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Review Article

Magnetic resonance imaging for prostate cancer: Comparative studies including radical prostatectomy specimens and template transperineal biopsy

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ABSTRACT

Purpose: Multiparametric magnetic resonance imaging (mpMRI) is an emerging technique aiming to improve upon the diagnostic sensitivity of prostate biopsy. Because of variance in interpretation and application of techniques, results may vary. There is likely a learning curve to establish consistent reporting of mpMRI. This study aims to review current literature supporting the diagnostic utility of mpMRI when compared with radical prostatectomy (RP) and template transperineal biopsy (TTPB) specimens.

Methods: MEDLINE and PubMed database searches were conducted identifying relevant literature related to comparison of mpMRI with RP or TTPB histology.

Results: Data suggest that compared with RP and TTPB specimens, the sensitivity of mpMRI for prostate cancer (PCa) detection is 80–90% and the specificity for suspicious lesions is between 50% and 90%.

Conclusions: mpMRI has an increasing role for PCa diagnosis, staging, and directing management toward improving patient outcomes. Its sensitivity and specificity when compared with RP and TTPB specimens are less than what some expect, possibly reflecting a learning curve for the technique of mpMRI.

1. Introduction

Prostate cancer (PCa) is the second most common cause of cancer death in Australian men and is the most commonly diagnosed internal malignancy with one in seven Australian men being diagnosed with PCa by the age of 75.[1] PCa may first present with elevated prostate-specific antigen (PSA) on screening or symptomatically with lower urinary tract symptoms, bony pain from metastases or uncommonly with hematuria, urinary retention, or renal failure.[2] The definitive diagnosis of PCa is generally made by a biopsy, typically transrectal ultrasound (TRUS)-guided biopsy. Staging is typically by a nuclear medicine bone scan or computed tomography–positron emission tomography.[3]

An influential work by McNeal et al in 1988[4] demonstrated trends in the zonal origin of PCa, particularly the predominance of malignancy within the peripheral zone (PZ) and hence its amenability to detection on digital rectal examination (DRE) and TRUS-guided biopsy. However, a minority of cancers arose from more anterior regions of the prostate leading to a newly articulated phenomenon "prostatic evasive anterior tumor syndrome (PEATS)." PEATS describes a subset of PCa which, due to anatomical location, may be missed by traditional investigations such as DRE and TRUS biopsy, both of which primarily focus on the PZ, but may be detected by multiparametric magnetic resonance imaging (mpMRI) or transperineal biopsy (TPB).[5]

Management of PCa depends on risk stratification, most commonly the Gleason score, TNM staging, and PSA level. Lower risk cancers may be indolent and require active surveillance (AS) involving (with local variation) monitoring PSA levels (serial PSA tests), DREs, biopsy, and possibly mpMRI or watchful waiting for

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patients deemed not suitable for active treatment with curative intent by their treating clinician. Higher risk cancers may be treated with radical prostatectomy (RP), external beam or interstitial (brachytherapy) radiotherapy, androgen deprivation therapy, or a combination of these. Newer focal therapies are under investigation.[3]

This literature review aims to describe mpMRI and to explore the evolving role for PCa diagnosis and staging.[6] The sensitivity and specificity of mpMRI reported in the literature is approximately 80–90% and 50–90%, respectively, when compared with RP and template TPB (TTPB) specimens.

2. Materials and methods

MEDLINE and PubMed database searches were conducted from August 2014 to January 2015 using combinations of the MeSH terms “prostate,” “prostatic neoplasia,” “diagnosis,” “magnetic resonance imaging,” and using specific search terms such as “mpMRI,” “multiparametric,” or “erMRI.”

3. Discussion

Multiparametric MRI (mpMRI) is an emerging technique that aims to improve upon the diagnostic sensitivity of prostate biopsy, and ultimately reduce the number of biopsies performed and better direct management decisions. The recently released 2014 National Institute for Health and Care Excellence (NICE) guidelines for management of PCa in the United Kingdom recommended an increasing role for mpMRI based on clinical and cost effectiveness. However, these guidelines recommended against utilizing mpMRI before biopsy due to insufficient cost benefit.[3] It is important to distinguish multiphasic MRI from conventional 1.5-T MRI techniques without dynamic contrast-enhanced MRI (DCE-MRI) or diffusion-weighted imaging (DWI), which have been shown not to be provide sufficiently reliable information for clinical decision making.[7] The sequences involved in mpMRI are detailed in Table 1. Tables 2 and 3 summarize the literature regarding the diagnostic utility of mpMRI for PCa.

