Upper Tract Oncologic Imaging

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Vandan Caur, Nathalie Ibrahim, Yulia Lakhman, and Scott Gerst

Urothelial tumors involving the renal pelvis and ureter are relatively uncommon and account for approximately 5 % of all urological malignancies [1]. The vast majority (90 %) are transitional cell carcinoma (TCC) and most arise in the renal pelvis; 9 % are squamous cell carcinoma and 1 % are mucinous adenocarcinoma [2]. Most upper tract urothelial tumors occur in the sixth to seventh decade of life and are seen three times more frequently in men than in women, with a ratio of 3:1 [3].

TCC within the renal pelvis occurs most commonly in the extrarenal part of the pelvis, followed by the infundibulocaliceal region [4]. Within the ureter, the highest incidence is in the distal ureter with decreasing incidence proximally, with a ratio of 70:20:10 for the distal, mid, and proximal ureter, respectively [5].

Several factors contribute to the development of upper urinary tract TCC and are very similar to those for bladder cancer. The most important factor is smoking, which accounts for a two to three times increased likelihood of developing TCC than in nonsmokers [4]. Other factors include environmental exposure to substances, including phenacetin, chemical carcinogens (aniline, benzidine), cyclophosphamide, and Balkan nephropathy [4, 6, 7].

In the case of adenocarcinoma and squamous cell carcinoma, chronic infection, inflammation, obstruction, and stones are associated with increased risk [8, 9].

Presentation

Similar to its presentation in the bladder, upper urothelial tumors most commonly present with hematuria, either frank or microscopic. Other presenting symptoms include dull flank pain or acute renal colic due to obstruction.

Tumor spread occurs by local extension, hematogenous, or lymphatic invasion. Pelvis and upper ureteral TCC initially spread via the paraaortic and pericaval lymph nodes, with distal ureteral TCC spread to pelvic nodes. The most common sites of distant metastases, in decreasing order of frequency, are lung, bone, and liver.

Bilateral upper tract tumor involvement occurs in 2–4 % of upper tract TCC [10]. Furthermore, recurrence at additional ipsilateral sites occurs in approximately 40 % (range, 20–70 %), necessitating cautious urological and radiological follow-up [11].

Staging

Radiological evaluation, in conjunction with ureteroscopy and biopsy, are essential tools for clinical staging. The TNM (tumor, node, metastasis) staging supported by the American Joint Committee on Cancer (AJCC) is most frequently used for pathological staging of upper tract tumors (*see* Table 2.1 and 2.2) [12]. This system only applies to carcinomas and papillomas; nonepithelial or metastatic tumors are excluded.

Many studies have demonstrated strong correlation between survival and tumor stage, grade, and multifocality,

V. Caur, M.D.
Wirral University Teaching Hospitals NHS Foundation Trust,
Arrowe park road, Wirral, CH49 5PE, UK
e-mail: v.arora@nhs.net

S. Gerst, M.D. (✉)
Department of Radiology, Memorial Sloan-Kettering Cancer Center,
1275 York Avenue, New York, NY, 10065, USA
e-mail: gersts@mskcc.org

N. Ibrahim, M.D.
Radiology Department, McGill University Health Center,
Montreal, QC, Canada
e-mail: natibrahim@yahoo.com

Y. Lakhman, M.D.
Department of Radiology, Memorial Sloan-Kettering Cancer Center,
303 East 66 Street, Room 703, New York, NY, 10065, USA
e-mail: lakhmany@mskcc.org

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Table 2.1 TNM staging system for cancer of renal pelvis and ureter [12]

Primary Tumor (T)
Tx: Primary tumor cannot be assessed
T0: No evidence of primary tumor
Ta: Noninvasive papillary carcinoma
Tis: Carcinoma in situ
T1: Tumor invades subepithelial connective tissue
T2 : Tumor invades muscularis
T3 (renal pelvis only): Tumor invades beyond muscularis into peripelvic fat or the renal parenchyma
T3 (ureter only): Tumor invades beyond the muscularis into periureteric fat
T4: Tumor invades adjacent organs or through the kidney into perinephric fat
Regional Lymph Nodes (N)[a]
Nx: Regional lymph nodes cannot be assessed
N0: No Regional lymph node metastasis
N1: Metastasis in a single lymph node, 2 cm or less in greatest dimension
N2: Metastasis in a single lymph node, more than 2 cm but not more than 5 cm in greatest dimension; or multiple lymph nodes, none more than 5 cm in greatest dimension
N3: Metastasis in a lymph node more than 5 cm in greatest dimension
Distant Metastasis (M)
Mx: Distant metastasis cannot be assessed
M0: No distant metastasis
M1: Distant metastasis

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[a]Laterality does not affect the N classification

Table 2.2 Anatomic staging and prognostic groups [12]

	Stage grouping		
Stage 0a	Ta	N0	M0
Stage 0is	Tis	N0	M0
Stage I	T1	N0	M0
Stage II	T2	N0	M0
Stage III	T3	N0	M0
Stage IV	T4	N0	M0
	Any T	N1	M0
	Any T	N2	M0
	Any T	N3	M0
	Any T	Any N	M1

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with staging being the most important factor [13]. The 5-year survival rate for patients with Ta or T1 disease ranges from 60 to 90 %, decreasing to only 5 % in T3 or T4 disease [14].

Table 2.3 Histologic grading [12]

GX	Grade cannot be assessed
G1	Well differentiated
G2	Moderately differentiated
G3-4	Poorly differentiated or undifferentiated

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Furthermore, the histological grade (*see* Table 2.3) has also demonstrated close correlation with staging (*e.g.*, superficial tumors tend to be of lower grade whereas higher grade tumors have higher propensity to be invasive) [15].

Studies suggest that renal pelvis tumors tend to have better prognosis than ureteral tumors; this is thought to be due to the renal parenchyma acting as a barrier [2, 11].

Treatment and prognosis are largely dependent on the depth of tumor infiltration, the degree of lymph node involvement, metastases, and the histology of the tumor, further emphasizing the need for proper staging.

After the detection of hematuria or diagnosis of suspected upper tract TCC, radiological evaluation is important in detecting and determining tumor extent and stage (*see* Table 2.4). Intravenous urography has been largely replaced by computed tomography urography (CTU), capable of detecting lesions larger than 5 mm [18], as this technique can image the entire urinary tract and provide information on locoregional extension, as well as nodal and distant metastases. However, not all filling defects within the collecting system represent urothelial tumors. Although rare, other malignant lesions such as sarcomas (leiomyosarcoma, Ewing's, liposarcoma, rhabdomyosarcoma) and benign conditions (*e.g.*, blood clot, fungus ball, calculi, sloughed papilla, malakoplakia, tuberculosis, ureteritis cystic, and endometriosis) may present in a similar fashion, making differentiation more challenging, sometimes requiring endoscopy and biopsy for differentiation before treatment.

Magnetic resonance imaging (MRI) urography is not currently considered standard due to its inferior spatial resolution to CT, long scanning time and cost [19]. However, it remains an attractive alternative technique that does not involve ionizing radiation. Currently, MR urography is a noninvasive alternative that has found use predominantly in patients allergic to iodinated contrast media.

Management

Traditionally, organ-confined renal pelvis and proximal upper ureteral disease in patients with otherwise normal contralateral kidney has required radical nephroureterectomy with resection of bladder cuff [20]. There are several reasons for this: the synchronous and metachronous nature of TCC,

Table 2.4 Imaging techniques summary

Evaluation of patient with hematuria and staging
Intravenous urography
Largely replaced by CTU
Examination of choice if CTU not available
Does not provide information about surrounding structures
CT urography
Current standard for minimally invasive imaging
Useful for staging and diagnosis
Allows assessment in multiple planes
Evaluates periureteric and renal infiltration
Evaluates for nodal and distant metastasis
Split bolus technique, with two runs may minimize radiation
Prone positioning, intravenous saline bolus and oral water hydration help maximize ureteral opacification and collecting system distension
Currently, there is no single universal standard CTU protocol. However, for the past 5 years there has been an increasing trend toward CTU techniques with improved ureteral opacification and minimal radiation dose. Radiation dose including cumulative dose from repeated examination is a specific point of consideration when utilizing CT urography in imaging work-up, particularly for younger patients who may undergo repeat follow-up examination. The effective dose for CTU is undeniably higher than that of conventional urography. Nawfel et al. [16] calculated an estimated effective dose of 14.8 mSv for CTU utilizing a single bolus three-phase technique compared to 9.7 mSv for conventional urography. However, Martingano et al. [17] demonstrated that CTU estimated effective dose may reach levels up to 17.1 mSv for nephrographic-excretory phase, but with optimization of radiation a value of 6.2 mSv was obtained.
MR urography (MRU)
Less spatial resolution compared to CTU
Alternative for patients with iodinated contrast allergy
Possible alternative in patients with mild renal insufficiency
Exception: patients with severely impaired renal function, due to potential nephrogenic systemic fibrosis (NSF)
Patients must be able to be exposed to the magnetic field without contraindications
Pyelography
Anterograde: Rarely performed when CTU is inconclusive for evaluation of renal pelvis because of theoretical risk of tumor seeding
Retrograde: Indicated if poor renal function, contrast allergy or partial or incomplete visualization of the collecting system, however even then, MRU may prove a superior alternative when not contraindicated.
Representative CTU protocol and technical factors
IV injection:
Saline 2.5 mL/s for 200 mL
Contrast 2.5 mL/s for 150 mL (*e.g.,* iohexol 300), followed by saline 2.5 mL/s 200 mL
Oral contrast:
400 mL H_2O 20 min before scan
Precontrast, parenchymal phase and excretion phase imaging:
Injection to scan delay: parenchymal phase 80 s; excretion phase: 12 min
Scan coverage:
Precontrast: just above kidneys through ischial tuberosity
Parenchymal phase: just above hepatic dome through tuberosity
Excretion phase: same as precontrast
Technical factors:
Exposure:
Precontrast and excretion phases: 0.7 s rotation time; low mA (*e.g.,* 130)
Parenchymal phase: 0.7 s rotation time; auto mA
Pitch/table speed: all phases, 0.984/39.37 mm
Reconstruction thickness: 2.5 × 2.5 mm standard all phases
Reconstruction 2: 1.25 × 1 mm standard
Additional delays:
Only scan targeted 12 min supine and/or 18 min prone, if necessary
Additional delays will be determined by the radiologist, if pathology is suspected
(Abdominal compression: none)
Reformats:
Parenchymal phase:
1.6 × 0.8 mm coronal reformats through kidneys, ureters, and bladder
3D reconstruction: use 1.25 × 1 mm reconstructions from excretion phases to push to workstation

the high tumor recurrence rate (30–50 %) [21] within the ureteral stump when only a nephrectomy is performed, and the low frequency of contralateral lesions (1–5.8 %) [22].

Regional lymphadenectomy is then performed, especially for patients with high-grade tumors; however, the role and extent of routine lymphadenectomy are still to be determined [23].

Segmental ureteral resection with anastomosis or ureteroneocystostomy for proximal or midureteral tumors and distal ureterectomy for tumors of the distal ureter without evidence of multifocality are feasible options, especially for low-grade, low-stage lesions, and in patients in whom renal function preservation is vital.

There is an increasing trend toward conservative management with recent advances in endoscopic technology and minimally invasive surgery. Such conservative management allowing for renal function preservation is generally accepted for patients with low-grade tumor, solitary kidney, bilateral disease, poor renal function, or comorbidities precluding open surgery [24].

Despite no accepted protocol for radiological follow-up, endoscopic and cytological surveillance for upper urinary tract TCC is essential, irrespective of the surgical procedure employed, to detect local recurrence.

