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REVIEW

Urinary bladder: normal appearance and mimics of malignancy at CT urography

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Abstract

The objective of this review article is to learn how to recognize anatomic variants and benign entities that mimic bladder cancer at computed tomography (CT) urography. Building on recent data that suggest that CT urography can be used to diagnose bladder cancer, recognition of anatomic variants and benign entities will help improve radiologists' ability to diagnose bladder cancer.

Keywords: *Computed tomography; urography; bladder cancer; anatomic variants; pitfalls.*

Introduction

With an estimated 70,530 new cases and 14,680 deaths in the United States in 2010, bladder cancer is the most common malignancy of the urothelium and kidneys[1]. Metachronous disease is common, and surveillance for additional tumors is a lifelong challenge in patients with bladder cancer[2].

CT urography (CTU) is defined as a CT examination of the urinary tract that is performed both before and after intravenous (IV) contrast material, and includes excretory phase images[3]. CTU is emerging as the imaging test of choice for the evaluation of the urinary tract for a variety of disorders, including hematuria[4,5]. Although the precise role of CTU has not been defined, recent data suggest that CTU can be used to detect bladder cancer with a sensitivity and specificity close to cystoscopy[6–9]. This article reviews the anatomic variants and benign entities that mimic bladder cancer at CTU.

CT urography technique

Although techniques vary among institutions, the goal of CTU is to achieve a set of images that include a fully opacified and distended intrarenal collecting system, ureters, and bladder[4]. Excretory phase images are considered essential in the evaluation of the urothelium[3,4,10]. We obtain an unenhanced CT scan of the abdomen and pelvis to identify calculi, including those in the bladder, that could be masked by excreted contrast material. Unenhanced CT scans also allow measurement of the native attenuation of masses throughout the urinary tract that can be used to assess for enhancement. In patients over the age of 40 years, we image the kidneys in the nephrographic phase at 100 s after contrast material injection (80 ml of iodinated contrast material; 370 mg I/ml), to detect and characterize renal masses. An excretory phase scan of the abdomen and pelvis is obtained at 15 min[3–5,7,10–14]. In patients 40 years or younger, a split-bolus, two-phase protocol is used to limit radiation exposure. Following an unenhanced scan of the abdomen and pelvis, 40 ml of IV contrast medium are administered. After an 8-min delay, 80 ml of IV contrast medium are administered and followed by a scan of the abdomen and pelvis at 100 s. Both protocols may be augmented with 250 ml of IV normal saline infused during the delay periods[3–5,7,10–14]. We prefer to administer 10 mg of IV furosemide (Lasix; Abbott Laboratories, North Chicago, IL) 2–3 min before the intravenous contrast material in patients over the age of 40 years. Furosemide, and to some extent saline, contribute to

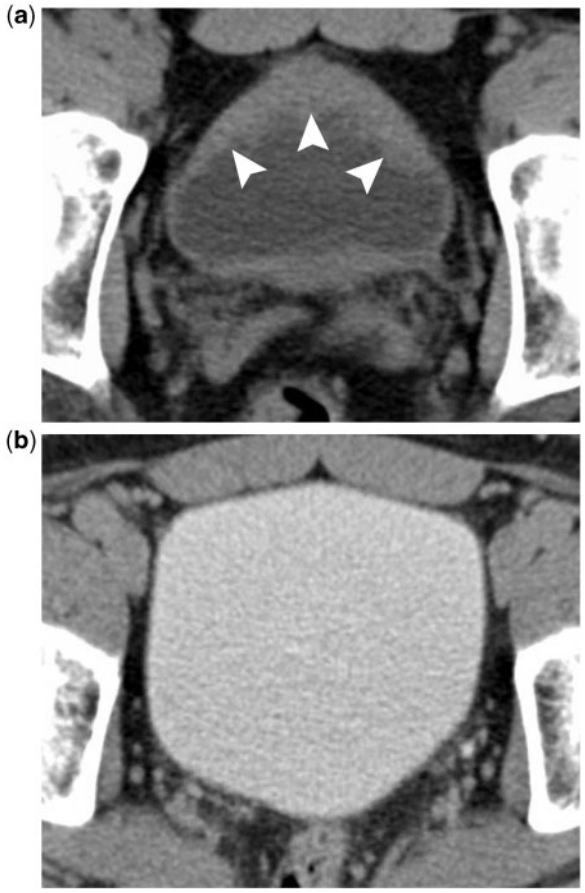

Figure 1 **(a) A 67-year-old man with painless hematuria. Axial image from the unenhanced phase of a CT urogram shows apparent thickening of the anterior bladder wall (arrowheads) concerning for bladder cancer. (b) Axial image from the excretory phase of a CT urogram supplemented with IV furosemide demonstrates that the bladder is normal. The bladder is well distended, and the urine and contrast material are mixed providing a homogeneous background ideal for detection of bladder masses.**

