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## Introduction

- The diagnosis of renal inflammatory diseases is primarily based on a combination of clinical and laboratory findings such as bacteriuria, pyuria, positive urine culture, and leukocytosis.
- In general, imaging is not required for diagnosis and treatment of uncomplicated infections in adult patients.
- However, patients suspected of having an acute renal infection and those who are not responding to intravenous antibiotic treatment within 72 h require imaging.
- Imaging of urinary tract infection (UTI) in children is more important than in adults because of the much higher potential for significant irreversible renal damage with sequelae of hypertension and chronic renal failure.

## Acute Pyelonephritis

### Acute Bacterial Renal Infection in Children

#### General Information

- Approximately 1–3 % of prepubertal children are diagnosed with UTI as a bacterial infection of the renal parenchyma, bladder, or urethra.
- Acute pyelonephritis is a bacterial or fungal infection of the renal parenchyma and collecting system.

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- Bacterial pyelonephritis may occur by hematogenous seeding, while an ascending route from the bladder is the most common pathway in children.

## Imaging

### Intravenous Pyelography

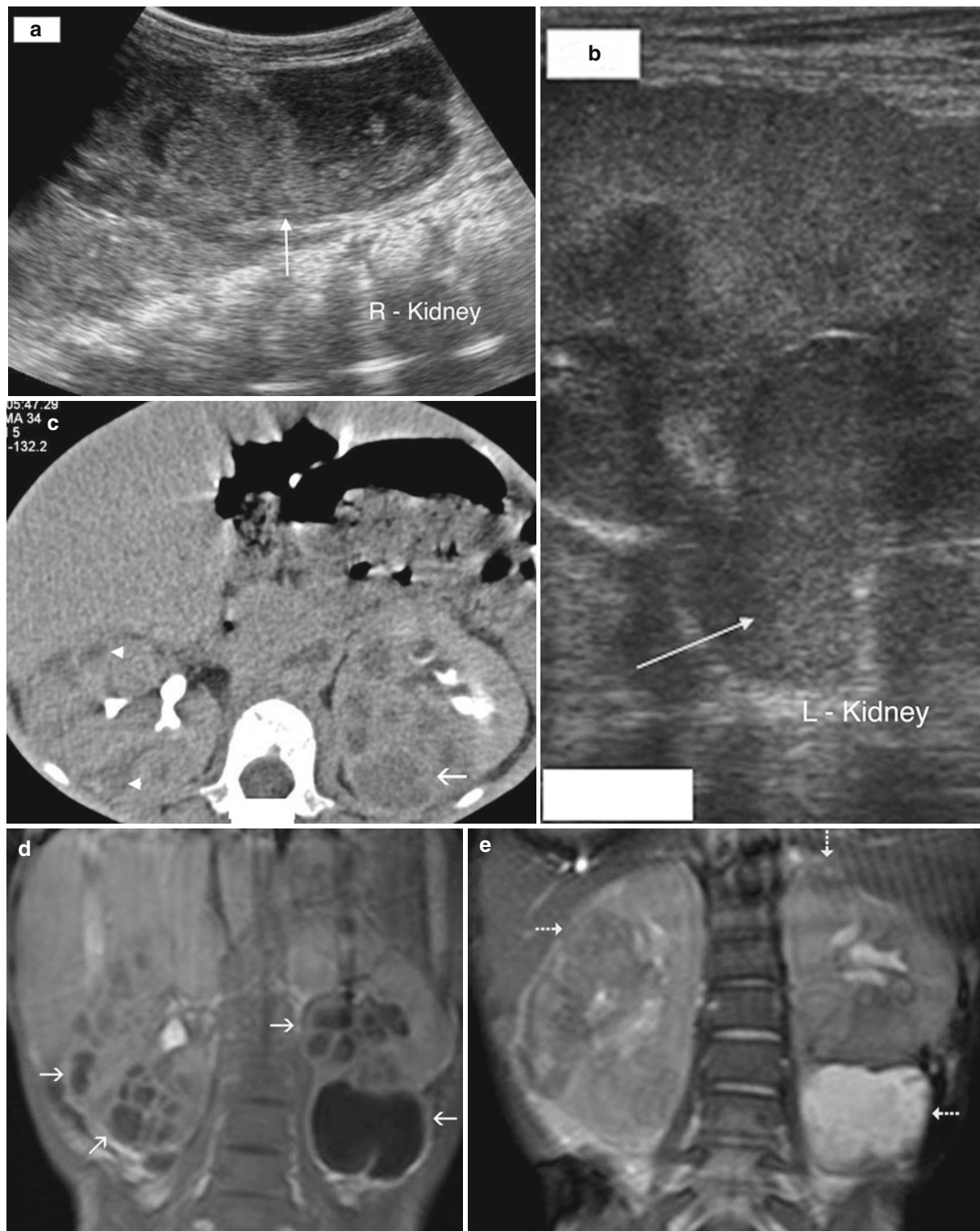
- Intravenous pyelography (IVP) can be used to assess the morphology of the urinary tract, if renal function is adequate.
- Approximately 20–25 % of patients with acute renal infection have abnormal imaging findings, including dilatation of the ureter, loss of visualization of a portion of renal outline, diffuse renal enlargement, and decreased nephrogram.

