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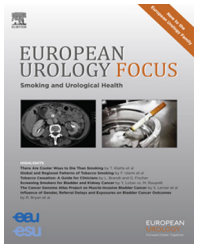

Review–Bladder Cancer

Improving Staging in Bladder Cancer: The Increasing Role of Multiparametric Magnetic Resonance Imaging

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Abstract

Context: In bladder cancer (BCa) patients, accurate local and regional tumor staging is required when planning treatment. Clinical understaging frequently occurs and leads to undertreatment of the disease, with a negative impact on survival. An improvement in staging accuracy could be attained by advances in imaging. Magnetic resonance imaging (MRI) is currently the best imaging technique for locoregional staging for several malignancies because of its superior soft tissue contrast resolution with the advantage of avoiding exposure to ionizing radiation. Important improvements in MRI technology have led to the introduction of multiparametric MRI (mpMRI), which combines anatomic and functional evaluation.
Objective: To review the fundamentals of mpMRI in BCa and to provide a contemporary overview of the available data on the role of this emerging imaging technology.
Evidence acquisition: A nonsystematic literature search using the Medline and Cochrane Library databases was performed up to March 2016. Additional articles were retrieved by cross-matching references of selected articles. Only articles reporting complete data with regard to image acquisition protocols, locoregional staging, monitoring response to therapy, and detection of locoregional recurrence after primary treatment in BCa patients were selected.
Evidence synthesis: Standardization of acquisition and reporting protocols for bladder mpMRI is paramount. Combining anatomic and functional sequences improves the accuracy of local tumor staging compared with conventional imaging alone. Diffusion-weighted imaging may distinguish BCa type and grade. Functional sequences are capable of monitoring response to chemotherapy and radiation therapy. Diffusion-weighted imaging enhanced by lymphotropic nanoparticles showed high accuracy in pelvic lymph node staging compared with conventional cross-sectional imaging.
Conclusions: In BCa patients, mpMRI appears a promising tool for accurate locoregional staging, predicting tumor aggressiveness and monitoring response to therapy. Further large-scale studies are needed to confirm these findings.
Patient summary: Better imaging through improved technology will improve outcomes in bladder cancer patients. We reviewed the emerging use of multiparametric magnetic resonance imaging for staging and monitoring bladder cancer. Multiparametric magnetic resonance imaging appears more accurate than current methods for local and nodal staging and monitoring tumor response to treatment, but requires further investigation.

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1. Introduction

Bladder cancer (BCa) is a common malignancy and one of the most expensive to manage [1,2]. BCa is best classified into non–muscle-invasive bladder cancer (NMIBC) and muscle-invasive bladder cancer (MIBC) because this division reflects the biology and phenotype of the cancers and is used to stratify treatment intent. Approximately 80% of urothelial tumors are NMIBC at diagnosis. Clinical staging of an individual bladder tumor is critical to the care of affected patients and is usually performed through a combination of clinical, pathologic, and radiologic means [3]. However, staging through bimanual examination, cystoscopy, and transurethral resection (TUR) is associated with an inaccuracy rate of 23–50% [4]. Most importantly, patients with apparent high-risk NMIBC are often found to have muscle invasion, if treated radically [5], and those with low-volume metastases can be missed. Therefore, obtaining an accurate imaging study is pivotal when planning and choosing treatment.

Various methods have been explored with a view to improving the accuracy of staging BCa. Although some are focused on the detection of occult metastases, such as positron emission tomography/computed tomography [6], there is still a need to better stage the primary lesion (the T stage). Magnetic resonance imaging (MRI) is considered superior to computed tomography (CT) for local staging because of its high soft tissue contrast resolution and lack of ionizing radiation [7]. Multiparametric MRI (mpMRI), which combines functional sequences such as diffusion-weighted imaging (DWI), dynamic contrast-enhanced imaging (DCEI), and lymphotropic nanoparticle in addition to the anatomic T1- and T2-weighted images (T1-T2WI), improves the accuracy of tumor detection and staging, and it helps monitor post-therapy response and identify local disease recurrence [7].

This article reviews the fundamentals of mpMRI in BCa and provides an overview of the currently available data concerning this new imaging technology.

2. Evidence acquisition

A nonsystematic review of the literature was performed by searching Medline and Cochrane Library databases from 1992 up to March 2016. Additional articles were retrieved by cross-matching references of selected articles.

Primary terms for the search fields were *multiparametric MRI, bladder cancer, DWI, DCE*, and *lymphotropic nanoparticle.* Electronic searches were limited to the English language. Original articles and review articles were included and clinically reviewed.

3. Evidence synthesis

In our research, we found 47 articles focused on the role of MpMRI in BCa. We principally included in the analysis studies that clearly reported data on the detection, staging, monitoring response to therapy, and identification of locoregional disease recurrence after treatment. Evidence for currently used mpMRI in BCa management is presented in a descriptive manner.

3.1. Technical aspects for bladder multiparametric magnetic resonance imaging

A dedicated bladder mpMRI protocol should include at least anatomic T2WI with a small field of view (FOV) in three planes (axial, sagittal, and coronal), a large FOV axial T1WI, DWI, and DCEI. The study of the bladder requires high spatial resolution that can be achieved with the use of a phased-array external surface coil (such as a cardiac coil) to increase signal-to-noise ratio, thin sections (3 mm), no interslice gaps, and a large matrix size [7,8].

Significant artifacts in bladder imaging include lack of bladder distention, motion artifact, and chemical shift artifact [7,8]. Lack of bladder distention may limit the detection of small tumors secondary to detrusor muscle thickening; however, overdistension of the bladder may result in uncontrollable movements due to discomfort, and the thinness of bladder wall can decrease sensitivity for detecting plaquelike lesions. Adequate bladder distention can be achieved by instructing the patient to void 1 h before imaging or by instructing the patient to start drinking an adequate amount of water 30 min to 1 h before the MRI study. In patients with a urethral catheter, 250–400 ml sterile saline can be used to distend the bladder. Constant bladder filling with urine throughout the duration of a scan, which might take 40 min to acquire, will result in some spatial mismatch in the anatomic areas of interest between sequences.

Artifact from bowel peristalsis can be minimized by administering an intramuscular antiperistaltic agent and by using saturation bands on the anterior abdominal wall that reduce respiratory influences. Image intensity correction algorithms can partially reduce motion artifact in the region of interest. Chemical shift artifact refers to misregistration of spatial information caused by the difference in the resonant frequencies of water and fat. This artifact is evident only in the frequency-encoding (readout) direction and occurs at a water–fat interface. Chemical shift artifact typically manifests as high and low signal-intensity (SI) bands along a water–fat interface perpendicular to the frequency-encoding direction [7,8]. This artifact appears as a thickened dark line along the lateral bladder wall on one side and as a bright line on the contralateral side. To reduce this artifact, the bandwidth must be increased and the frequency-encoding gradient changed to select the direction that least interferes with examination of the bladder wall adjacent to the tumor [7,8].

3.2. T1-weighted and T2-weighted imaging

T1WI is used for identifying intraluminal extension of the tumor, extravesical fat infiltration, pelvic lymphadenopathy, and bone metastases [7,8]. T2WI provides information on tumor depth and extravesical disease spread (Table 1). Differentiation of the BCa from the detrusor muscle is problematic on T1WI because both have intermediate SI. On