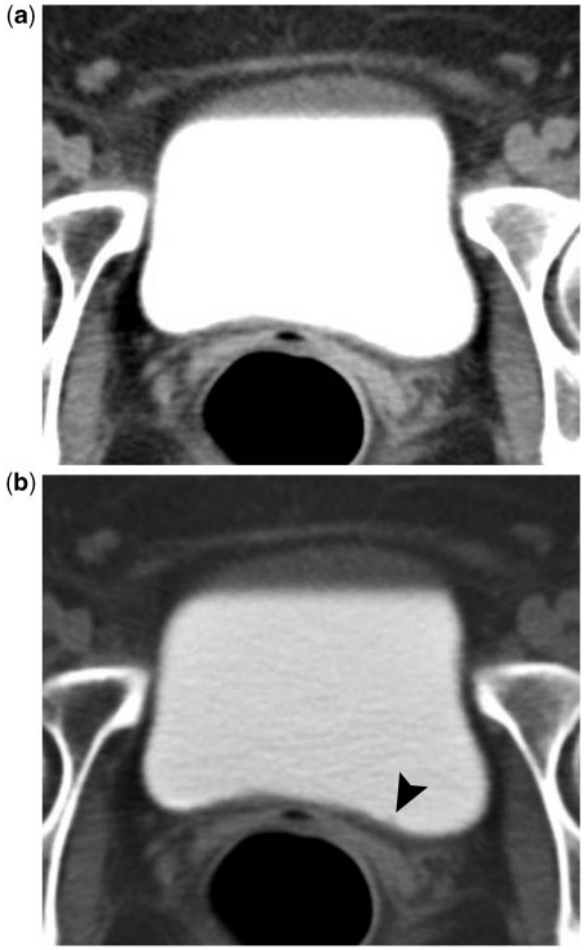

Figure 2 **(a) A 61-year-old woman with hematuria. Axial image from the excretory phase of a CT urogram (window level 50, window width 350) supplemented with IV normal saline demonstrates a distended bladder with dense contrast material layering dependently. No mass is visible. (b) Same image viewed with a wider windowing (window level 50, window width 630) demonstrates a 2-mm papillary urothelial carcinoma (arrowhead) that was obscured using soft tissue windows.**

distension of the upper urinary tracts and bladder during excretory phase imaging.

An underdistended bladder can appear thickened, particularly along its anterior wall, and mimic bladder cancer (Fig. 1). Since the specific gravity of contrast medium is higher than urine, incomplete mixing of unopacified urine and contrast material often results in a urine contrast level. Furosemide increases urinary flow rate, thereby increasing both distention and mixing of the contrast material, the latter likely via an increased ureteral jet phenomenon[11]. Others have used a log-rolling technique to promote mixing of contrast material and urine in the bladder[3]. Wide window settings may be required, particularly if CTU is not supplemented with furosemide, as dense contrast material may obscure small urothelial masses[12] (Fig. 2).

Normal anatomy

The distended bladder has a round or oval form with a peritoneum-covered dome. The remaining surfaces of the bladder abut the extraperitoneal space. The apex of the bladder, connected to the umbilicus by the urachus during embryologic development, is directed anterosuperiorly; the bladder neck is positioned inferiorly. A prominent urachal remnant may cause focal nodularity at the anterosuperior aspect of the bladder and mimic a mass (Fig. 3). This pitfall may be avoided by noting that the

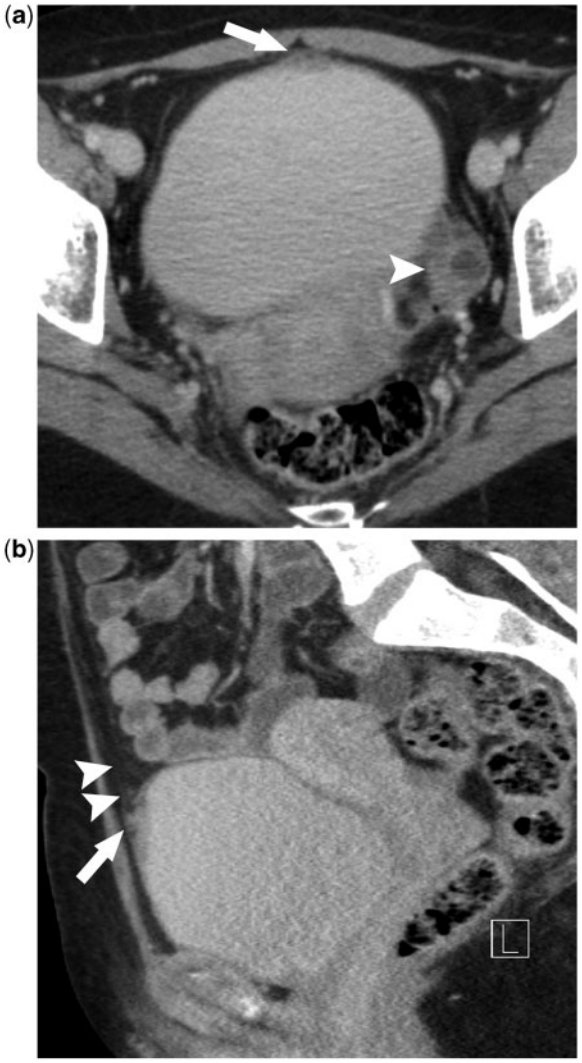

Figure 3 **(a) A 31-year-old woman with hematuria and a prominent urachal remnant. Axial image from the excretory phase of a CT urogram demonstrates focal thickening of the anterior bladder wall in the midline (arrow). Physiologic changes are seen in the left ovary (arrowhead). (b) Sagittal image from the excretory phase of a CT urogram demonstrates thickening limited to the serosal surface of the bladder wall (arrow). Also note a thin linear remnant extends from the bladder dome to the umbilicus (arrowheads). The urine analysis was normal 2 years after the examination, and no cause for the patient's hematuria was found.**