Due to its rarity, recommendation on topical chemotherapy, immunotherapy, and neoadjuvant systemic chemotherapy of upper tract disease extrapolates from the management of lower urothelial tract tumors. Controversy still exists on the role of radiotherapy and chemotherapy in reducing tumor recurrence and lengthening survival, and further confirmation in randomized multicenter trials is needed to ensure efficacy [25].

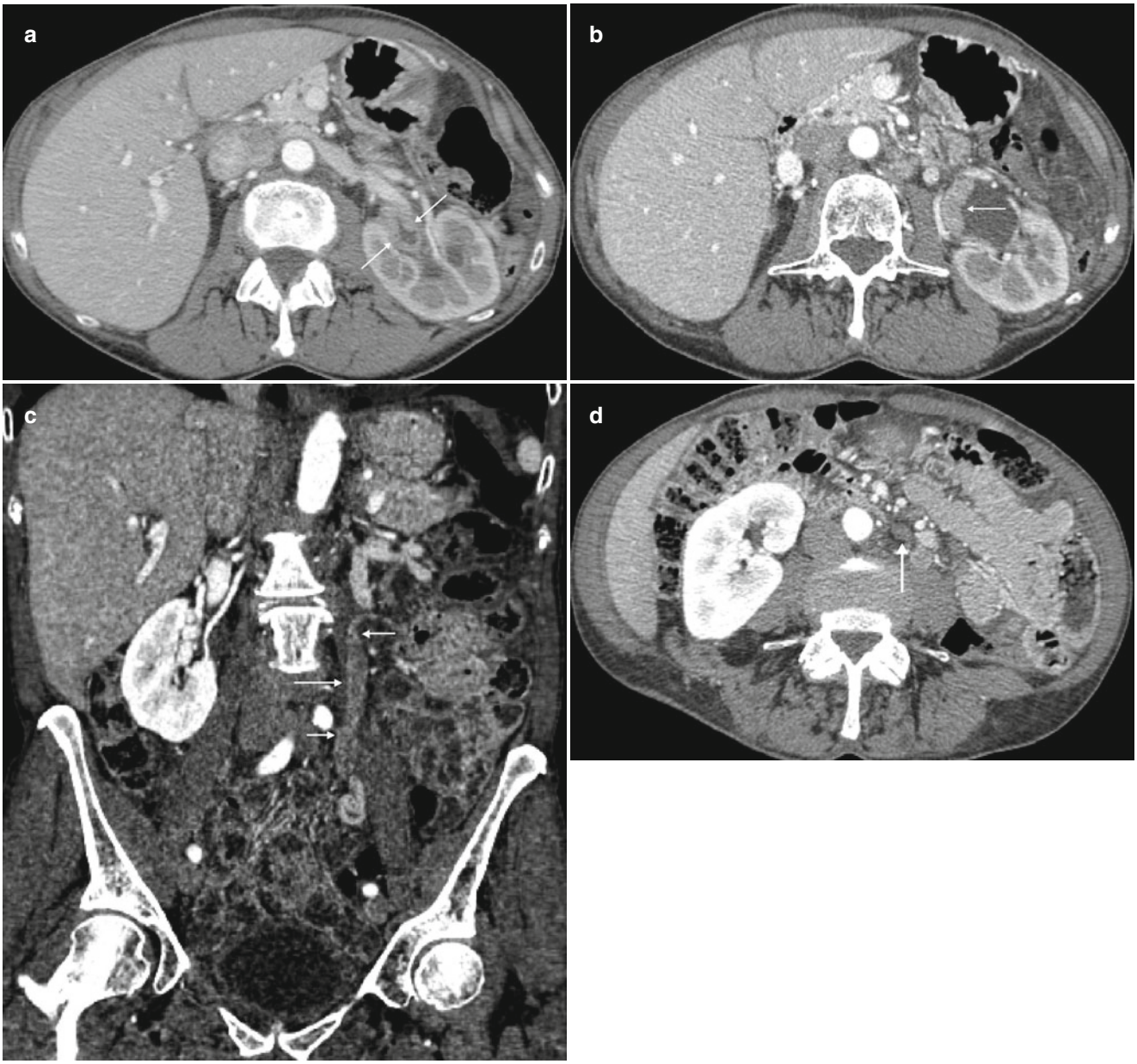


Fig. 2.1 A 68-year-old woman with a history of hematuria with bladder cancer after transurethral resection of bladder tumor (TURBT). CTU demonstrated extensive upper tract tumor and borderline enlarged retroperitoneal lymph nodes. T1 papillary involving the lamina without muscularis invasion was confirmed by histopathologic analysis. (**a**) Axial parenchymal phase images showed multifocal enhancing tumor within the left renal pelvis (*arrows*), as well as involving the upper moiety and upper ureter with moderate hydronephrosis. (**b**) Axial parenchymal phase images at a lower level show eccentric thickening (*arrow*) along the ureteropelvic junction. (**c**) Coronal multiplanar reformatted (MPR) showing the extent of urothelial tumor involving the left ureter (*arrows*) in this patient who also had a delayed nephrogram. (**d**) Axial parenchymal phase images at the level inferior to the left lower pole show prominent, borderline-enlarged para-aortic nodes (*arrow*). Node-positive tumors of the renal pelvis can involve upper retroperitoneal nodes (retrocrural, suprahilar, paracaval, paraaortic, and interaortocaval) and extend caudally to the external iliac lymph nodes. Node-positive tumors of the middle and lower third of the ureter can involve both the retroperitoneal and pelvic lymph nodes. Lymph node metastases have consistently been associated with an adverse prognosis [23]

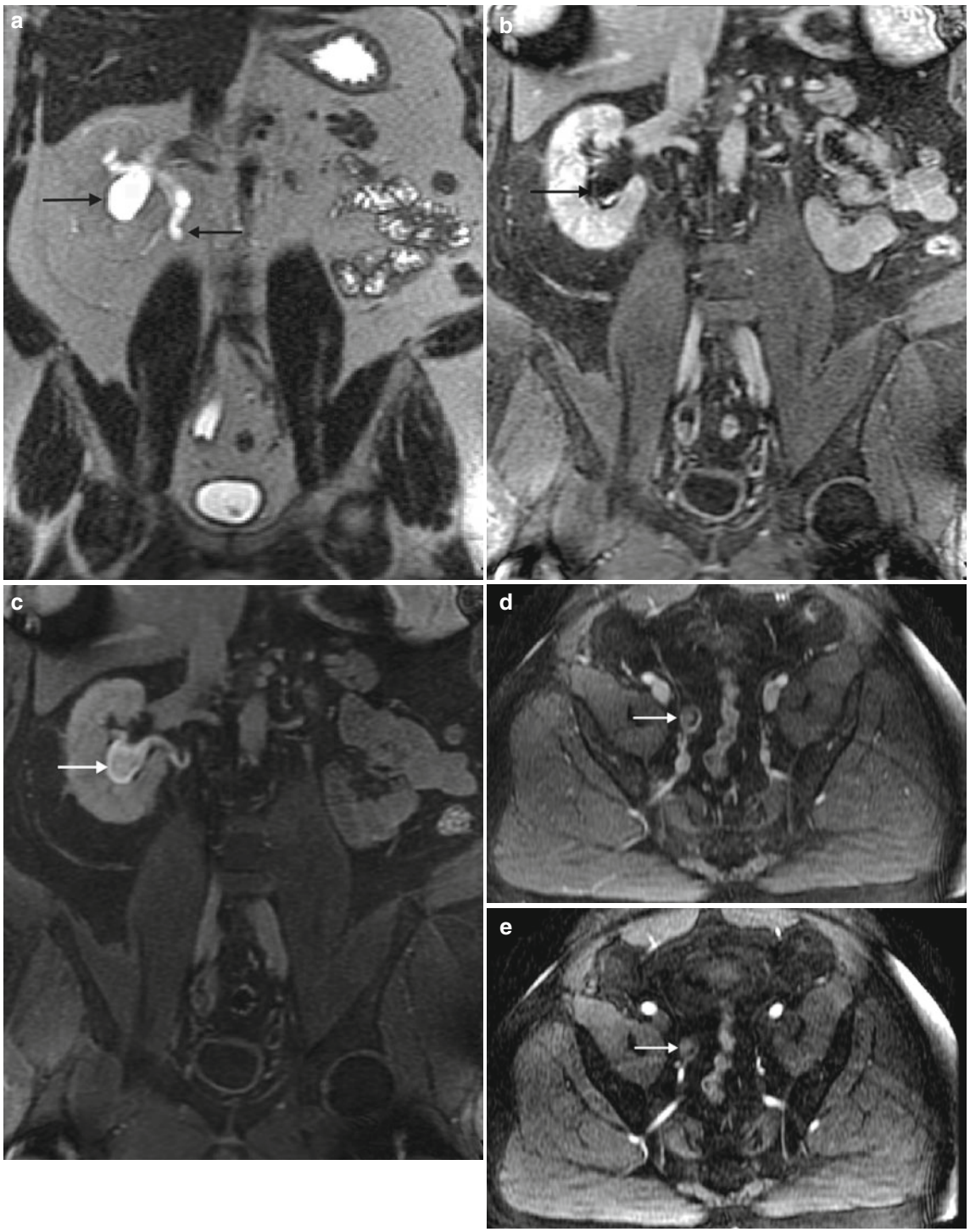


Fig. 2.2 A 55-year-old man with history of low-grade TCC involving the bladder and left upper tract after TURBT and left nephroureterectomy. Routine follow-up MRU revealed new right hydroureteronephrosis and lobulated enhancing lesion obliterating the distal ureteral lumen. Although ureteral washings at time of placement of JJ stent were negative for malignant cells, histopathology from subsequent right distal ureterectomy confirmed noninvasive urothelial carcinoma. (**a**) Coronal T2 image shows dilated renal collecting system and proximal hydroureter (*arrows*) or a variant of "champagne glass sign" related to more distal ureteral disease. Coronal, postintravenous, gadolinium-enhanced early (**b**) and excretory phase (**c**) imaging demonstrates a dilated lower pole moiety with confirmed nonenhancing filling defect consistent with debris (*arrow*). (**d**) Axial T1 fat-saturated postintravenous gadolinium images show distal ureteral enhancing tumor (*arrow*). (**e**) Distal ureteral tumor confirmed on subtraction images (*arrow*). Patients with a history of lower or upper tract urothelial carcinoma are at high risk of developing synchronous or metachronous urothelial carcinoma in the upper tract. MRU is a promising alternative for CTU in the evaluation of upper tract urothelial carcinoma, especially when the patient has a contraindication to iodinated contrast material. When the lesions are obstructive, MRU can detect upper tract urothelial carcinoma with an accuracy of 88 % or higher using gadolinium-enhanced pyelographic phase or T2-weighted single-shot fast spin-echo MRU but has a limited role in accurately staging low-volume tumor (Ta, T1, T2), which may be important in deciding the treatment option (nephroureterectomy versus endoscopic treatment) [26]

