The role of MRI in prostate cancer

A changing paradigm

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Multiparametric magnetic resonance imaging is proving to be an excellent tool for detecting aggressive prostate cancers and performing targeted biopsies. Potentially, it will reduce overdetection and underdetection and optimise active surveillance and other aspects of cancer assessment and treatment

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In recent years, magnetic resonance imaging (MRI) technology has improved and MRI is now evolving to have an encouraging role in the diagnosis and management of men with prostate cancer. The ability to accurately detect prostate cancer and risk-stratify patients is central to being able to counsel men about treatment options.

The gold-standard prostate cancer diagnostic pathway has traditionally combined clinical history, digital rectal examination, prostate specific antigen (PSA) testing and systematic random (i.e. not visually targeted) prostate sampling with transrectal ultrasound (TRUS) guidance.[1,2] This has resulted in substantial overdetection of indolent disease, a proportion of missed or undersampled significant cancers and inaccurate tumour risk stratification.

MRI is becoming an increasingly reliable means of obviating these problems. Not only does it have a growing role in cancer detection, but it also facilitates targeting of prostate biopsies, monitoring patients whose cancer is under active surveillance, staging, surgical planning and assessing treatment response to emerging focal therapies.[3]

Multiparametric MRI of the prostate

Initial trials of MRI of the prostate in the 1980s using anatomical T1- and T2-weighted images alone showed a lack of sensitivity and specificity for significant cancer detection.[4] Modern MRI of the prostate involves three imaging sequences combining anatomical and functional parameters.[5] The combination of T2-weighted, diffusion-weighted and dynamic contrast-enhanced imaging sequences is known as multiparametric MRI (mpMRI; Box 1).

1. PARAMETERS FOR MULTIPARAMETRIC MRI[5]

- T2-weighted imaging
  - Assessment of anatomical prostate zones
- Diffusion-weighted imaging
  - Tumour detection and characterisation including an apparent diffusion coefficient (ADC) map
- Dynamic contrast-enhanced imaging
  - Cancer vascularisation evaluation after gadolinium contrast administration

A full mpMRI scan takes approximately 30 minutes on a 1.5 Tesla or 3 Tesla MRI scanner.

PI-RADS scoring for mpMRI prostate

Prostate Imaging Reporting and Data System Version 2 (PI-RADS v2) is the updated reporting scheme used by radiologists to characterise and assess all suspicious prostate lesions found on mpMRI.[6] It uses a five-point assessment scale indicating the likelihood that mpMRI findings correlate with the presence of clinically significant prostate cancer at a particular anatomical location (Table 1). Clinically significant disease is defined by a Gleason score greater than or equal to 7 (including 3 + 4 with prominent but not predominant Gleason grade 4), with a tumour volume greater than 0.5 mL and/or extraprostatic extension.[6]

Clinical applications

Cancer detection

Acknowledging that the traditional diagnostic pathway has limitations, mpMRI of the prostate is proving to be an excellent instrument to aid detection of aggressive cancers within the prostate, while potentially reducing overdetection of insignificant low-grade foci.[3,4] The reported sensitivity of mpMRI in detection of any significant prostate cancer varies widely (76 to 96%) and is largely dependent on the experience of the radiologist.[3,7] However, a recent study under Professor Stricker showed a sensitivity of 96% for detecting significant cancer and a negative predictive value of 92%, when assessing biopsy-naive men more than 40 years of age who had an abnormal PSA level or digital rectal examination result.[8]

TABLE 1. PROSTATE IMAGING REPORTING AND DATA SYSTEM VERSION 2 (PI-RADS v2) ASSESSMENT SCORING CATEGORIES[6]

PI-RADS score	Probability of significant cancer	Clinical implication
1	Very low	Clinically significant cancer is highly unlikely to be present
2	Low	Clinically significant cancer is unlikely to be present
3	Intermediate	The presence of clinically significant cancer is equivocal
4	High	Clinically significant cancer is likely to be present
5	Very high	Clinically significant cancer is highly likely to be present

Targeted biopsy and localisation in patients with previous negative biopsy

Currently, there are three ways to use mpMRI to perform targeted biopsies: cognitive fusion biopsy, MRI/TRUS-fusion biopsy and in-bore MRI-guided biopsy (Box 2).