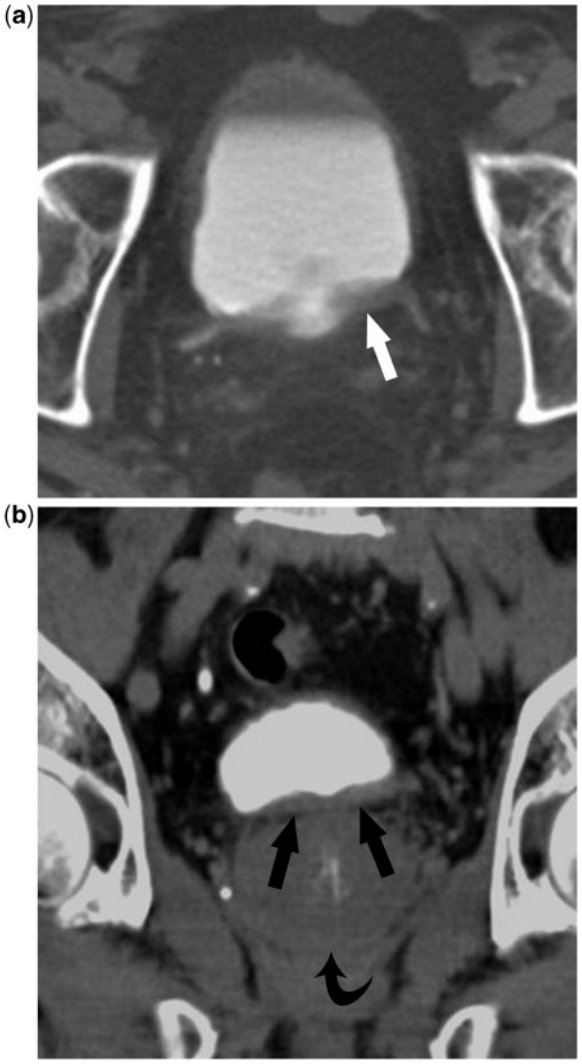

Figure 4 **(a) An 84-year-old man with a history of bladder cancer and normal CT urogram. Axial image from the excretory phase of a CT urogram shows apparent thickening of a normal left ureterovesical junction (UVJ) (arrow). (b) Coronal reformations demonstrate normal symmetric appearance of the bilateral ureterovesical junctions (arrows). Note the enlarged prostate gland (curved arrow).**

thickening is limited to the serosal side of the bladder, midline, and is contiguous with the fibrous urachal remnant (the median umbilical ligament) extending anterosuperiorly towards the umbilicus.

The internal urethral orifice is located at the bladder neck at the inferior angle of the trigone. The ureters traverse a short, oblique, intramuscular course before opening at the posterolateral angles of the trigone at the ureterovesical junction (UVJ). The intramural ureter may appear to protrude into the bladder lumen, and can simulate a bladder mass depending on the location of the UVJ, the angle at which the ureter inserts, and the imaging plane (Fig. 4). A tumor can often be excluded by noting that the bulge is subtle, located at the UVJ, and bilateral, with symmetry in at least one imaging plane. In contradistinction, cancers at the UVJ (Fig. 5) typically cause more mass effect. However, benign processes such as post-operative changes

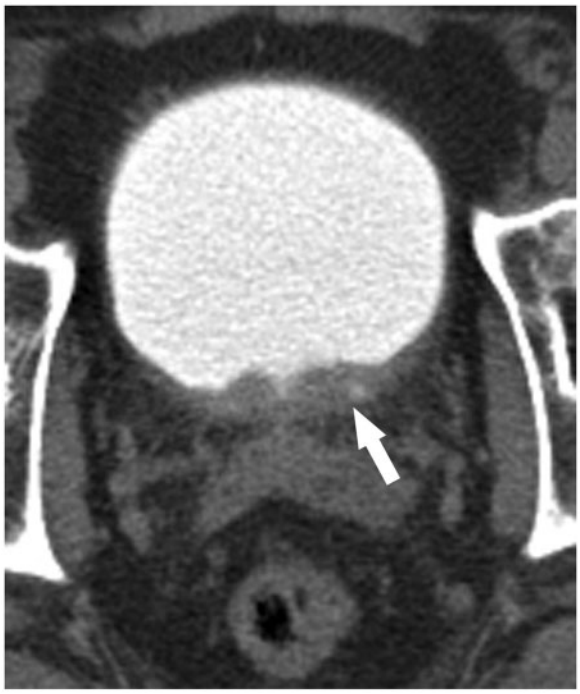

Figure 5 **A 50-year-old man with hematuria. Axial image from the excretory phase of a CT urogram shows mild asymmetric thickening of the left UVJ (arrow). Cystoscopic biopsy demonstrated urothelial carcinoma.**

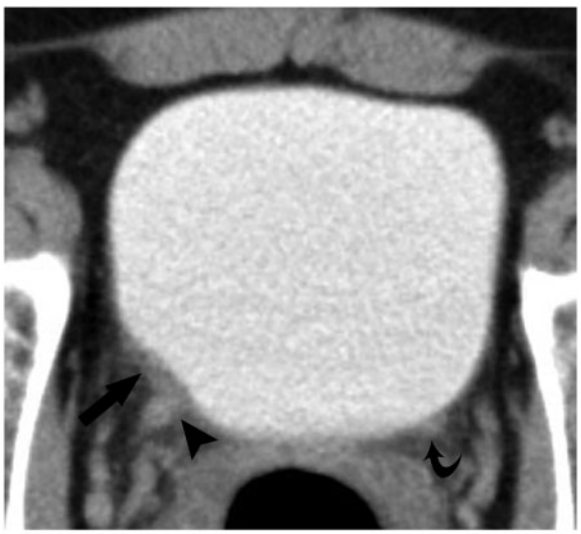

Figure 6 **A 71-year-old man with a history of resected bladder cancer. Axial image from the excretory phase of a CT urogram demonstrates focal wall thickening (arrow) just anterolateral to the right UVJ (arrowhead), at the site of the previous resection. Urine cytology was negative, and cystoscopic biopsy demonstrated postoperative inflammatory changes. Note the normal left UVJ (curved arrow).**

