Lower tract neoplasm: Update of imaging evaluation

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A B S T R A C T

Cancers of the lower urinary tract can arise from the bladder, urachus or urethra. Urothelial carcinoma of the bladder (UCB) is the most common of these. The presentation of bladder, urachal and urethral cancers can differ but many result in hematuria as an initial indication. The diagnosis and staging of these cancers often necessitate radiologic imaging often in the form of cross-section CT urography or MR urography. The following article reviews the specific nature of lower tract cancers and their imaging.

1. Introduction

Tumors of the lower urinary tract can affect the bladder, urachus or urethra. Depending on the tumor type and location the imaging modality best suited for evaluation may differ. This article will discuss the different types of tumors, their epidemiology, diagnosis and staging with emphasis on the radiologic imaging often utilizing cross-sectional Computed tomography (CT) and/or MRI.

2. Urinary bladder cancer

2.1. Epidemiology

Urothelial carcinoma of the bladder (UCB) is the most common malignant neoplasm of the lower urinary tract with an age-standardized incidence rate in the world of 9.0 for men and 2.2 for women (per 100,000 person years). However the incidence of UCB varies within regions of the world. The age-standardized incidence in the European Union for instance is 19.1 for men and 4.0 for women [1]. In the United States UCB is the 6th most common malignancy with an annual incidence of around 79,000 new cases per year [2]. UCB in the U.S. typically affects Caucasian patients older than 65 years [3–6]. The incidence is about 4 times higher in men than in women.

Multiplicity and a higher rate of recurrence are typical for urothelial carcinoma. In the United States it tends to be one of the most expensive cancers to treat due to frequent recurrence [7]. Given the fact that the tumors can arise anywhere throughout the urinary tract, all of the urothelium may be susceptible to malignancy which is known as the field defect theory [8]. Tobacco smoking is the most significant and common risk factor although additional causes of carcinogenesis have been implicated as well [9].

2.2. Diagnosis of bladder cancer

Patient signs and symptoms, most notably hematuria, are often the initiating event leading to the search for lower tract malignancy. Initial evaluation including physical examination, cytology and eventually cystoscopy with biopsy most often lead to the diagnosis of a lower tract malignancy, specifically UCB. Cystoscopy and biopsy are necessary to delineate non-muscle invasive bladder cancer (NMIBC) from muscle invasive bladder cancer (MIBC).

2.3. Histology

UCB accounts for 90% of bladder tumors and can exhibit different patterns of growth characterized as either papillary or infiltrative. The pattern of growth tends to correlate with grade ranging from well-differentiated grade 1 to poorly differentiated grade 3 [10]. At the time of diagnosis most patients have NMIBC. However many can recur and a significant portion can progress to higher stage disease over time. Approximately 25% of patients will present with MIBC [11]. The treatment and imaging related to NMIBC is markedly different from MIBC.
2.4. Staging

The TNM staging system of the American Joint Committee on Cancer (AJCC) is most commonly used [17] (Table 1, Bladder Cancer TNM Staging). This is preferred as the extent of tumor within the bladder wall and involvement of adjacent or distal sites are both important [8]. It is important to note that approximately 5% of patients who present with UCB will develop metachronous tumors in the upper urinary tract. Conversely up to 50% of patients with tumors in the upper urinary tract will develop metachronous tumors in the bladder [18–20]. For this reason any patient with identified UCB should have dedicated imaging of the upper and lower urinary tract.

Clinical staging, including cystoscopy, is typically sufficient for staging of NMIBC. For NMIBC (carcinoma in situ, cTa or cT1) the American Urological Association (AUA) and National Comprehensive Cancer Network (NCCN) recommend upper tract imaging. However for MIBC, stage T2 and above, clinical staging may only be accurate in 25% to 50% of patients [21]. Therefore if the bladder tumor has an appearance suggestive of invasion into the muscle, more advanced imaging, such as CT of the abdomen and pelvis, should be undertaken prior to TURBT [22].

CT and MRI have relatively high sensitivity and specificity for the differentiation of patients with transmural spread of disease to the extravesical space versus those with tumor confined to the bladder [11,23,24]. The overall accuracy for local bladder cancer staging approaches 60% with a tendency to over stage [21].

CT and MRI are also useful in detection of lymphatic metastases. The obturator, internal iliac, external iliac and presacral lymph nodes are the primary nodal groups impacted [25]. However CT and MR are both dependent on lymph node enlargement to detect potential metastases. Typically lymph nodes with a short axis diameter greater than 1 cm are considered suspicious [26].

2.5. Prognosis

For all stages combined the 5 year survival rate is 77% which drops to 70% at 10 years and 65% at 15 years. Cancer-specific survival correlates highly with tumor stage. The clinical and imaging findings of the patient’s disease determine the stage according to the AJCC stage groupings (Table 2, Anatomic stage and prognosis). The survival rate for people with stage 0 cancer is 98%, stage I 88%, stage II 63%, stage III 46%, and stage IV 15% [23].

2.6. Imaging of bladder cancer

Many modalities including ultrasound, CT, MRI and positron emission tomography-computed tomography (PET-CT) can be used for the staging of UCB, urachal and urethral cancers.

Some form of upper urinary tract imaging is recommended by the AUA and NCCN guidelines when NMIBC, which consists of carcinoma in situ, cTa or cT1, is discovered. Notably, when tumors are sessile, multifocal, or high grade on resection pathology, more advanced imaging of the abdomen and pelvis is recommended [7]. This is due in part to previously reported 25–40% rate of up-staging to NMIBC to MIBC [27,28].

Stage of MIBC following diagnosis of cT2 disease usually requires more extensive imaging. The AUA and NCCN guidelines recommend contrast enhanced cross-sectional imaging of the abdomen and pelvis typically in the form of CT urography. MR urography may be an alternative in certain situations. These cross-sectional studies are performed in conjunction with chest x-ray or unenhanced CT of the chest. In patients with symptoms suggestive of a bony metastasis and/or elevated serum alkaline phosphatase level, a nuclear medicine bone scan is recommended [7,29].

3. Imaging modalities

3.1. Computed tomography urography (CTU)

CT imaging for detection and staging of urothelial carcinoma is typically obtained through the use of a CTU protocol. CTU provides comprehensive evaluation of the entire urinary system to allow for detection of urolithiasis, renal parenchymal lesions and urethral carcinoma [30].

CTU in brief requires at least two series, one before and a second following contrast injection. The unenhanced series allows for identification of high attenuation blood clots, urolithiasis or calcifications in a mass.

There are different protocols for obtaining the enhanced series. A single bolus protocol will acquire enhanced images of the renal parenchyma and urinary tract mucosa approximately 90 s after injection.