Although in-bore MRI-guided biopsy is the most reproducible technique, cognitive fusion and MRI/TRUS-fusion techniques are more cost-effective and universally applicable.[7]

A recent study among 1003 men undergoing conventional TRUS biopsy and mpMRI with MRI-targeted biopsy showed that the MRI/TRUS-fusion technique led to diagnosis of 30% more high-grade cancers and 17% fewer low-grade cancers compared with TRUS biopsy.[9] These results were echoed in a recent meta-analysis of the evidence comparing the diagnostic benefits of MRI-targeted biopsy with standard TRUS biopsy. The review showed similar overall cancer detection rates for the two techniques; however, MRI/TRUS-fusion biopsy significantly improved detection of significant cancer, reduced detection of insignificant cancer and improved detection of significant cancer in patients with previous negative biopsies.[10] Further studies are required to validate the possibility of replacing or enhancing systematic random biopsy with MRI-targeted approaches.

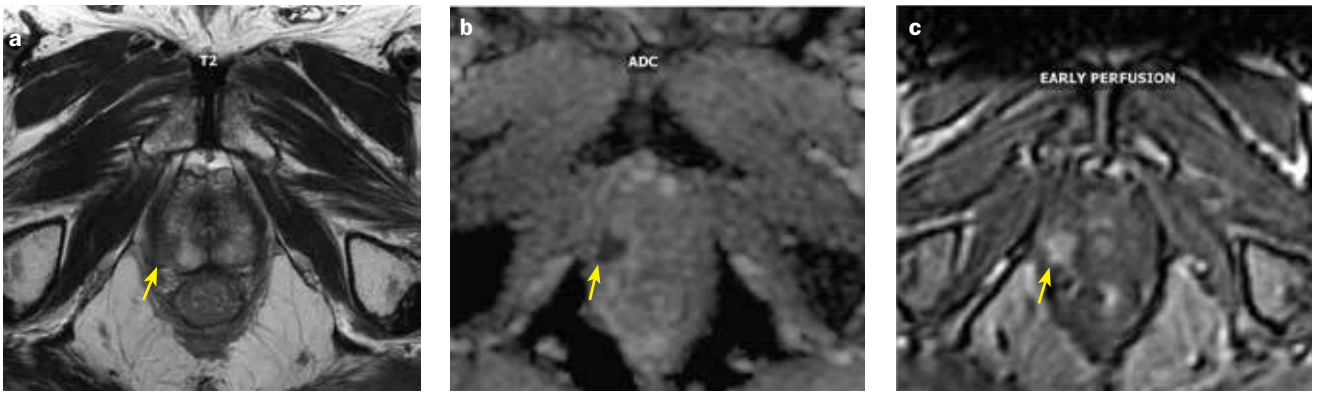
Active surveillance population

Active surveillance of patients diagnosed with prostate cancer relies on accurate risk stratification of affected men and a precise means of following up patients. mpMRI appears to not only aid in selection of patients for active surveillance, but may also be a means to monitor patients on active surveillance protocols, decreasing the frequency of follow-up prostate biopsy.[11] Validation studies of this principle are currently being performed.

2. THREE WAYS TO USE mpMRI TO PERFORM TARGETED BIOPSIES

- Cognitive fusion biopsy
  - The surgeon aims to target the lesion manually based on knowledge of suspicious areas seen on the MRI images of the prostate.
- MRI/TRUS-fusion biopsy
  - MRI is co-registered with real-time ultrasound images via specialised software to facilitate region-of-interest sampling.
- In-bore MRI-guided biopsy
  - Prostate biopsies are performed while the patient is undergoing an MRI of the prostate to ensure absolute concordance with the MRI region of interest.

Abbreviations: MRI = magnetic resonance imaging; TRUS = transrectal ultrasound.



Figures 1a to c. Multiparametric MRI of Gleason 9 cancer in the right posterolateral apex (arrows) showing a Prostate Imaging Reporting and Data System Version 2 (PI-RADS v2) category 4 lesion. a (left). T2-weighted MRI image. b (centre). Diffusion-weighted MRI image with an apparent diffusion coefficient (ADC) map. c (right). Dynamic contrast-enhanced image with early perfusion.