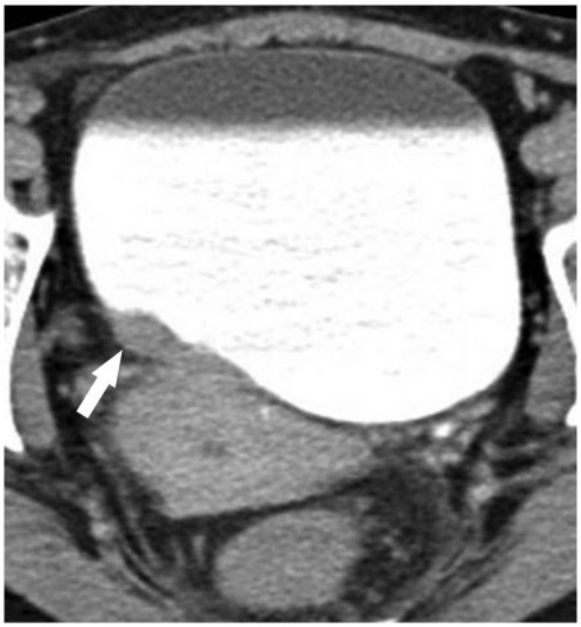

Figure 7 **A 53-year-old woman with endometriosis. Axial image from the excretory phase of a CT urogram demonstrates focal mass-like wall thickening just superolateral to the right UVJ (arrow). Cystoscopic biopsy demonstrated endometriosis.**

(Fig. 6) and endometriosis (Fig. 7) can be mass-like and mimic cancer.

Inflammatory processes

Several inflammatory and infectious processes, such as hemorrhagic cystitis (Fig. 8), schistosomiasis, tuberculosis, and radiation-induced cystitis generally cause diffuse, symmetric bladder wall thickening[13]. Bladder cancer only rarely causes diffuse symmetric bladder wall thickening[14]. Diffuse or multifocal bladder cancer typically causes asymmetric, multifocal wall thickening (Fig. 9). Rarely, inflammatory conditions such as cystitis glandularis (Fig. 10) and endometriosis (Fig. 7) can cause focal bladder wall thickening and mimic cancer. Calcifications not associated with a mass or focal thickening (Fig. 11), and those associated with diffuse wall thickening are likely benign. However, urothelial carcinoma may calcify (Fig. 12), and therefore cancer should be suspected when calcification is associated with a mass.

Treatment effects

In patients with a history of bladder cancer, prior surgical treatment may cause focal wall thickening and abnormal enhancement that may be indistinguishable from recurrent tumor, even at cystoscopy[14] (Figs. 6, 13, 14).

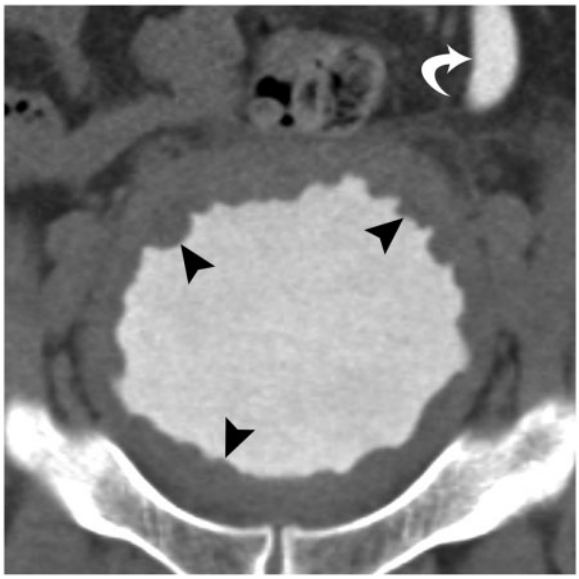

Figure 8 **A 55-year-old man with gross hematuria. Coronal image from the excretory phase of a CT urogram shows diffuse bladder wall thickening with irregularity of the urothelial surface (arrowheads). Cystoscopy revealed severe hemorrhagic cystitis. The left ureter (curved arrow) is mildly obstructed due to the thickened wall.**

