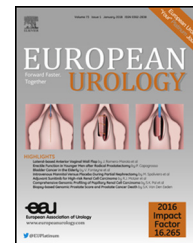


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Platinum Priority – Review – Bladder Cancer

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## Multiparametric Magnetic Resonance Imaging for Bladder Cancer: Development of VI-RADS (Vesical Imaging-Reporting And Data System)

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### Abstract

**Context:** Management of bladder cancer (BC) is primarily driven by stage, grade, and biological potential. Knowledge of each is derived using clinical, histopathological, and radiological investigations. This multimodal approach reduces the risk of error from one particular test, but may present a staging dilemma when results conflict. Multiparametric magnetic resonance imaging (mpMRI) may improve patient care through imaging of the bladder with better resolution of the tissue planes than computed tomography and without radiation exposure.

**Objective:** To define a standardized approach to imaging and reporting mpMRI for BC, by developing a VI-RADS score.

**Evidence acquisition:** We created VI-RADS (Vesical Imaging-Reporting And Data System) through consensus using existing literature.

**Evidence synthesis:** We describe standard imaging protocols and reporting criteria (including size, location, multiplicity, and morphology) for bladder mpMRI. We propose a five-point VI-RADS score, derived using T2-weighted MRI, diffusion-weighted imaging, and dynamic contrast enhancement, which suggests the risks of muscle invasion. We include sample images used to understand VI-RADS.

**Conclusions:** We hope that VI-RADS will standardize reporting, facilitate comparisons between patients, and in future years, will be tested and refined if necessary. While we do not advocate mpMRI for all patients with BC, this imaging may compliment pathology or reduce radiation-based imaging. Bladder mpMRI may be most useful in patients with non-muscle-invasive cancers, in expediting radical treatment or for determining response to bladder-sparing approaches.

**Patient summary:** Magnetic resonance imaging (MRI) scans for bladder cancer are becoming more common and may provide accurate information that helps improve patient care. Here, we describe a standardized reporting criterion for bladder MRI. This should improve communication between doctors and allow better comparisons between patients.

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## 1. Introduction

### 1.1. Bladder cancer

Bladder cancer (BC) is one of the most common and expensive human malignancies to manage [1–3]. Most BCs are urothelial cell carcinomas (UCCs), and histologically stratified into cancers with low and high grade [4]. The latter are subdivided into those with and without muscle invasion. Non-muscle-invasive BCs (NMIBCs) are often low grade and have an indolent natural history [5]. Treatment is aimed at reducing local recurrence and stage progression, and maintaining quality of life [6]. High-grade lesions represent around one-third of NMIBCs, and can progress to muscle invasion and metastases in around 20–25% patients [7–9]. Treatment aims to reduce stage progression and preserve quality of life, while maintaining close surveillance to detect the onset of muscle invasion. Muscle-invasive BCs (MIBCs) are aggressive tumors with an ominous prognosis [10]. Success of treatment is dependent on the stage of the primary tumor and status of the regional lymph nodes. Cure can be achieved in 75–80% of patients with organ-confined disease, 60% of those with T3 node-negative disease and 30% with lymph node-positive disease [11–15]. Despite increasing use of systemic therapy, overall survival rates from BC have not improved over the last 30 yr [16] and these patients have some of the lowest healthcare experience ratings [17].

### 1.2. Transurethral resection

BC is usually detected by flexible cystoscopy following an episode of hematuria or for mixed urinary symptoms [6]. The diagnosis of BC is made by transurethral resection of bladder tumor (TURBT) of all or the most exophytic/intraluminal tumor component. TURBT is used as definitive treatment for most NMIBCs and serves as a diagnostic procedure for most MIBCs. A properly performed TURBT samples the underlying bladder wall including the muscularis propria. Understaging occurs with TURBT, and it may miss muscle infiltration in up to 25% of invasive cancers [18–20]. TURBT is operator dependent, and so residual tumor rates (reflecting incomplete BC resection) vary widely with experience [9,21]. Re-resection of the bladder is advised in high-risk NMI cancers, prior to bladder preserving chemoradiation, or where the clinical and pathological findings differ [6,22,23]. Recent technological advances, such as narrow band imaging or the use of fluorescence agents (“blue light cystoscopy”), may improve the outcomes from TURBT [24,25]. While TURBT is the mainstay of diagnosis that has been used safely since the 1950s, there are concerns that it could lead to cancer embolization [26] and the oncological risks of perforation remain unknown [27].

### 1.3. Radiological staging of BC

The prognosis and management of BC mostly reflects tumor stage. For the primary tumor, this includes depth of

invasion into the lamina propria, detrusor muscle, perivesical fat, adjacent organs, or pelvic side wall [28]. For metastases, this includes regional lymph nodes (number and location) and the presence of distant metastases. BC staging is accomplished through the combination of clinical (examination), pathological (TURBT specimens), and radiological means. Radiological examination should look for second urinary tract malignancies (5% of BCs may have an upper tract UCC) or other pathologies. Most guidelines suggest cross-sectional imaging for MIBCs and high-grade NMI cancers, due to the risks of invasion and regional or distant metastases, and upper urinary tract involvement.

### 1.4. Potential role of mpMRI in BC care

The multimodal approach to BC staging reduces the risk of error from one particular test, but may present a staging dilemma when results conflict [29,30]. Despite their apparent rigor, each modality is operator dependent and the concordance between individuals varies widely. For example, the quality of the TURBT will vary among surgeons, pathologists may disagree in BC grading (10–29% discordance) and staging (15–56% discordance) [4,31], while radiologists differ in agreement about muscle invasion [32]. Multi-parametric magnetic resonance imaging (mpMRI) offers an opportunity to reduce staging errors through better anatomical visualization [33,34]. Given its lack of radiation, mpMRI also offers a potentially safer tool to investigate individuals at risk of BC and to image the same patients prior to, during, and following treatment to determine response.

## 2. Evidence acquisition

### 2.1. Materials and methods

VI-RADS started with a nonsystematic literature review using Medline, PubMed, and Web of Science in July 2017. Search terms included “bladder cancer”, “urothelial carcinoma”, “MRI,” and “multi-parametric MRI.” This fed organization of the subtopics and informed literature selection. The VI-RADS system was achieved through a Delphi-like consensus using multidisciplinary team members from Europe, North and South America, and Asia, in a combination of electronic and face-to-face rounds.

1. Panel members were asked to summarize the evidence in the given area and highlight areas of controversy. Members of the working group met in Chicago in November 2017 (RSNA meeting) to agree with the statements. A facilitator collated the proposals.
2. Members of the working group evaluated each proposal, based on evidence-based research and professional experience, before drafting VI-RADS and deriving consensus.

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