3.1. MRI after a negative TRUS

The NICE guidelines recommended consideration of an MRI after negative TRUS biopsy to assess the requirement for an additional biopsy.[3] This particularly relates to PEATS, because anterior or apical tumors may be missed by TRUS biopsy but still be visible on mpMRI.[5,8]

3.2. Active surveillance

mpMRI has an emerging role within AS for low-grade disease, partly to minimize morbidity due to repeat biopsy.[9,10] The Prostate Cancer Research International: Active Surveillance (PRIAS)—guideline and study for the expectant management of localized prostate cancer with curative intent study is a multicenter, international, ongoing study that includes a subgroup of men undergoing mpMRI as part of their AS for low-risk PCa. The PRIAS protocol includes an MRI 3 months after diagnosis, similar to the NICE guidelines recommending mpMRI for all men commencing AS.[3] In addition, PRIAS includes yearly mpMRI and some targeted biopsies. The number, size, and prostate imaging-reporting and data system (PI-RADS) progression of visible lesions direct whether targeted biopsy is undertaken and longitudinal information will be collected regarding correlation of MRI with biopsy and RP specimens. PRIAS is expected to conclude in 2021 and may dictate the future role of mpMRI in AS.[11,12]

3.3. Preoperative staging

The NICE guidelines recommended mpMRI to investigate for regional nodal disease and the extent of the primary tumor in men with histologically proven PCa if the tumor growth affects management, such as in preoperative staging.[3] Organ-confined disease enables an operative approach to spare the neurovascular bundle, minimizing concerns regarding positive surgical margins, and thereby reducing postoperative morbidity relating to erectile dysfunction without increasing mortality risk.[13] mpMRI has been

Table 1
Details of magnetic resonance sequences.

Magnetic resonance sequence	Technical details	Clinical implications
DWI/ADC	The apparent diffusion coefficient (ADC) of a tissue dictates Brownian motion of water molecules within that tissue.[15] Lower ADC within PCa may result from the replacement of fluid containing ducts with tightly packed glandular tissue.[17]	ADC negatively correlates with tumor grade.[18,19] DWI is more sensitive for tumors of a higher grade, stage and volume.[20]
DCE	Malignant tissue has increased permeability and vascularity relative to normal tissue causing early enhancement and washout of the contrast agent.[15]	Higher tumor grades correlate with proportionately earlier enhancement and washout.[21] DCE-MRI may reduce accuracy within the TZ.[21,22]
Magnetic resonance spectroscopy	Magnetic resonance spectroscopy detects increasing (choline + creatinine)/citrate ratios, which have been correlated with Gleason score.[23]	A large clinical trial suggested that magnetic resonance spectroscopy provides little additional information compared with T2WI.[23] Magnetic resonance spectroscopy may not be included in mpMRI sequences[16,24] and is optional in the PIRADS scoring system.[15]
T1WI	Detects postbiopsy hemorrhage, which confounds other sequences.[25]	
T2WI	Delineates the zonal anatomy of the prostate and capsule, and helps elucidate extracapsular extension.[15] Suspicious characteristics include homogenous areas of low signal with ill-defined margins.[15,26]	

Note. From “The role of magnetic resonance imaging in the diagnosis and management of prostate cancer,” by J. Thompson, N. Lawrentschuk, M. Frydenberg, L. Thompson, and P. Stricker, USANZ, 2013, *BJU Int, 112*, p. 6–20; Also from “MRI for men undergoing active surveillance or with rising PSA and negative biopsies,” O. Raz, M. Haider, J. Trachtenberg, D. Leibovici, and N. Lawrentschuk, 2010, *Nat Rev Urol, 7*, p. 543–51.
ADC, apparent diffusion coefficient; DCE, dynamic contrast enhanced; DWI, diffusion-weighted imaging; mpMRI, multiparametric magnetic resonance imaging; MRI, magnetic resonance imaging; PCa, prostate cancer; PIRADS, Prostate imaging and reporting data system; T1WI, T1-weighted imaging; T2WI, T2-weighted imaging; TZ, transition zone.