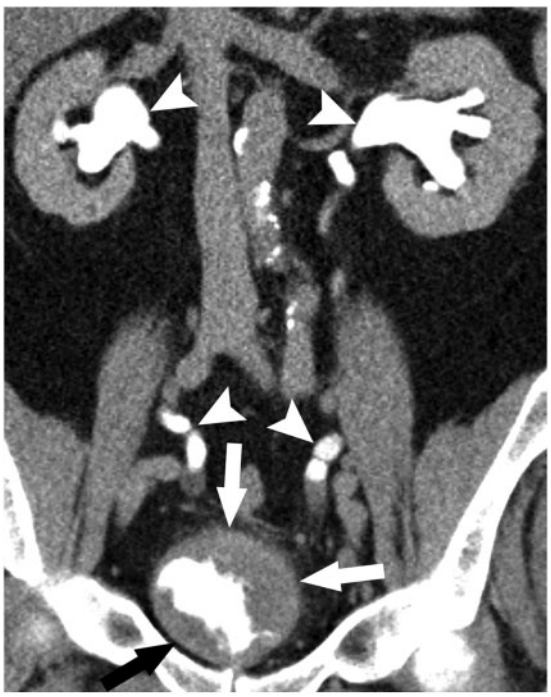

Figure 9 **A 53-year-old man with gross hematuria and urothelial carcinoma. Coronal image from the excretory phase of a CT urogram demonstrates multifocal nodular wall thickening (arrows) involving most of the bladder, and causing bilateral hydronephrosis and hydroureter (arrowheads). Cystoscopic biopsy revealed urothelial carcinoma. Surgical pathology at cystectomy revealed multifocal high grade urothelial carcinoma.**

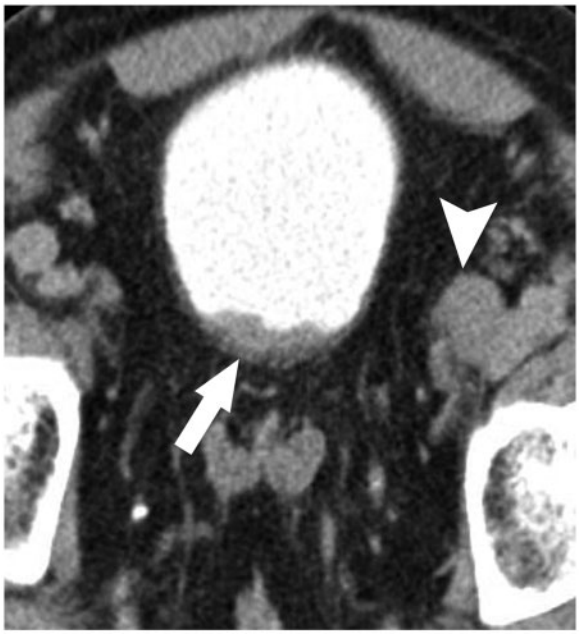

Figure 10 **A 75-year-old man with hematuria. Axial image from the excretory phase of a CT urogram shows focal thickening of the posterior bladder wall (arrow), and an enlarged left external iliac lymph node (arrowhead). Cystoscopic biopsy revealed cystitis glandularis.**

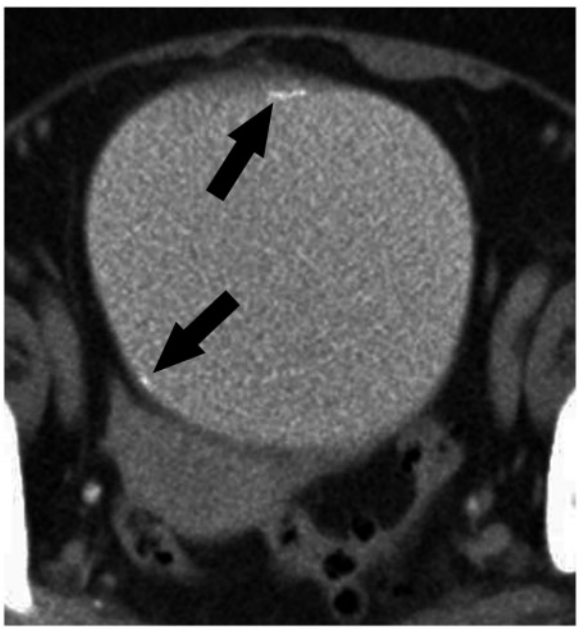

Figure 11 **A 75-year-old woman with a history of bladder cancer treated with intravesical Bacillus Calmette-Guérin (BCG). Axial image from the excretory phase of a CT urogram demonstrates foci of bladder wall calcification (arrows) without associated mass or wall thickening. Multiple other similar foci were present. Biopsy revealed chronic inflammation and granulomas at all sites, related to prior BCG treatment.**

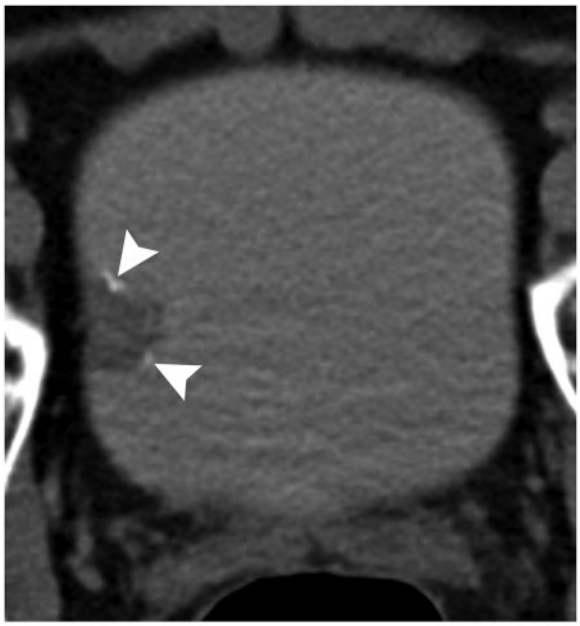

Figure 12 **A 57-year-old man with hematuria and urothelial carcinoma of the bladder. Axial image from the excretory phase of a CT urogram shows a mass along the right lateral bladder wall with calcifications (arrowheads). Cystoscopic biopsy revealed urothelial carcinoma.**