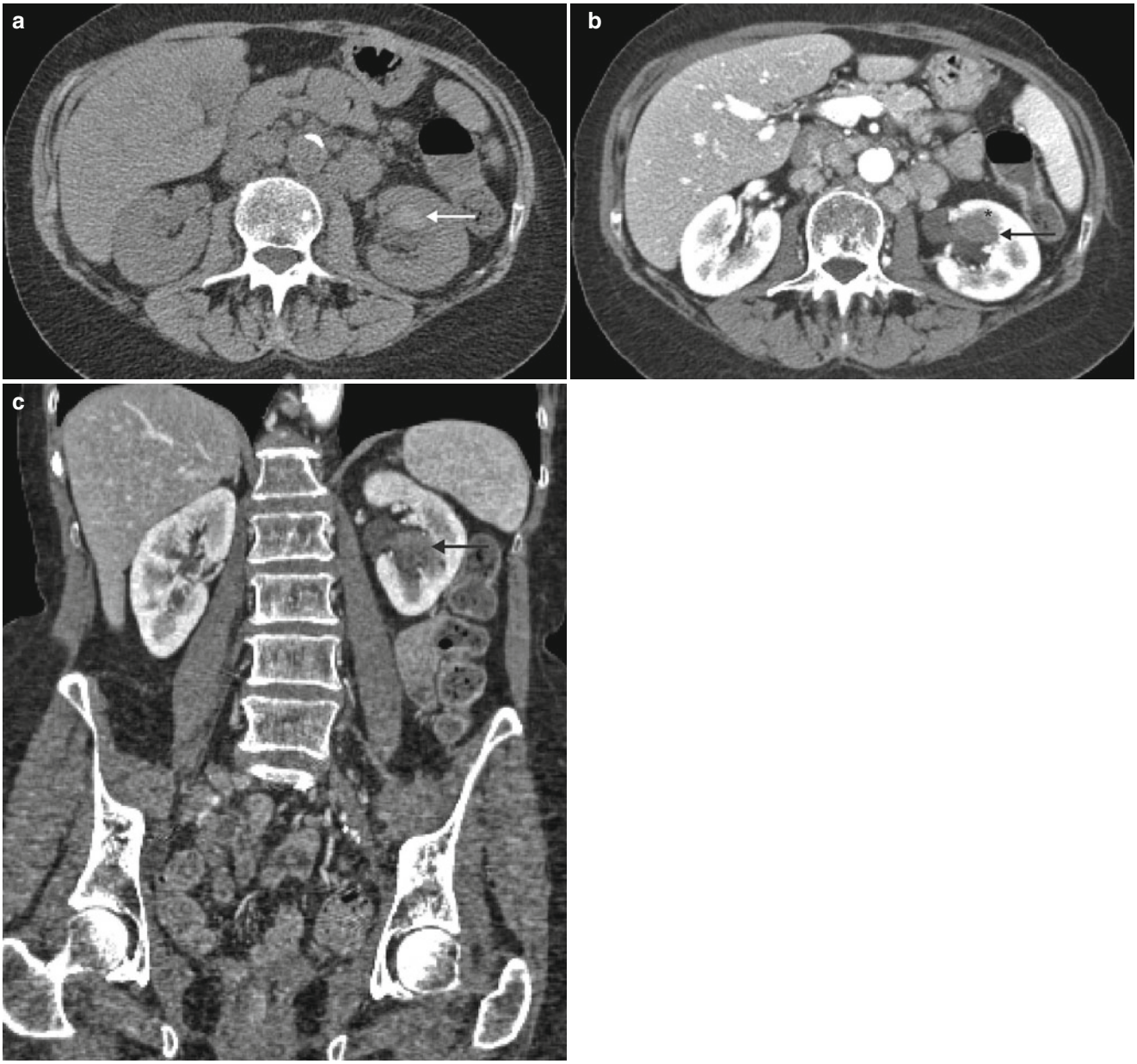
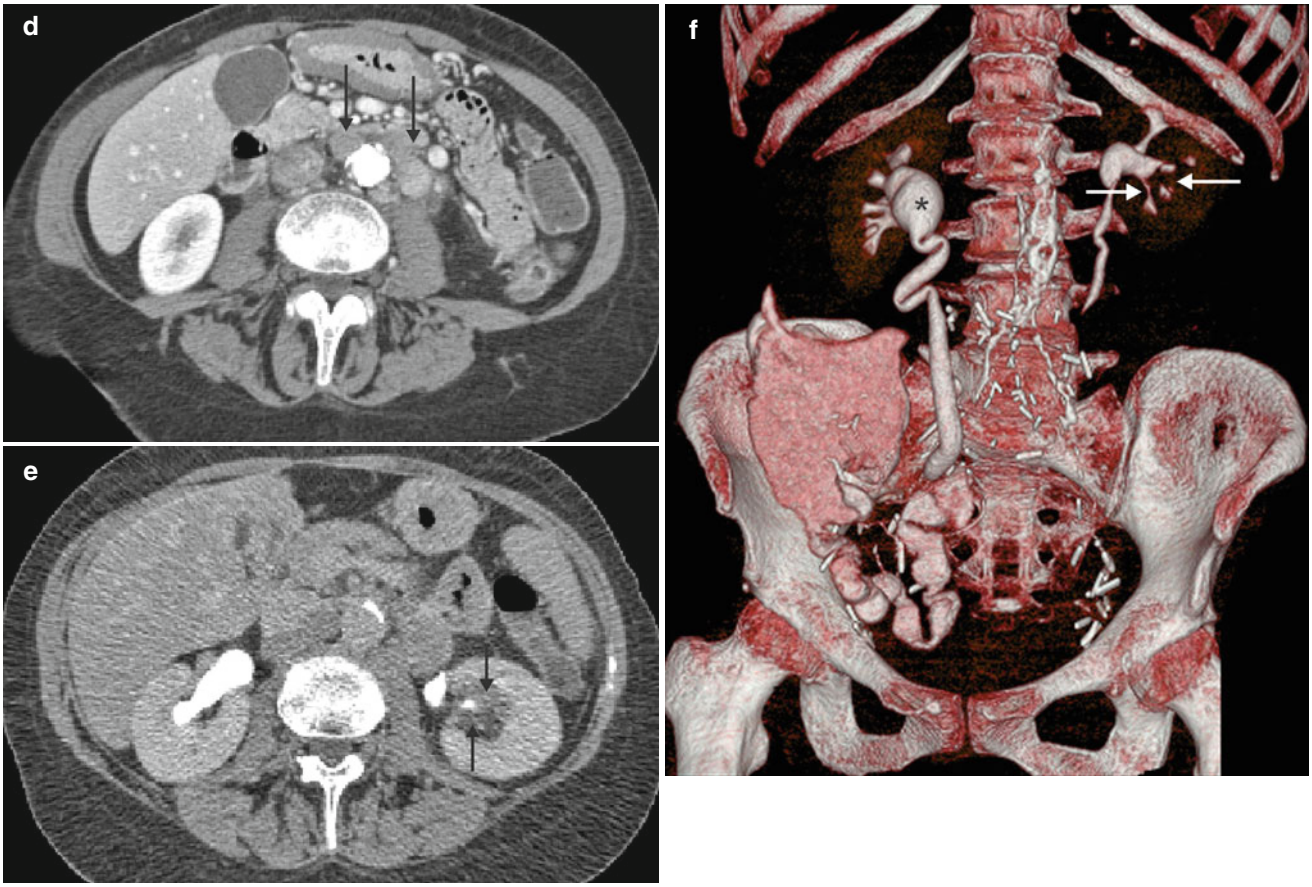


Fig. 2.3 A 69-year-old woman with history of pT3N2 bladder cancer after neoadjuvant chemotherapy and radical cystectomy found to have renal mass and adenopathy on routine follow-up CTU. The patient was managed with adjuvant chemotherapy. (**a**) Axial precontrast images show a hyperattenuating mass (*arrow*) in the anterior lower pole calyx of the left kidney. (**b**) Axial parenchymal phase images show enhancing lower pole mass (*arrow*) with extension into the adjacent renal parenchyma (*asterisk*). (**c**) Coronal maximum intensity projection (MIP) images show tumor filling the lower moiety and mild distortion of the collecting system. (**d**) Axial corticomedullary phase image shows paraaortic adenopathy (*arrows*). (**e**) Axial excretory phase image shows diffuse tumor (*arrows*) with a small amount of excreted contrast centrally. (**f**) Volumetric three-dimensional (3D) excretory phase reconstruction shows truncation, narrowing, and distortion of the left lower and mid-lower moiety (*arrows*) in this diverted patient. Note mild fullness of the right collecting system, which is often seen in diverted patients. The renal contour is preserved. On precontrast images, TCC is typically hyperattenuating (5–30 HU) to urine and renal parenchyma but less attenuating than other pelvic filling defects such as clot (40–80 HU) or calculus (100 HU). Advanced TCC extends into the renal parenchyma in an infiltrating pattern that distorts normal architecture. However, reniform shape is typically preserved, unlike in renal cell carcinoma [26]. With urinary diversion procedures, hydroureter and mild pelvicaliectasis are often seen early and may either resolve or remain stable. However, severe pelvicaliectasis implies obstruction from a stricture, stone, or recurrence [27]. all arrows in all images better delineate margins of tumor / important findings for the target audience / reader



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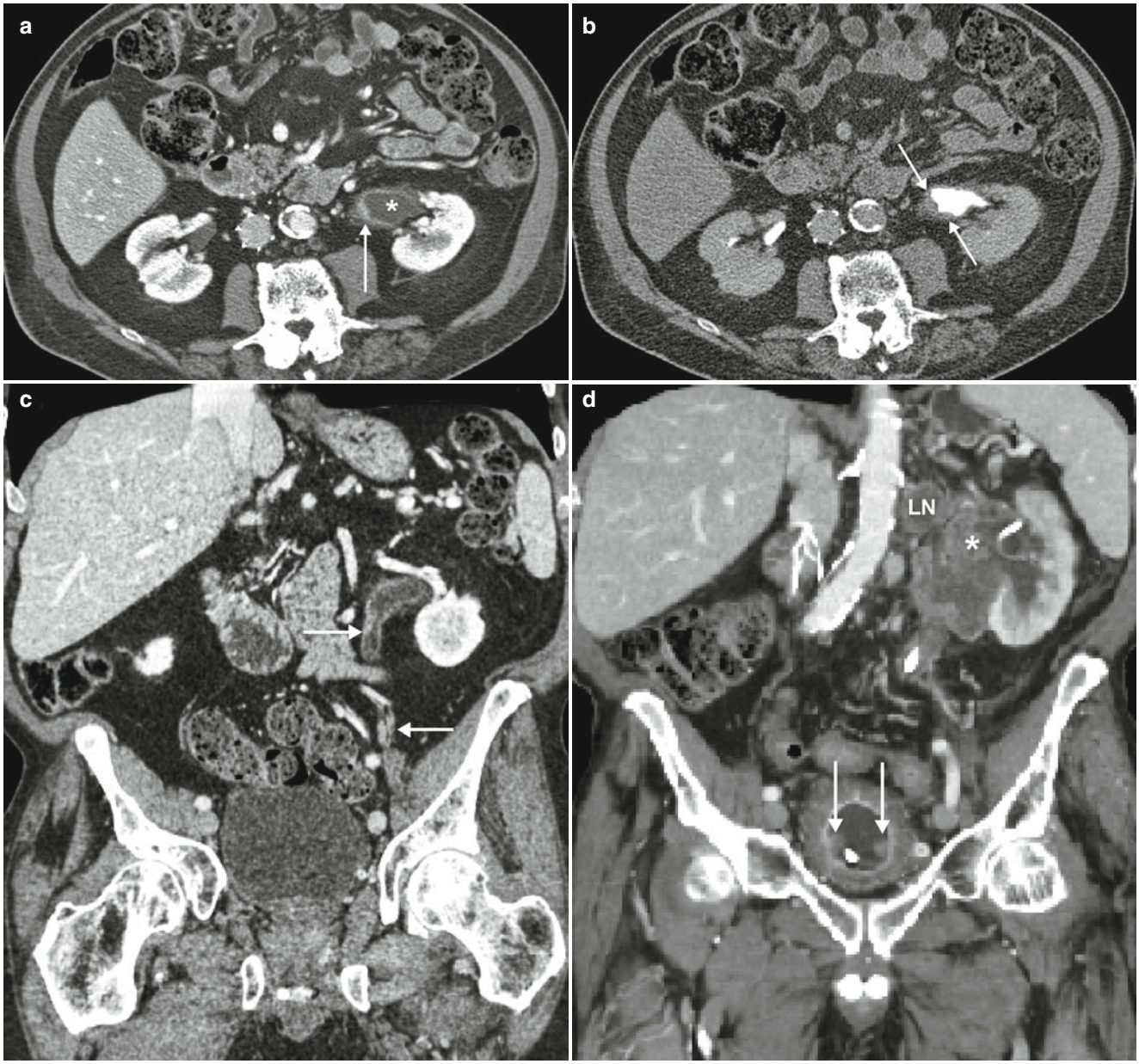


