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REVIEW

MR imaging of the prostate

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Abstract

There is no set protocol for imaging prostate cancer, and a selection of a particular modality (TRUS, CT or MRI) often depends on the equipment and local expertise available. None of the imaging modality is perfect and a judicious combination provides the best results. MR imaging and MR spectroscopic imaging are powerful new tools for the local anatomic and metabolic evaluation of prostate cancer. MRI/MRSI offers new insights into the assessment of tumor location, volume, and aggressiveness and improve staging. The techniques are novel; indications and effectiveness continue to be defined; examination is expensive and the potential role of these studies still evolving. However, with increasing patient demand for minimally invasive and patient specific treatment, it is likely that the prostate MRI and MRSI will become the recognized modality of choice for loco-regional imaging evaluation of prostate cancer.

Keywords: *Prostate cancer, MRI, MRSI.*

Introduction

The use of diagnostic imaging in staging evaluation of prostate cancer (PCa) is a subject of controversy. The recommendations range from denial to a strong advocacy for imaging prior to any decision about therapy. Considering the disagreements about PCa detection and choice of treatment, the debate concerning imaging is not surprising.

There are evidence-based guidelines regarding the use of imaging in assessing the risk of distant spread of PCa. Radionuclide bone scans and computed tomography (CT) supplement clinical and biochemical evaluation (PSA, prostatic acid phosphates) in any suspected metastatic disease to the bones and lymph nodes[1,2]. Guidelines for the use of bone scans (in-patients with PSA $> 10\,\mathrm{ng\,ml^{-1}}$) and CT (in-patients with PSA $> 20\,\mathrm{ng\,ml^{-1}}$) have been reported and are in clinical use. No such consensus exists at the current time for the use of imaging in evaluating PCa local tumor extent, or for the specific use of MRI.

Variable results have been found for the diagnostic accuracy of MRI in the local staging of PCa. The reported accuracy of MRI in staging PCa ranges from 54 to 90%[3–5]. These results have raised concerns about inter-observer variability and the lack of reproducibility. Over the past 3 years, however, more encouraging results have been obtained for endorectal MRI. Diagnostic performance has improved, with reported accuracy consistently between 75 and 90%. One of the strengths of MRI is its high specificity (>90%) in excluding extra-prostatic tumors. The improved performance of endorectal MRI is probably due to the maturation of MRI technology, including improvements in MRI technique (e.g. faster imaging sequences, more powerful gradient coils, and post-processing image correction), a better understanding of morphologic criteria used to diagnose extra-prostatic disease, and increased reader experience.

MR imaging

The signal intensity and the detection of PCa depend on the type of imaging sequence used. On T1-weighted

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images, the prostate demonstrates homogeneous medium signal intensity. On T2-weighted MR images, PCa is shown most commonly with decreased signal intensity within the high-signal-intensity normal peripheral zone. The detection of PCa on MRI (similar to transrectal US (TRUS)) is applicable only to the tumors located in the peripheral zone. Even in the peripheral zone, tumor detection may be hampered by post-biopsy changes. Depending on the time interval between biopsy and MRI scan, the biopsy changes may cause either under- or over-staging of tumor presence and extent.

It has been demonstrated that MRI study should be performed at least 3 weeks after biopsy. While PCa detection rates as high as 92% have been reported, the results of large multi-center studies are disappointingly low, with only 60% of lesions greater than 5 mm in any one dimension being detected on MRI scans. The role of MRI is in the evaluation of tumor extra-capsular and seminal vesicle invasion. MRI findings of extra-capsular extension on endorectal coil MRI include: irregular bulge of the prostate margin; contour deformity with step-off or angulated margin; breech of the capsule with direct tumor extension; obliteration of rectoprostatic angle; and asymmetry of neurovascular bundles. Seminal vesicle invasion is diagnosed when contiguous low-signal-intensity tumor extension into and around seminal vesicles is demonstrated, and/or when a tumor extension along the ejaculatory duct results in non-visualization of the ejaculatory duct, decreased signal intensity of seminal vesicles, and loss of seminal vesicle wall on T2-weighted images. While transaxial planes of section are essential in the evaluation of extra-capsular invasion, the evaluation of transaxial and coronal planes of section facilitates the invasion of the seminal vesicles. Using the Jewitt classification and endorectal coil MRI, accuracies for extra-capsular extension of 82 and of 97% for seminal vesicle invasion have been reported. In the evaluation of lymph node metastases, efficacy data for MRI and CT are similar.

In addition to staging accuracy, the role of MRI in patient management has been evaluated. It has been shown that the use of endorectal MRI prior to radical prostatectomy improves the surgical decision to spare or resect the neurovascular bundles, especially in high-risk patient groups. In a study reported by Wei *et al*. of 76 patients, 24% had a more aggressive surgical plan when MRI was reviewed together with clinical examination[6]. In the high-risk group, the Bayesian analysis showed that the probability of needing neurovascular bundle resection increased from 39 to 78% with positive MRI findings and decreased from 39 to 19% with negative MRI findings[6]. Furthermore, MRI can be applied in the prediction of interoperative blood-loss during radical retropubic prostatectomy[7]. It has been shown that the prominence of the apical periprostatic veins on MR imaging is associated with greater inter-operative blood-loss during radical prostatectomy. Furthermore, MRI can be used for the prediction of urinary continence after radical retropubic prostatectomy[8]. After controlling for age and surgical technique, multivariant analysis showed that the membranous urethral length is related to the time for stable post-operative continence, such that a membranous urethra greater than 17 mm was associated with a shorter time to stable continence. Therefore, pre-operative use of endorectal MRI renders the following information important in patient management: a longer membranous urethra is associated with an increased likelihood of full urinary continence 1 year after surgery, prominence of the apical veins is associated with blood loss >1500 ml and evaluating the need for neurovascular bundle resection is a significant help in surgical planning.

MR spectroscopic imaging

The recent developments of MR spectroscopic imaging expand diagnostic assessment beyond anatomic information. MR spectroscopic imaging provides metabolic information specific to the prostate through the detection of the cellular metabolites citrate, creatine and choline[9,10]. The information obtained from this new technology may allow an expanded assessment of tumor aggressiveness and the attendant risk of disease progression[11]. In the localization of PCa, positive results from combined MRI and MRS demonstrate 91% specificity, the highest value obtained by a noninvasive method. Furthermore, the combined use of MR imaging and spectroscopy significantly improves evaluation of extra-capsular cancer extention and decreases inter-observer variability, so increasing even further the value of MRI in the evaluation of PCa[9–13].

Recommended approach to imaging

In the staging of PCa each modality, TRUS, MRI and CT, has advantages and disadvantages. Evaluation by TRUS is restricted to local staging only, while both CT and MRI allow detection of local, nodal, and distant metastatic invasion[3–5,10,13,14]. The role of CT in staging PCa is reserved for the search for lymph node metastasis, evaluation of advanced disease, and planning radiation therapy. MRI offers the most complete evaluation of PCa assessing loco-regional and nodal disease. The endorectal coil provides higher staging accuracy than the body coil. Discrepancies in opinion on the value of the endorectal coil attest to the immaturity and still-developing field of MR imaging. The combination of MR imaging and spectroscopic imaging offers anatomic and metabolic information and appears to be the method of the future.

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