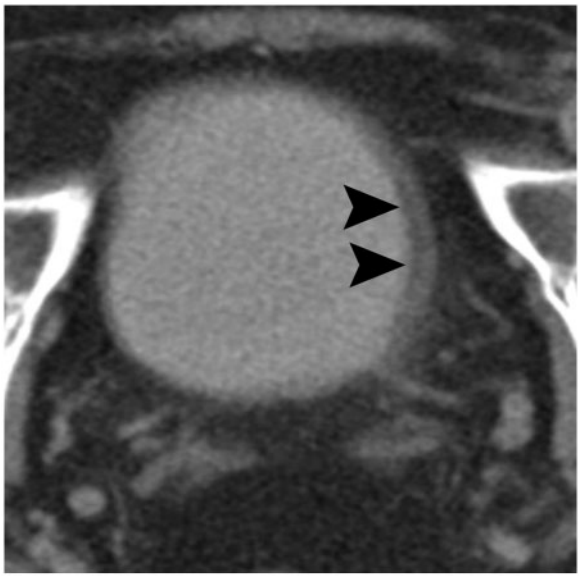

Figure 14 **A 62-year-old man with a history of resected bladder cancer. Axial image from the excretory phase of a CT urogram demonstrates focal bladder wall thickening along the left lateral wall (arrowheads), at the site of previous resection. Cystoscopy revealed no evidence of malignancy.**

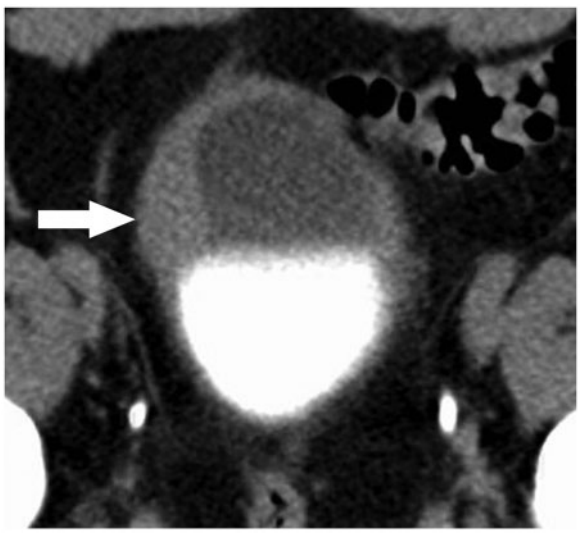

Figure 13 **A 56-year-old man with hematuria 6 weeks following transurethral resection of superficial bladder cancer. Axial image from the excretory phase of a CT urogram shows focal wall thickening at the site of prior resection (arrow). Cystoscopic biopsy and urine cytology revealed no evidence of residual malignancy.**

Patients who have received intravesical immunotherapy with Bacillus Calmette-Guérin (BCG) may develop granulomatous changes in the bladder wall, mimicking bladder cancer[15] (Fig. 12). As above, radiation therapy can cause diffuse bladder wall thickening due to cystitis. Knowledge of past history and the presence of radiation-induced changes in nearby small bowel loops can help reach the diagnosis.

Blood clot

Blood clots can simulate bladder neoplasms, however, they are typically odd-shaped or linear, smoothly marginated; they do not enhance. Also, they are luminal findings, and multiplanar reformations can be used to demonstrate that they do not arise from the bladder mucosa (Fig. 15). Cystoscopy may be needed to distinguish clots that abut or adhere to the bladder wall, from urothelial cancer (Fig. 16).

Enlarged prostate gland

Benign prostatic hyperplasia (BPH) can cause bladder outlet obstruction and bladder wall thickening due to detrusor muscle hypertrophy (Fig. 17). Both BPH (Fig. 18) and prostate cancer (Fig. 19) can cause protrusion of nodular, mass-like tissue into the bladder at its