Fig. 2.4 An 83-year-old man with a history of bladder cancer status post-TURBT 20 years prior was found to have incidental hydronephrosis and ureteral thickening on CTU. Ureteroscopic resection and laser fulguration was performed, followed by insertion of a double J stent. Histopathology was positive for invasive pT2 urothelial malignancy; however, there was inability to assess for muscle invasion due to combined superficial biopsy and thermal artifact. Patient subsequently progressed to unresectable disease. (**a**) Axial parenchymal phase images show mild dilation of the left renal pelvis (*asterisk*) with generalized wall-thickening and enhancement most marked at the ureteropelvic junction (*arrow*) and proximal ureter. (**b**) Axial excretory phase images show circumferential wall-thickening most marked at the ureteropelvic junction (*arrows*). (**c**) Coronal MPR parenchymal phase images show the extent of urothelial thickening (*arrows*). Patients with bladder cancer are at lifelong risk for late oncologic recurrence in the upper tract urothelium. Left ureteroscopy and biopsy was positive for high-grade TCC. Tumor progressed to unresectable disease despite laser fulguration. (**d**) Parenchymal phase coronal MIP images show extensive upper tract tumor (*asterisk*), para-aortic adenopathy (*LN*), and circumferential bladder thickening with multifocal polypoid tumor recurrence (*arrows*). Note double J ureteral stent and penile prosthesis in situ. The 3- and 5-year cumulative incidence of upper tract recurrence is 4 and 7 %, respectively [28]. These patients should be monitored with routine upper tract cytology and imaging studies [29]. CTU has been proven to be a sensitive and specific method for the detection of urothelial malignancy, with sensitivity ranging between 88 and 100 %, and specificity between 93 and 100 % [30]

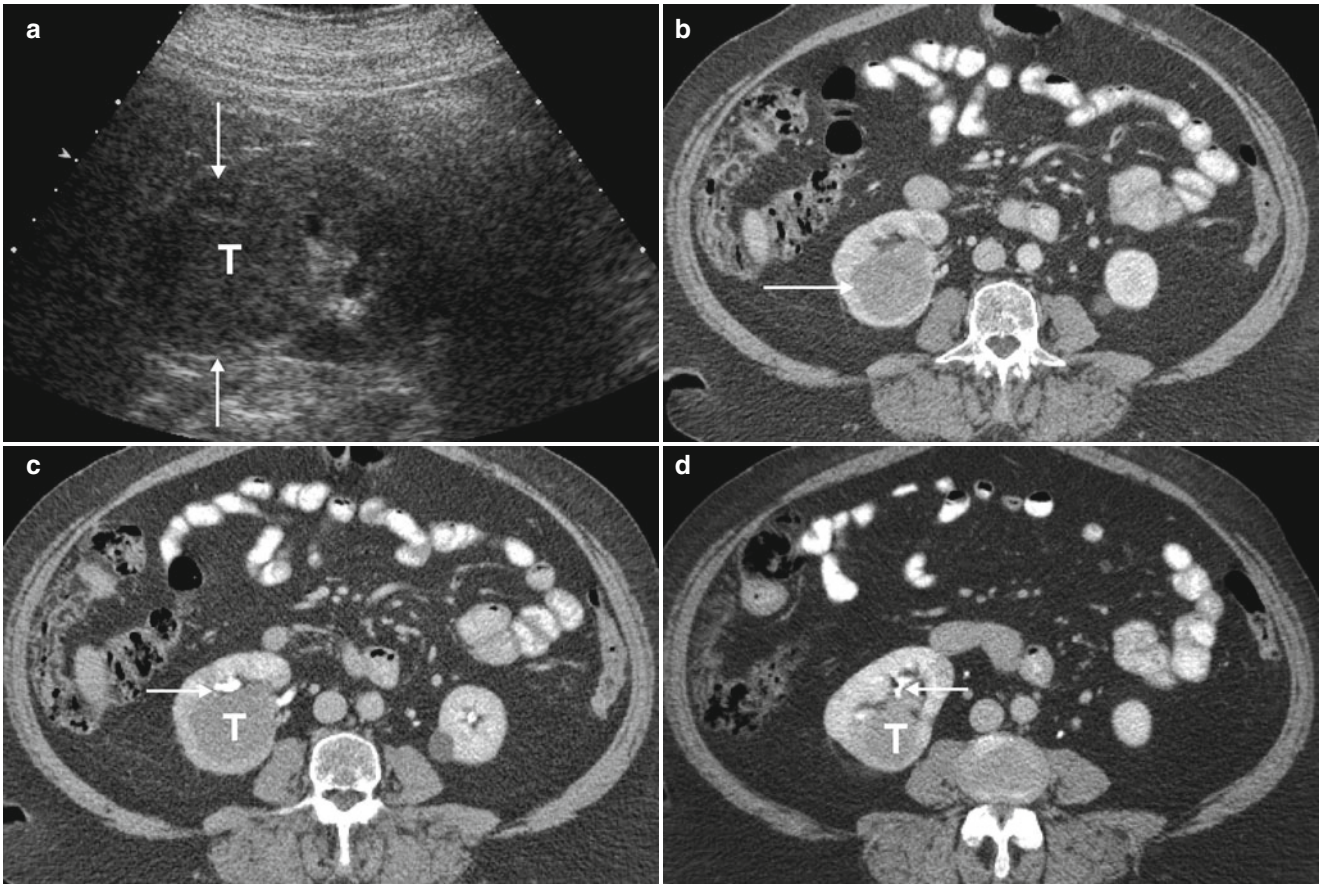


Fig. 2.5 A 56-year-old woman with hematuria underwent cystoscopy with negative findings. Outside CT showed a large upper pole renal mass. Patient underwent radical right nephrectomy and pathology was positive for high-grade urothelial neoplasm (T1N0). Subsequent completion laparoscopic ureterectomy was performed with histopathology showing the specimen to be free of tumor. (**a**) Longitudinal grayscale ultrasound image of the right kidney reveals a solid round isoechoic mass (*T*) measuring just under 5 cm in diameter (*arrows*). The mass displaces central echogenic pelvic fat. (**b**) Axial early parenchymal phase image through the right kidney shows a mass (*arrow*) in the posterior upper pole measuring up to 5 cm and displacing central pelvic fat with associated delayed nephrogram compared to the visualized left kidney, with small left renal cyst. (**c**) and (**d**) Axial excretory phase images confirm distortion of the collecting system (*arrow*) by tumor (*T*). At ultrasound, renal pelvic TCC typically appears as a central soft-tissue mass in the echogenic renal sinus with or without hydronephrosis. Tumor is usually slightly hyperechoic relative to surrounding renal parenchyma and it may be obscured by the surrounding hyperechoic renal sinus fat. Also, small nonobstructing TCCs may be impossible to differentiate from blood clots, sloughed papillae, or a fungus ball [31]. Ultrasound (US) is not as specific as CT in identifying or characterizing renal masses but is frequently requested in the evaluation of patients with hematuria to assess for renal parenchymal masses. A review of more than 1,000 cases in patients with hematuria suggested that US has value for evaluation of upper tract disease, as two patients with upper tract tumors and 21 patients with renal cortical tumors were properly diagnosed using the investigational protocol [32]

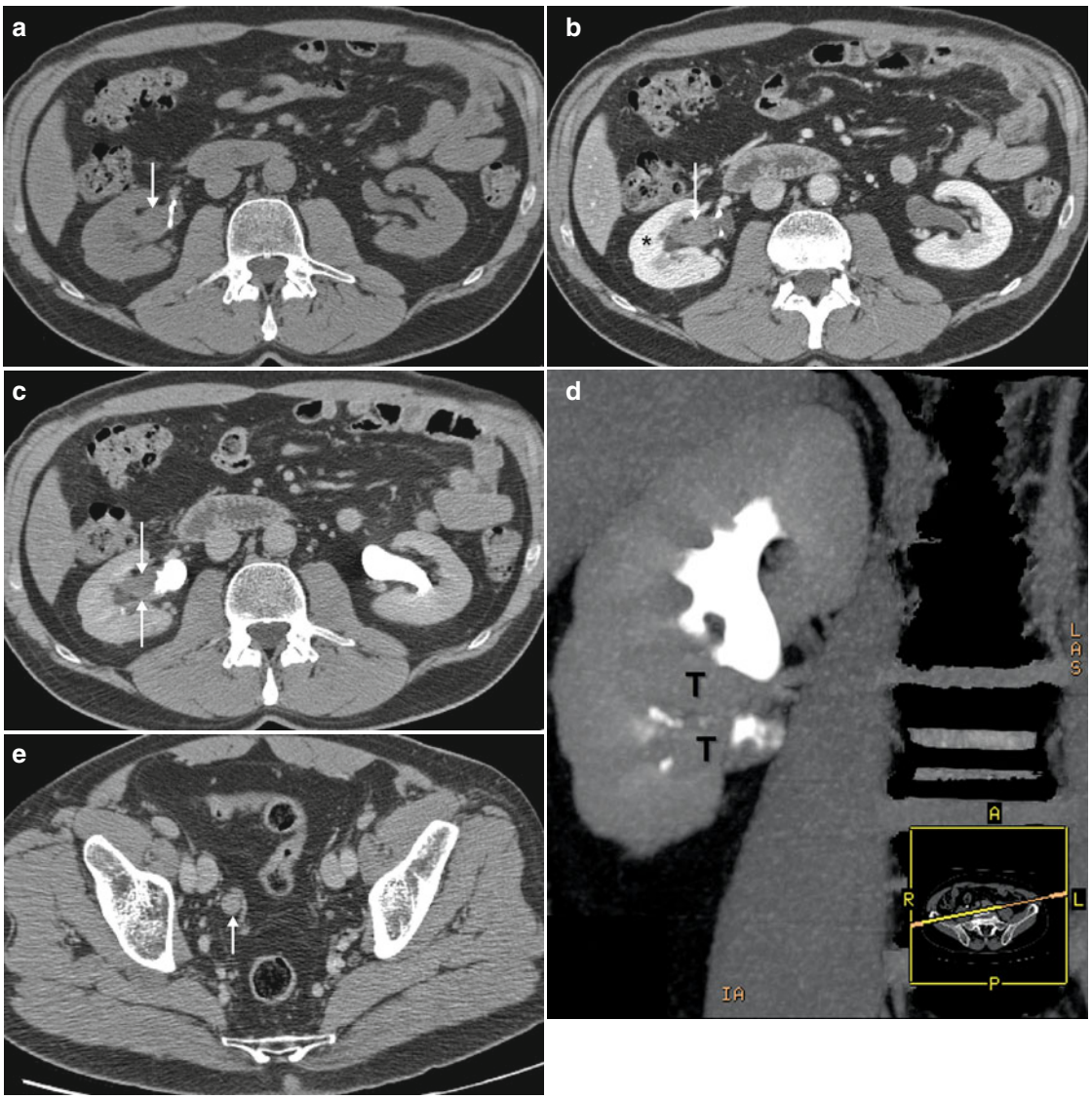
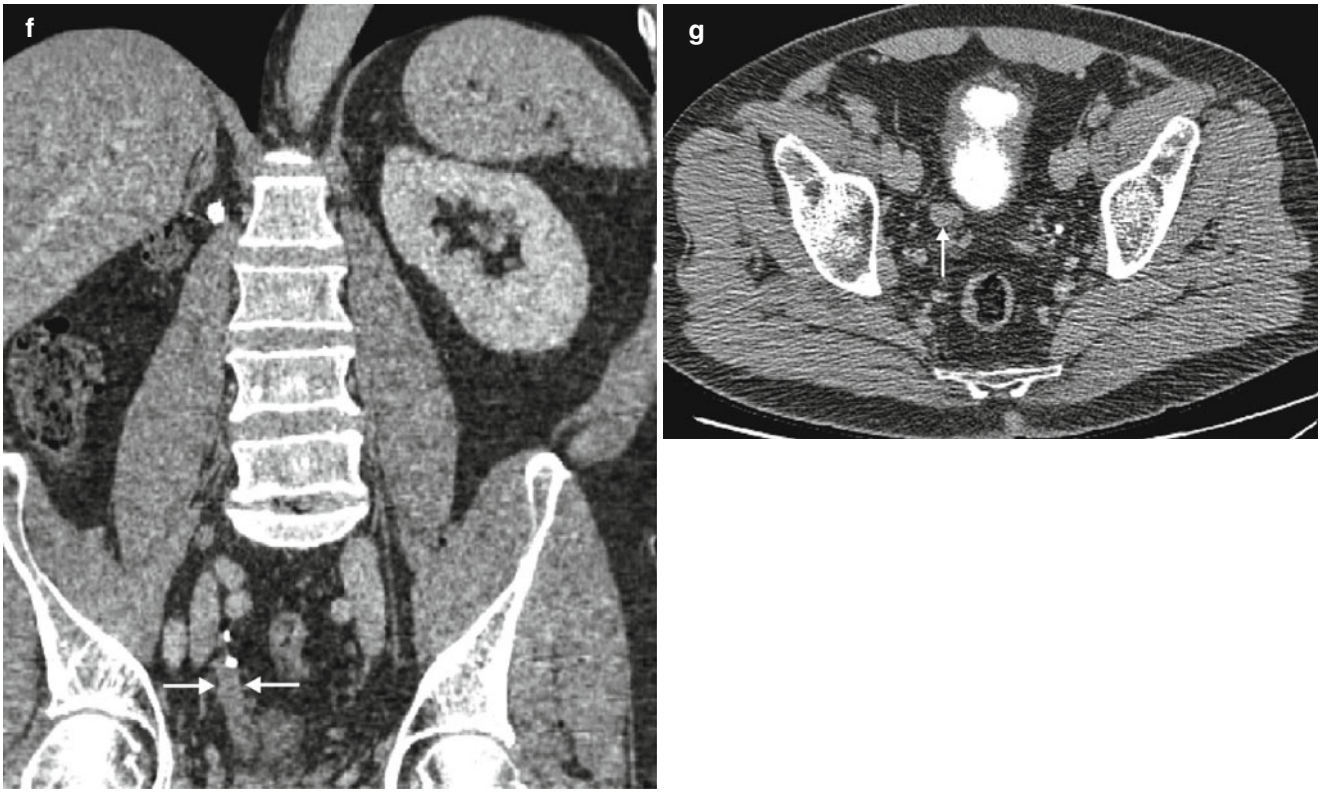