Staging, treatment planning and role in focal therapy

MRI of the prostate was initially introduced as a staging tool for patients with prostate cancer, providing information on extraglandular disease and involvement of the neurovascular bundles, seminal vesicles and lymph nodes. In 2012 the reporting of extraprostatic disease was standardised, and subsequently mpMRI is increasingly used as a decision tool to guide surgical technique such as nerve-sparing intent.[5] Emerging focal therapies for men with prostate cancer rely on accurate localisation to allow planning of limited ablation of the treatment zones while sparing normal tissue. mpMRI is currently being used in conjunction with transperineal biopsy to help detect appropriate lesions, guide treatment and follow up patients undergoing focal therapies such as irreversible electroporation, cryosurgery, high-intensity focal ultrasound, photodynamic therapy, radiofrequency ablation and laser-induced interstitial thermotherapy.[12]

Limitations and future directions

mpMRI of the prostate is still evolving and is not without limitations. For radiologists, a significant learning curve of at least 100 cases is associated with mpMRI reporting,[13] and ongoing education is required. Further, Medicare does not provide a rebate for mpMRI of the prostate, putting the cost burden on patients. More research on the utility and cost-effectiveness of mpMRI will be essential to establishing its role in the prostate cancer diagnosis and management paradigm. The Urological Society of Australia and New Zealand currently recommends that mpMRI be performed and reported by experienced radiologists and be ordered and interpreted by urologists; and that it should not yet be considered on its own, but should be considered in combination with patient history, examination and biopsy as part of a comprehensive assessment for prostate cancer. MT

References

1. Carter HB. American Urological Association (AUA) guideline on prostate cancer detection: process and rationale. BJU Int 2013; 112: 543-547.
2. Heidenreich A, Bastian PJ, Bellmunt J, et al. EAU guidelines on prostate cancer. part 1: screening, diagnosis, and local treatment with curative intent-update 2013. Eur Urol 2014; 65: 124-137.
3. Futterer JJ, Briganti A, De Visschere P, et al. Can clinically significant prostate cancer be detected with multiparametric magnetic resonance imaging? A systematic review of the literature. Eur Urol 2015; 68: 1045-1053.
4. Thompson J, Lawrentschuk N, Frydenberg M, Thompson L, Stricker P; USANZ. The role of magnetic resonance imaging in the diagnosis and management of prostate cancer. BJU Int 2013; 112 Suppl 2: 6-20.
5. Barentsz JO, Richenberg J, Clements R, et al; European Society of Urogenital Radiology. ESUR prostate MR guidelines 2012. Eur Radiol 2012; 22: 746-757.
6. Barentsz JO, Weinreb JC, Verma S, et al. Synopsis of the PI-RADS v2 guidelines for multiparametric prostate magnetic resonance imaging and recommendations for use. Eur Urol 2016; 69: 41-49.
7. Radtke JP, Teber D, Hohenfellner M, Hadaschik BA. The current and future role of magnetic resonance imaging in prostate cancer detection and management. Transl Androl Urol 2015; 4: 326-341.
8. Thompson JE, van Leeuwen PJ, Moses D, et al. The diagnostic performance of multiparametric magnetic resonance imaging to detect significant prostate cancer. J Urol 2016; 195: 1428-1435.
9. Siddiqui MM, Rais-Bahrami S, Turkbey B, et al. Comparison of MR/ultrasound fusion-guided biopsy with ultrasound-guided biopsy for the diagnosis of prostate cancer. JAMA 2015; 313: 390-397.
10. Schoots IG, Roobol MJ, Nieboer D, Bangma CH, Steyerberg EW, Hunink MG. Magnetic resonance imaging-targeted biopsy may enhance the diagnostic accuracy of significant prostate cancer detection compared to standard transrectal ultrasound-guided biopsy: a systematic review and meta-analysis. Eur Urol 2015; 68: 438-450.
11. Schoots IG, Petrides N, Giganti F, et al. Magnetic resonance imaging in active surveillance of prostate cancer: a systematic review. Eur Urol 2015; 67: 627-636.
12. Donaldson IA, Alonzi R, Barratt D, et al. Focal therapy: patients, interventions, and outcomes - a report from a consensus meeting. Eur Urol 2015; 67: 771-777.
13. Gaziev G, Wadhwa K, Barrett T, et al. Defining the learning curve for multiparametric magnetic resonance imaging (MRI) of the prostate using MRI-transrectal ultrasonography (TRUS) fusion-guided transperineal prostate biopsies as a validation tool. BJU Int 2016; 117: 80-86.

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