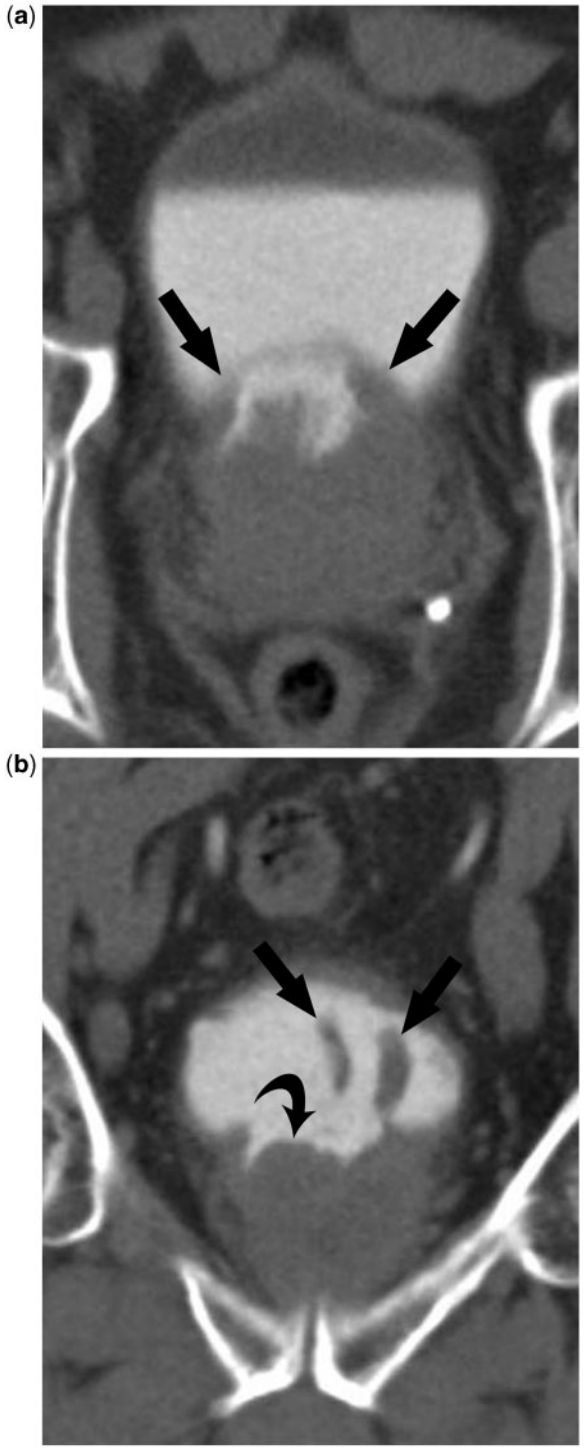

Figure 15 **(a) A 74-year-old man with hematuria. Axial image from the excretory phase of a CT urogram shows irregular soft tissue at the bladder base, projecting into the bladder lumen (arrows). (b) Coronal reformations demonstrate linear structures in the bladder lumen without attachment to the bladder mucosa (arrows). Also note nodular enlarged prostate gland indenting the bladder base (curved arrow). Cystoscopy demonstrated blood clots without bladder cancer.**

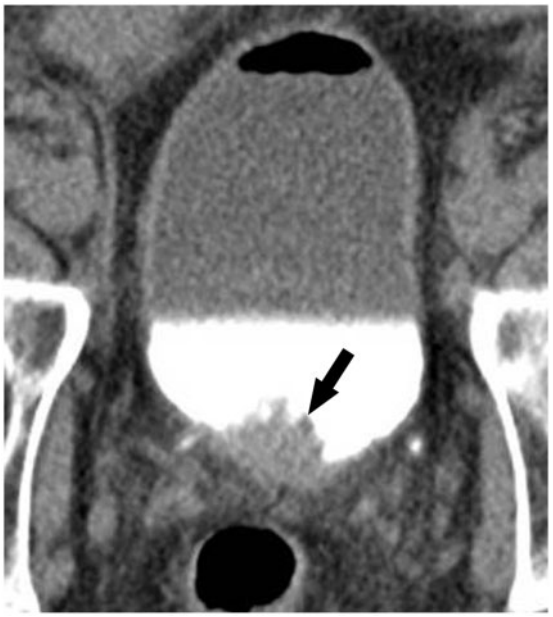

Figure 16 **A 77-year-old man with hematuria. Axial image from the excretory phase of a CT urogram shows an apparent papillary mass at the bladder base (arrow), concerning for bladder cancer. Cystoscopy revealed a blood clot adherent to the bladder wall, without evidence of bladder cancer.**

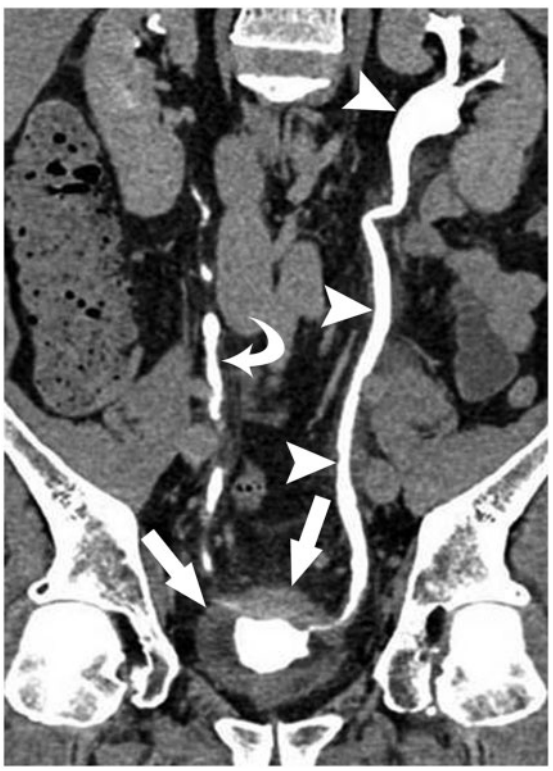

Figure 17 **An 83-year-old man with a prolonged history of urinary frequency, urgency and dysuria secondary to benign prostatic hyperplasia. Severe diffuse symmetric bladder wall thickening (arrows) due to detrusor muscle hypertrophy is mildly obstructive, manifested as mild left hydroureteronephrosis (arrowheads) and mild right hydroureter (curved arrow).**