Fig. 2.6 A 63-year-old man with history of high-grade papillary TCC right renal pelvis after nephroureterectomy and TURBT for superficial bladder lesion. One year later, the patient presented with an abnormal CTU, with a tubular soft tissue mass in the region of the anticipated right ureteral stump and vesicle-ureteral junction suspicious for recurrent tumor. TURBT was positive for low-grade papillary (pT1) TCC. (**a**) Axial noncontrast images from baseline CTU reveals a mass (*arrow*) in the right renal pelvis, which is slightly hyperattenuating to urine and renal parenchyma [33]. (**b**) Axial parenchymal phase images show characteristic mild early enhancement (*arrow*) less than that of the renal parenchyma (*asterisk*) [33]. (**c**) Axial images acquired in the excretory phase show the mass (*arrows*) as a filling defect in the renal collecting system [33]. (**d**) Coronal reformatted image showing tumor (*T*) filling the right renal lower moiety and pelvis. (**e**) Ureteral stump recurrence on CTU 1-year after surgical resection. Axial parenchymal phase images show enhancing soft tissue (*arrow*) filling the right distal ureteric stump. (**f**) Coronal MPR image in the nephrographic phase confirms linear enhancing soft tissue (*arrows*). (**g**) Axial excretion phase image demonstrates nodular tumor (*arrow*) within the distal ureteral stump with diminished attenuation consistent with contrast washout when compared with previous parenchymal phase. When nephrectomy alone or incomplete nephroureterectomy is performed, subsequent transitional cell carcinoma can develop in up to 30 % of the ureteral stumps [34]



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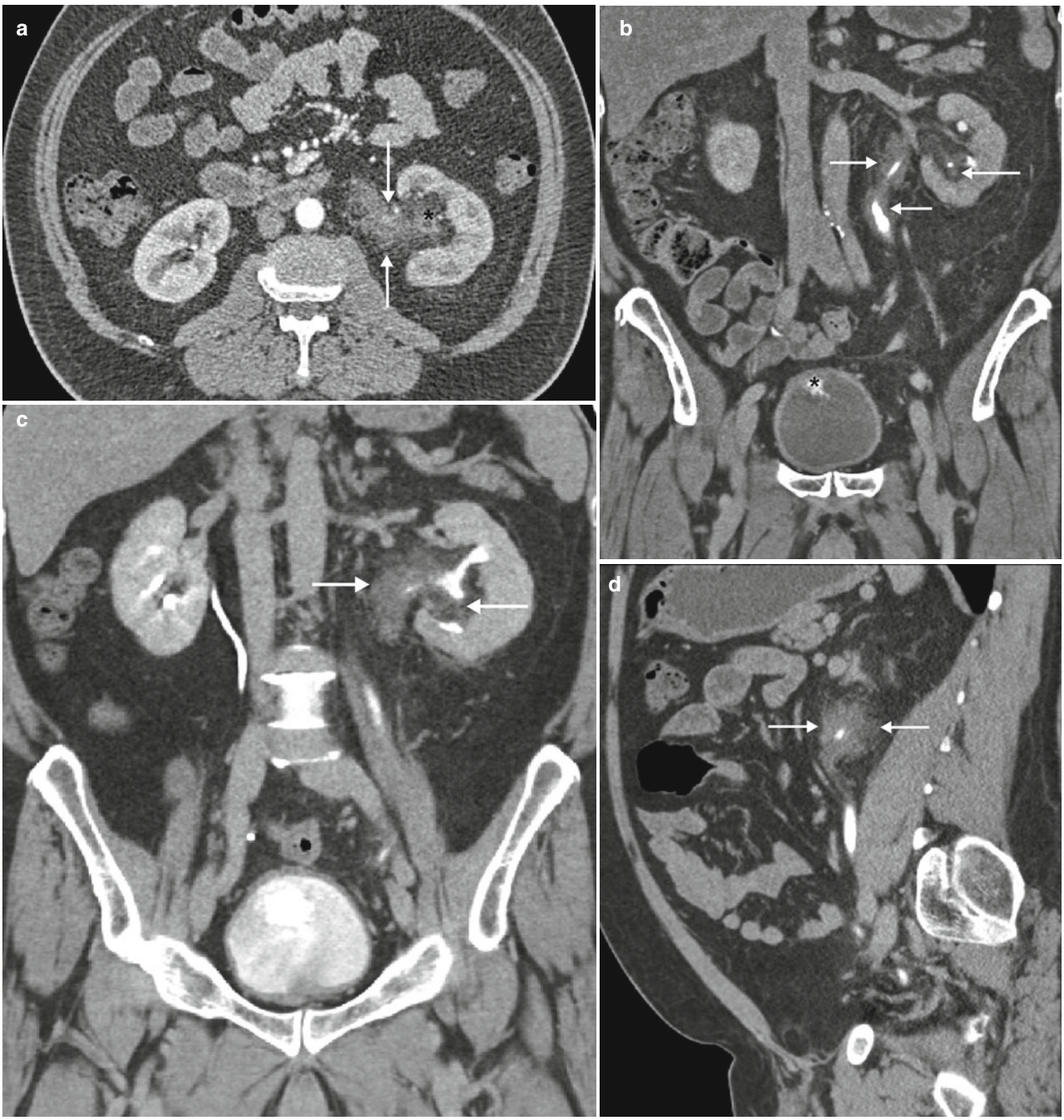

Fig. 2.7 A 59-year-old man with gross hematuria. Cystoscopy at an outside institution revealed carcinoma in situ of the bladder, whereas subsequent CTU imaging revealed marked surrounding fat-stranding and wall-thickening involving the left renal pelvis and lower moiety, as well as proximal ureteral narrowing and nonobstructing renal calculi. No lymphadenopathy was seen. Left nephroureterectomy was performed, with histopathology confirming pT3N0 transitional cell carcinoma within the upper tract. (**a**) Axial CTU parenchymal-phase shows abnormal left ureteropelvic junction thickening and enhancement with indistinct collecting system margins and surrounding fat infiltration (*arrows*). Thickening and circumferential enhancement of the lower moiety is noted en-face (*asterisk*) with delayed left nephrogram. (**b**, **c**) Coronal excretory-phase MPR confirms segmental circumferential tumor involving the proximal left ureter and lower moiety (*arrows*) with marked surrounding fat infiltration and narrowing of the ureteral lumen. Excreted contrast from ureteral jet is noted at bladder dome (*asterisk*). (**d**) Sagittal excretory phase MPR through the left proximal ureteral demonstrates the marked irregular circumferential tumor with ill-defined margins and infiltration involving the periureteral fat (*arrows*). Histopathologic analysis upon subsequent radical nephroureterectomy confirmed invasive high-grade urothelial carcinoma with tumor invasion into renal hilar and peripelvic tissue. Although the majority of focal infiltrative TCCs tend to have a more central location, eccentric or peripheral tumors may occur. In such a situation, the reniform shape can be preserved or distorted. When the reniform shape is distorted or lost, the mass effect of eccentric or peripheral TCC may simulate RCC. In addition, large infiltrative TCCs with both pelvic and parenchymal involvement may simulate other entities such as tuberculosis, lymphoma, metastasis, or xanthogranulomatous pyelonephritis [31]

