and 1000 s/mm^2	Acquire T1 map before contrast administration if a quantitative analysis is desired
TR	4000-6000 ms	11,200 ms	Minimal TR
TE	90-120 ms	89 ms	Minimal TE
Flip angle	180 (>150)	90	6-12
Echo train length	8-16	NA	1
Matrix size	512 × 512	128 × 128	256 × 256
Field of view (cm^2)	16 × 16	16 × 16	16 × 16
Number of averages	4	5	1-2
Slice thickness (mm)	3	3	3

NA, not applicable.