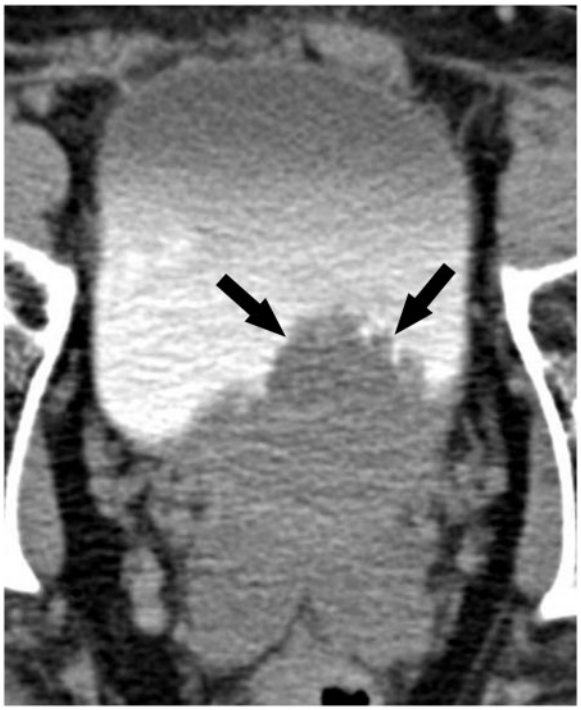

Figure 18 **A 76-year-old man with urinary frequency, urgency and dysuria. Axial image from the excretory phase of a CT urogram shows papillary-appearing soft tissue at the bladder base (arrows). Cystoscopy revealed benign prostatic hyperplasia with prostatic tissue protruding into the bladder lumen.**

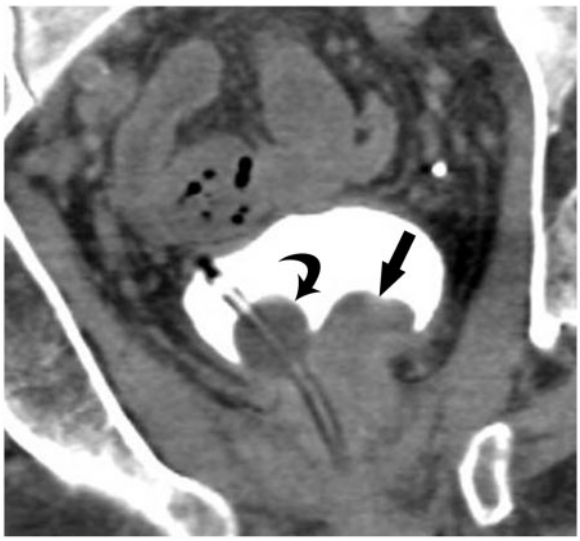

Figure 19 **An 87-year-old man with urinary frequency, urgency, and dysuria. Coronal image from the excretory phase of a CT urogram shows a smooth nodular soft tissue mass contiguous with prostate, projecting into the bladder base (arrow) to the left of a urinary catheter (curved arrow). Histopathology revealed prostate cancer.**

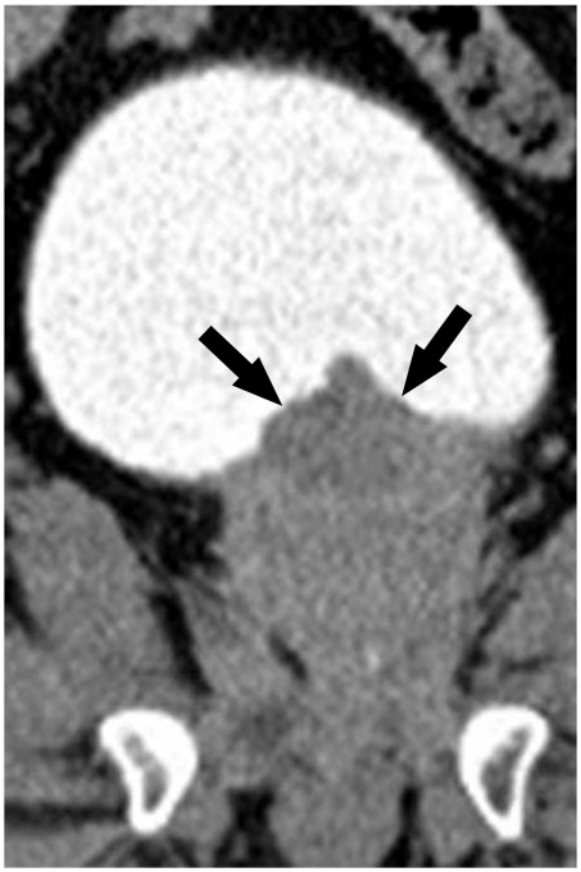

Figure 20 **An 81-year-old man with urinary frequency, urgency and dysuria. Coronal image from the excretory phase of a CT urogram shows an apparent mass (arrows) at the bladder base inseparable from the prostate gland. Cystoscopic biopsy revealed a urothelial carcinoma at the bladder base.**

base[16]. This nodular tissue may be asymmetric, and can have either a smooth or an irregular surface. Distinguishing a bladder base cancer from an enlarged prostate gland therefore may be difficult with excretory phase imaging, even using coronal reformations[14] (Fig. 20). Since urothelial cancers are typically hypervascular, bladder base urothelial cancers can be differentiated from the prostate gland when the pelvis is examined 70 s after the injection of IV contrast material, when the bladder is distended with unopacified urine[8,9]. However, addition of these images to the CTU protocol described above would increase the radiation dose of the examination.

CTU is emerging as a method that can be used to diagnose bladder cancer[6–9]. Knowledge of normal anatomy and benign conditions that mimic neoplastic disease will help reduce the number of false-positive CT urograms. Although cystoscopy will be needed to differentiate benign from malignant bladder processes in some situations, continued experience with CTU and

knowledge of the appearance of benign conditions will help limit the number of patients needing further investigation.

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