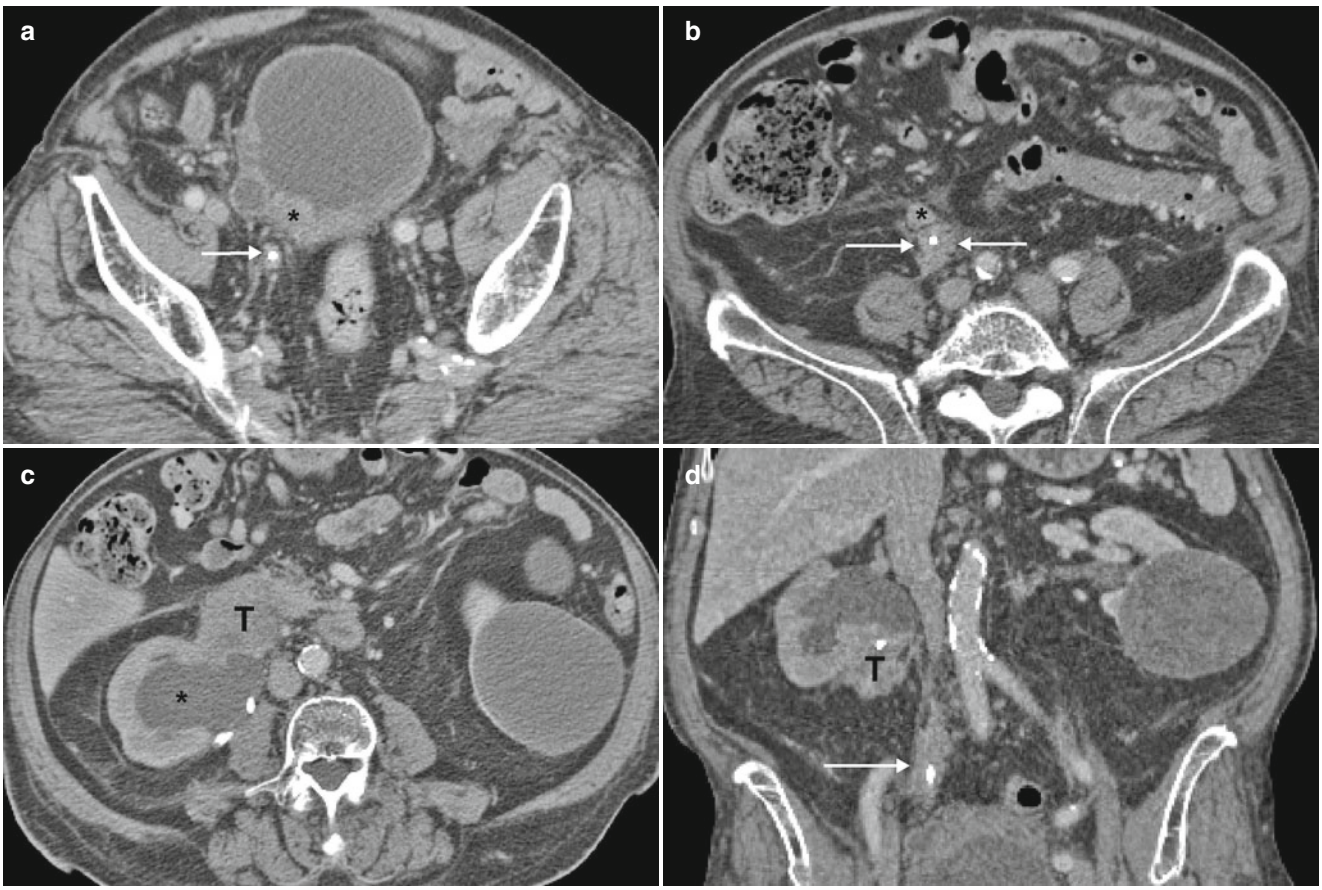

Fig. 2.8 A 92-year-old man with a history of gross hematuria and poorly differentiated muscle invasive pT2 urothelial tumor of the bladder, after TURBT and Bacillus Calmette-Guerin (BCG) over 8 weeks after initial diagnosis, with recurrence and repeat TUR showing poorly differentiated carcinoma with lymphovascular invasion. Urine cytologic fluorescence in situ hybridization (FISH) analysis revealed aneuploidy of chromosomes 3, 7, and 17. FISH analysis, assessing for denatured nuclei counterstain uptake to probe for DNA markers, shows high sensitivity for high-grade tumors and offers good specificity for detecting bladder cancer. It may be utilized in patients recently treated with BCG therapy, in contradistinction to other protein assays. FISH analysis is limited in sensitivity for low-grade tumors, however; it also requires trained personnel and sophisticated instrumentation for accurate performance [35]. (**a**) Axial nephrographic phase image. Despite diffuse trabeculation, focal nodular bladder thickening posteriorly (*asterisk*) was confirmed as focal abnormal bladder thickening on cystoscopy. Thickening and dilation of the distal right ureter is noted, with an indwelling stent (*arrow*). (**b**) Axial nephrographic phase image. Diffuse right periureteric tumor (*arrows*) with adjacent fat infiltration and subjacent lymphadenopathy (*asterisk*) noted just below the pelvic inlet. (**c**) Axial parenchymal phase image at the level of the renal pelvis demonstrates gross tumor mass (*T*) extending anteriorly within the perirenal fat as well as hydronephrosis (*asterisk*). The tumor was inseparable from portions of the inferior vena cava. Stent partially imaged. (**d**) Coronal plane reformatted parenchymal phase image confirms gross perinephric tumor (*T*) extension inferiorly as well, inseparable from the proximal ureteropelvic junction. Midureteral extensive tumor involvement (*arrow*) is also seen. In the bladder, thickened bladder wall with focal nodularity may be seen on CT or MRI after intravesical BCG and is very difficult to differentiate from bladder tumor. It is clinically important for the radiologist to consider the possibility of BCG reaction when local or disseminated masses are visualized on follow-up imaging in bladder cancer patients. If clinical concern for metastatic disease or another primary tumor is high, a biopsy may be needed to provide a definitive diagnosis [36]

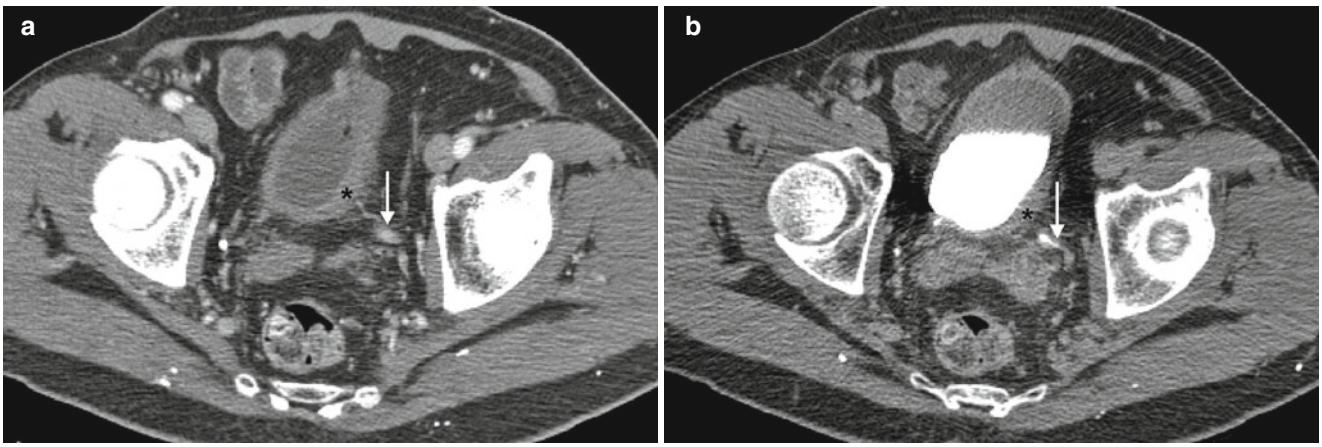

Fig. 2.9 A 74-year-old man with a history of Gleason 6 prostate cancer underwent cystoscopy and biopsy for hematuria; pathology was positive for superficial noninvasive urothelial carcinoma pTa. Surveillance cystoscopy showed tumor of the left distal ureter, and subsequent TURBT and distal ureteral resection confirmed pTa tumor. (**a**) Axial parenchymal phase image shows distal left ureteral thickening (*arrow*) and mild enhancement. Diffuse urinary bladder wall trabeculation and mild left more than right bladder wall thickening is also noted (*asterisk*). (**b**) Axial excretory phase image confirms distal ureter (*arrow*) and bladder wall (*asterisk*) thickening. Although the "gold standard" for urothelial tumors involving the upper urinary tract has been complete excision of the entire kidney and ureter, equivalent oncologic outcomes after conservative endoscopic management of low-grade superficial upper urinary tract TCC have been widely reported, suggesting that the removal of the entire ipsilateral tract is not always necessary. All patients with urothelial tumors require close surveillance of the entire urinary tract [37]

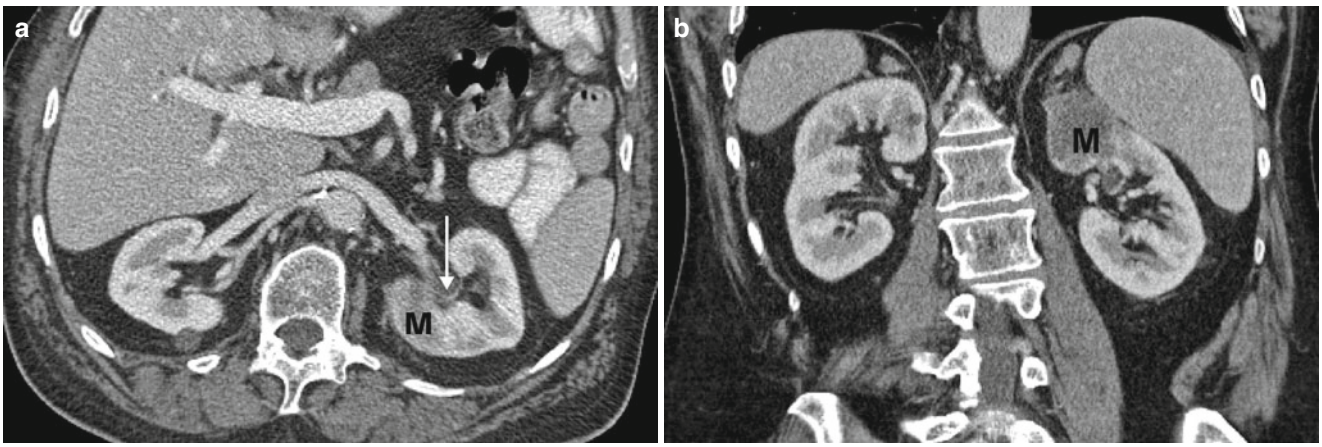

Fig. 2.10 A 69-year-old man with metastatic squamous cell carcinoma of the left lung (with brain, bone, and pleural metastases). An incidentally detected left upper pole renal mass was noted on standard CT, as well as slight urothelial thickening and enhancement of the left renal pelvis and ureter. Prior left video-assisted thoracic surgery procedure for lung lesion was positive for *Mycobacterium xenopi*, hence a differential diagnosis for the renal and upper tract lesion was tuberculosis, metastasis, or primary urothelial or renal cortical tumor. CT-guided biopsy positive for metastatic squamous cell carcinoma. (a) Axial parenchymal phase image shows vague heterogeneity of the medial upper pole posteriorly (*M*) as well as thickening and enhancement of the adjacent collecting system urothelium (*arrow*). (**b**) Coronal nephrographic phase MPR demonstrates a mass (*M*) at the left upper pole

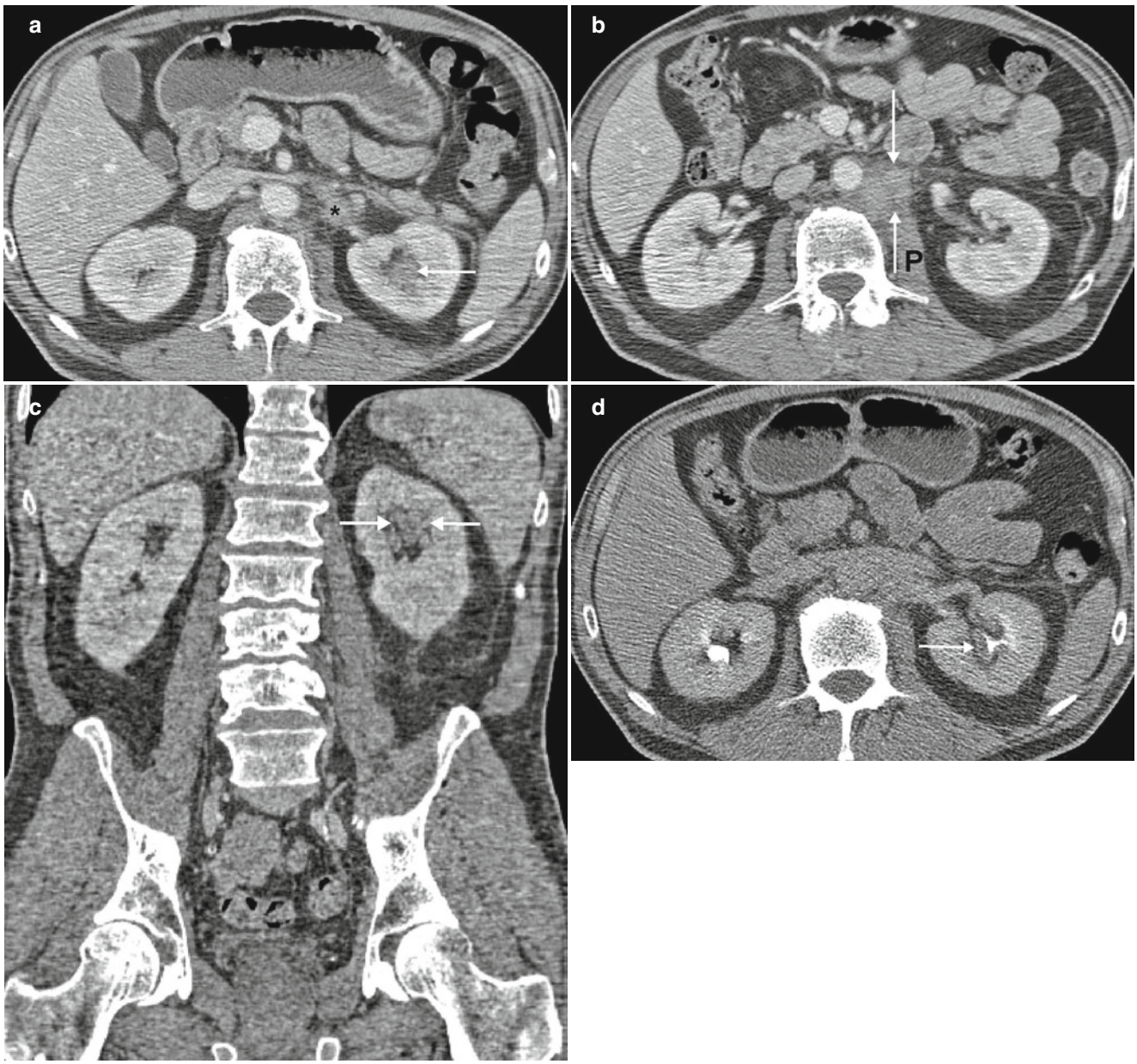

Fig. 2.11 A 62-year-old man with left flank pain (radiating to the left testicle) and unexplained weight loss. Outside institution CT showed a renal mass and retroperitoneal soft tissue masses. CTU performed showed a 1.8 × 1.6 cm soft tissue mass filling the left upper pole renal calyx and a nonobstructing 1.1 cm left renal calculus. Retroperitoneal adenopathy was also noted. Subsequent left retroperitoneal biopsy was positive for metastatic squamous cell carcinoma. Differentials included lung, urothelial, and head and neck primaries. The patient was treated with chemotherapy. (**a**) Axial parenchymal phase image shows abnormal enhancing left calyceal mass (*arrow*) and adjacent paraaortic adenopathy (*asterisk*). (**b**) Axial parenchymal phase image at a lower level shows ill-defined para aortic adenopathy (*arrows*) inseparable from the aorta and psoas muscle (*P*). (**c**) Coronal MPR parenchymal phase image demonstrates expansion and urothelial enhancement involving the left upper moiety (*arrows*). (**d**) Axial delayed phase image shows abnormal urothelial thickening (*arrow*) and distortion of the upper moiety on the left. Upper tract TCCs are more commonly spread by direct invasion and the lymphatic route than hematogenously. Tumors of the right renal collecting system can metastasize to the renal hilar, paracaval, retrocaval, and interaortocaval lymph nodes, as well as the right common iliac lymph nodes. Tumors of the left renal collecting system may involve hilar, paraaortic, inter-aortocaval, and left common iliac lymph nodes [31]

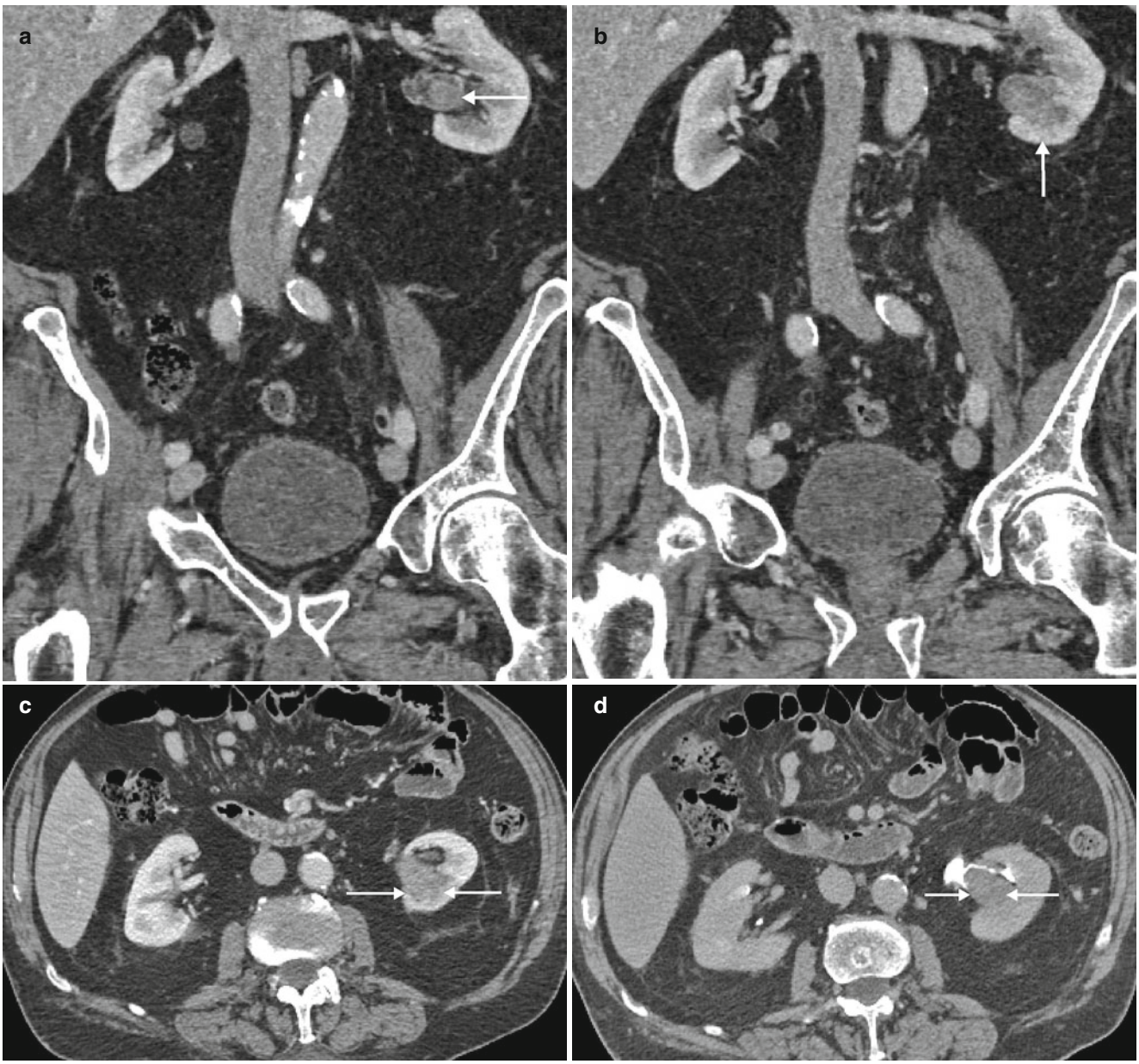

Fig. 2.12 An 87-year-old man with hematuria and left flank pain. CT work-up showed a left renal pelvis mass. Biopsy performed at ureteroscopic stent placement positive for papillary non invasive TCC, initially treated by local resection. Recurrent tumor led to left nephroureterectomy revealing pT3N0 tumor. (**a**) Coronal reformatted parenchymal-phase image shows enhancing tumor (*arrow*) projecting into the proximal left renal pelvis from the lower moiety. (**b**) Coronal reformatted parenchymal phase image in a slightly different plane suggests tumor involvement of adjacent renal parenchyma (*arrow*) with vague, irregular margins extending into the parenchyma. (**c**) Axial parenchymal phase image confirms involvement of the surrounding renal parenchyma (*arrows*) in the left lower pole. (**d**) Axial delayed phase image showing collecting system distortion due to the mass, as evidenced as a filling defect (*arrows*). Loss of renal sinus fat and abnormal enhancement of the adjacent parenchyma are signs of a T3 tumor. Advanced TCC extends into the renal parenchyma in an infiltrating pattern that distorts normal architecture. However, reniform shape is typically preserved unlike in renal cell carcinoma [2]

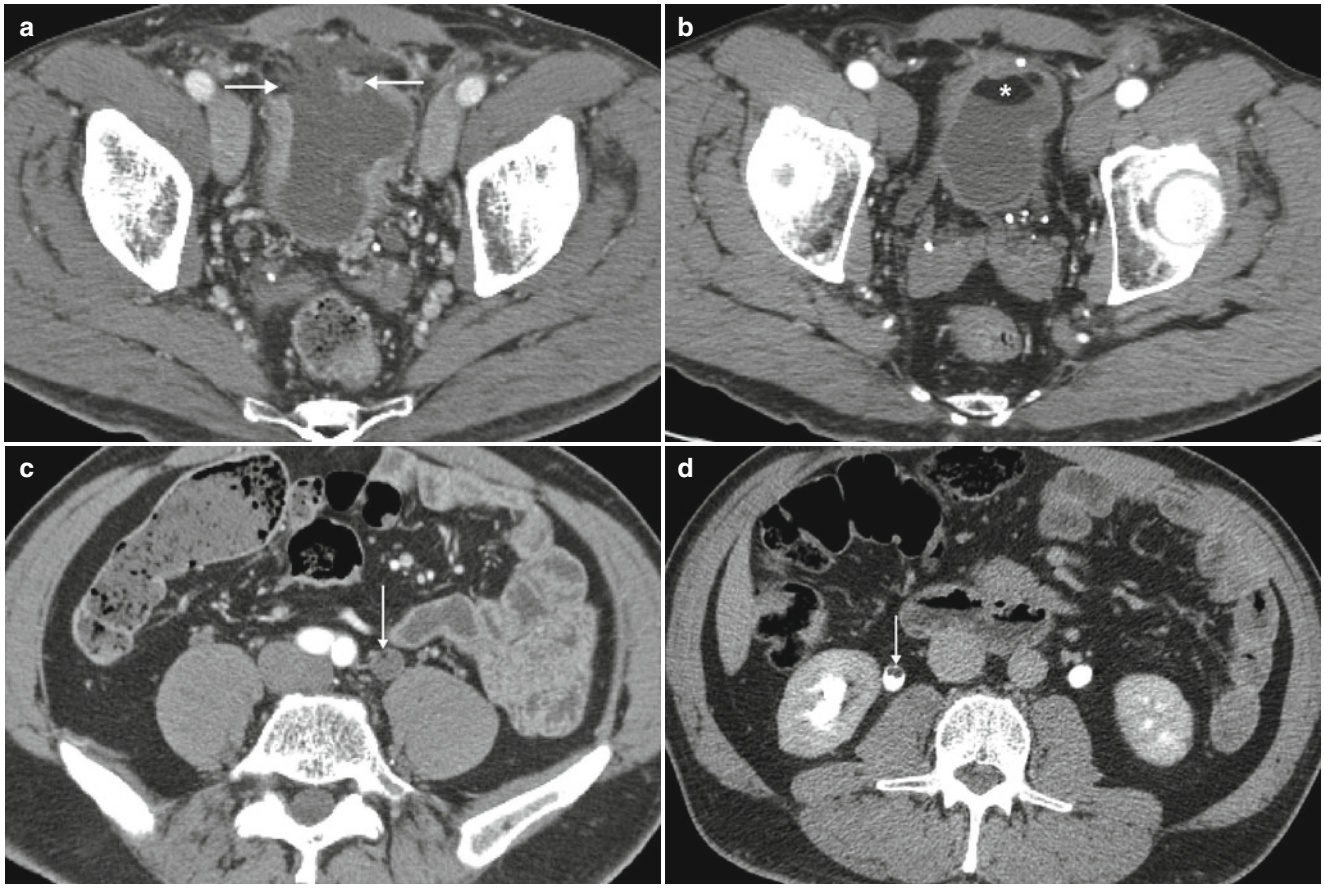

Fig. 2.13 A 58-year-old man with history of multifocal recurrent bladder cancer. TURBT at an outside institution was complicated by perforation. CTU showed walled off perforation of the bladder and bilateral hydroureteronephrosis. Mobile nondependent fat in the right collecting system and intraluminal fat in the urinary bladder near the dome. (**a**) Axial parenchymal phase image shows anterior bladder wall defect (*arrows*). (a) Axial late arterial phase shows intraluminal pelvic fat (*asterisk*) within the bladder. (**c**) Axial parenchymal phase image shows a punctate focus of fat within the left ureter anteriorly (*arrow*). (**d**) Axial excretory phase image at the level of the proximal right ureter shows nondependent intraluminal fat (*arrow*) confirmed by density measurements on earlier phases anterior to opacified urine. Follow-up CT scan 6 months later showed near complete closure of the bladder defect. Although small and clinically innocuous bladder perforations may be encountered in up to 58 % of patients undergoing transurethral resection [38], large perforations requiring open surgical repair are rare. Despite its potential for associated morbidity, bladder perforation does not seem to substantially increase the risk of extravesical tumor seeding [39]

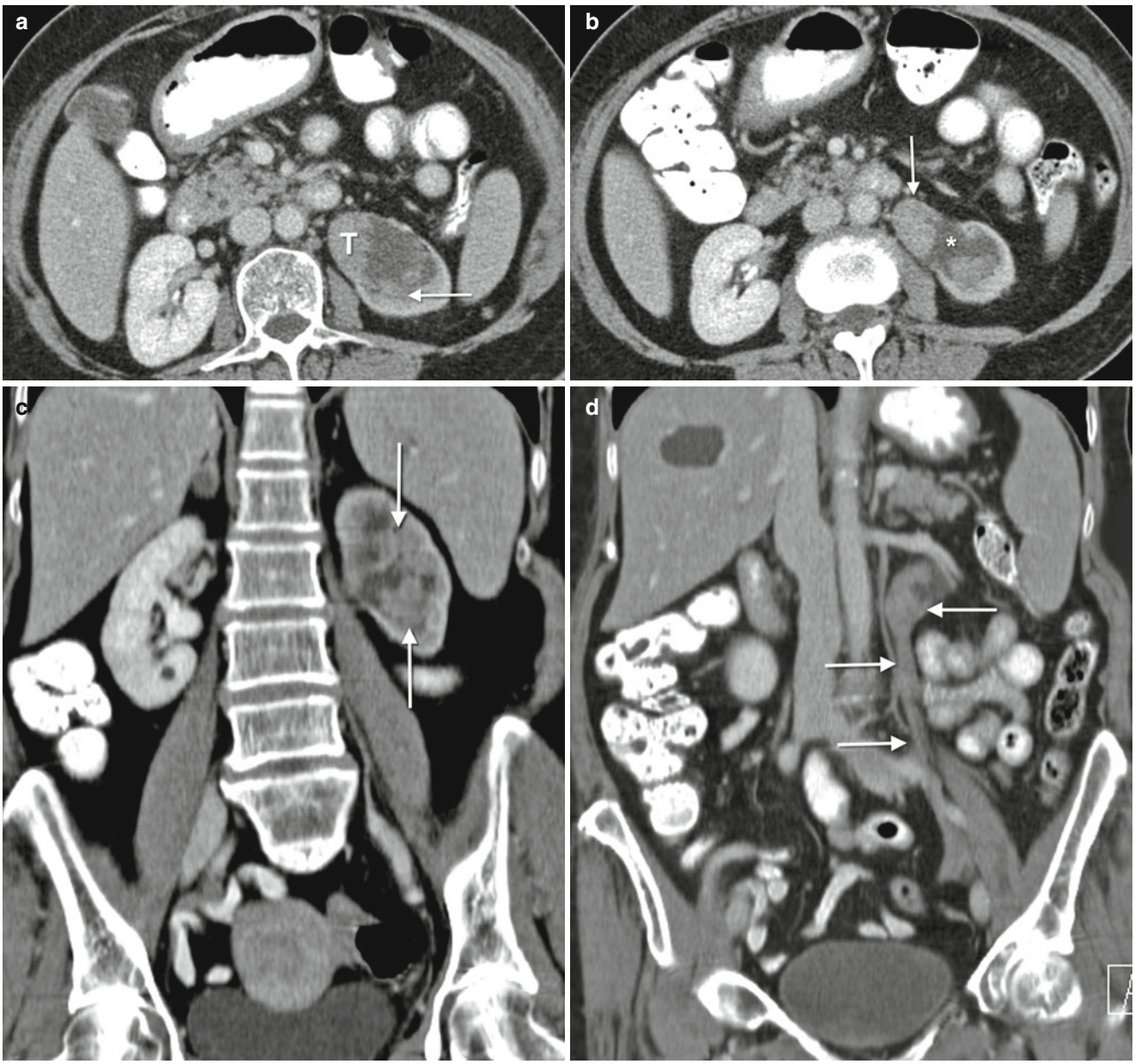

Fig. 2.14 A 70-year-old woman with history of hematuria. CT revealed a lobulated infiltrative appearing mass within the left renal pelvis, calyces, and proximal ureter. By CT imaging, invasion of the parenchyma was suspected. Patient underwent radical nephroureterectomy with histopathology revealing high-grade flat and papillary multifocal urothelial cancer in the renal pelvis and calyces with invasion of the lamina propria, stage pT1N0M0. (**a**) Axial parenchymal phase image shows irregular enhancing left collecting system tumor (*T*) with poorly defined margins posteriorly (*arrow*) suspicious for renal parenchymal involvement. (**b**) Axial parenchymal phase image at the level of the left renal pelvis shows tumor extension (*arrow*) into renal pelvis. Left hydronephrosis (*asterisk*) is present. (**c**) Coronal MPR parenchymal phase image showing extensive tumor (*arrows*) filling the dilated left collecting system at the level of the left kidney. (**d**) Coronal MPR parenchymal phase image of the left ureter demonstrates extensive ureteral tumor (*arrows*) to the pelvic inlet

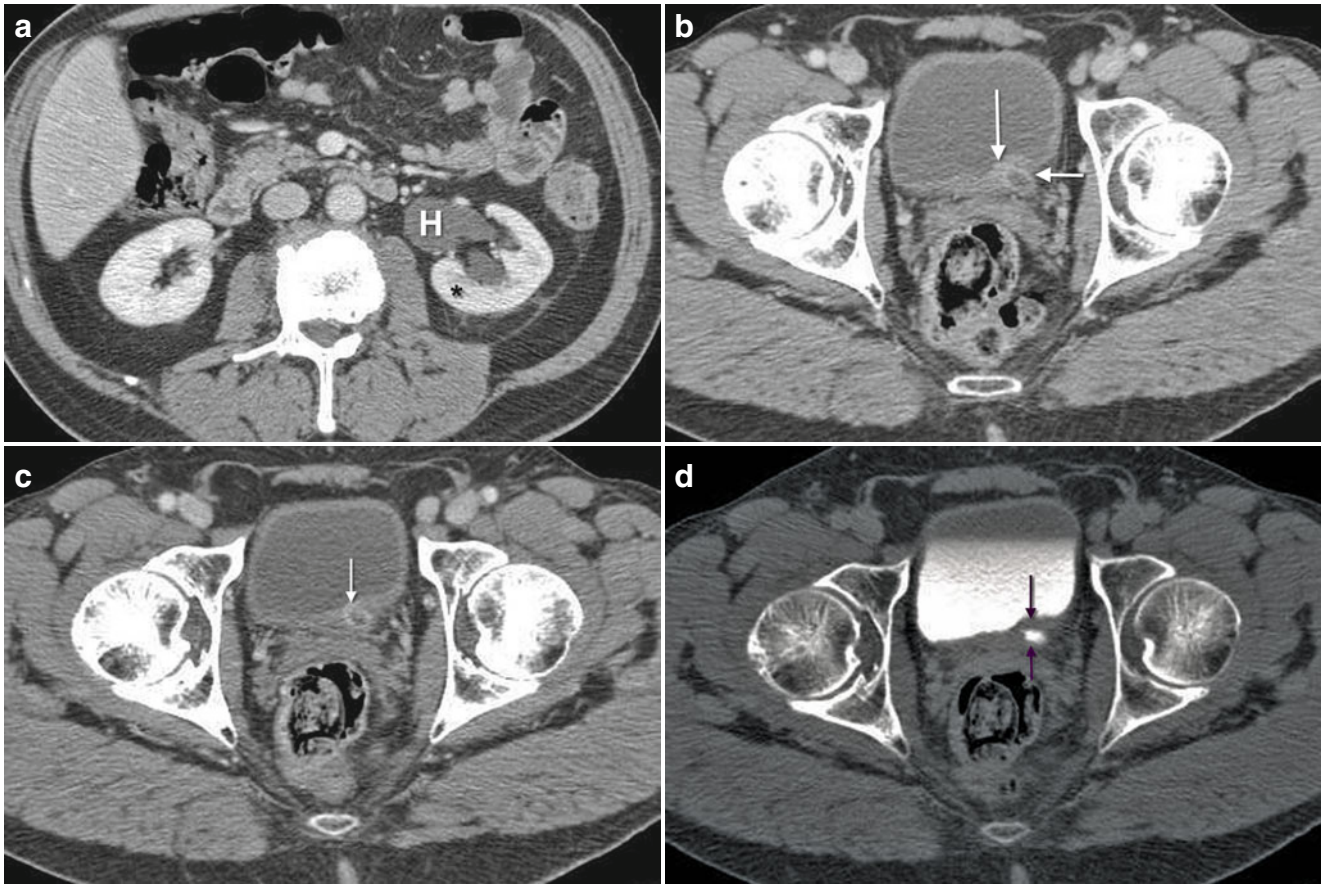

Fig. 2.15 A 64-year-old man with recurrent high-grade Ta and Tis of the bladder refractory to induction treatments with BCG, presenting with left hydronephrosis. (**a**) Axial parenchymal phase image at the level of the kidney shows moderate left hydronephrosis (*H*) and subtly delayed nephrogram (*asterisk*). (**b**) Axial parenchymal phase image at the level of the left ureteral vesicle junction (UVJ) shows thickening and enhancement of the urothelium (*arrows*). (**c**) Axial parenchymal phase image at slightly more inferior level shows avidly enhancing abnormal thickened urothelium at the left UVJ (*arrow*). (**d**) Axial excretory phase image at the level of the VUJ confirms circumferential wall thickening (*arrows*). Patient underwent radical cystoprostatectomy with resection of the distal ureter and nodal dissection confirmed noninvasive high-grade urothelial carcinoma pathologic stage Tis. Patients with CIS that involves the ureteral margin are at increased risk for upper tract recurrence and progression with an ipsilateral recurrence rate of up to 42 %. Aggressive follow-up with scheduled ureteroscopy may identify recurrences at an earlier stage [40]

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