### Ultrasound

- Ultrasound findings of acute bacterial renal infection in children are given in Table 2.1 (Fig. 2.1a, b).
- Focal pyelonephritis or lobar nephronia is a localized infection without major suppuration. It usually appears as a poorly defined mass with focal loss of the regional corticomedullary differentiation on ultrasound. The abnormal focus can be relatively anechoic with low-level echoes or can be more echogenic than the kidney.
- Renal ultrasound is also useful in the diagnosis of complications secondary to acute pyelonephritis such as abscess, pyonephrosis, and perirenal fluid collections (Figs. 2.1 and 2.2a, b).
- Combining gray-scale ultrasound and power Doppler ultrasound can provide a comprehensive evaluation of the renal parenchyma in acute pyelonephritis with impaired renal function.

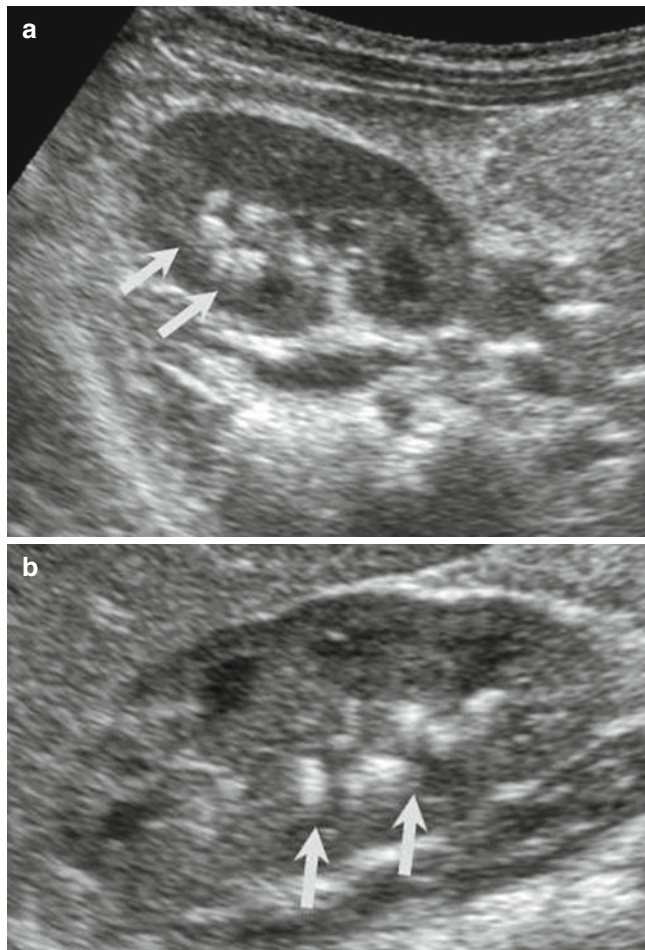
**Table 2.1** Ultrasound findings in acute bacterial renal infection in children

Renal enlargement
Decreased or increased parenchymal echogenicity
Minimal dilatation of renal pelvis
Loss of normal corticomedullary differentiation
Focal, poorly defined mass with variable echogenicity



**Fig. 2.1** Complicated acute bacterial pyelonephritis (ABP) in a 3-year-old girl with immunodeficiency. Ultrasound scans of right (a) and left (b) kidneys reveal bilateral diffuse enlargement with loss of the corticomedullary differentiation (arrow), multiple scattered areas of decreased echogenicity, and dilated renal pelvis (arrow) representing diffuse spread of the inflammatory process, features consistent with complicated acute pyelonephritis, and pyonephrosis. (c) Contrast-enhanced CT scan demonstrates bilateral diffuse renal involvement

with scattered nonenhancing foci representing microabscesses (arrow-heads) and a large cystic fluid collection in the left kidney (arrow) suggestive of a renal abscess. The maximum intensity projection image from excretory magnetic resonance urography (MRU) (d) and the maximum intensity projection image from T2-weighted half-Fourier acquisition single-shot turbo spin-echo (HASTE) sequence (e) reveal the true pathology that is consistent with bilateral multifocal renal abscesses associated with complicated ABP (dashed arrows)



**Fig. 2.2** Acute bacterial pyelonephritis. Transverse (a) and longitudinal (b) ultrasound scans of a 13 months old boy performed after an episode of UTI reveal echogenic caliceal debris associated with ABP (arrows) (Courtesy of Alparslan Ünsal, MD, Aydın, Turkey)

- Power Doppler ultrasound is superior to color-flow Doppler in defining extent of areas of hypoperfusion because most pyelonephritic lesions are ischemic.

#### Computed Tomography

- Computed tomography (CT) is a sensitive study in evaluation of the renal parenchyma in acute renal infection.
- Inflammatory edema and microabscess may be demonstrated in the abnormal renal parenchyma.
- Rounded or irregular parenchymal abnormalities appear as a patchy low-density areas on nonenhanced CT scans.
- After administration of radiographic contrast, these regions are seen as areas of decreased enhancement (Fig. 2.1c).

#### Magnetic Resonance Imaging

- Parenchymal alterations in complicated renal infections can be demonstrated on MRI.
- Abscess formations appear as hypointense on T1-weighted and hyperintense on T2-weighted images (Fig. 2.1d, e).

**Table 2.2** Differential diagnosis of acute pyelonephritis in children

Ureteric obstruction
Contusion
Tubular obstruction
Hypotension
Scarring
Autosomal recessive polycystic kidney disease
Renal abscess

#### Nuclear Scintigraphy

- In children, radionuclide imaging is strongly recommended both at early and late stages of the acute pyelonephritis because of the potential of significant functional deficits within areas of inflammation and suppuration.
- Radionuclide imaging with Tc-99m dimercaptosuccinic acid (DMSA) is considered the most sensitive modality for the imaging of renal cortex in children.
- It may show areas of peripheral decreased uptake related to acute pyelonephritis or scar formation.

#### Differential Diagnosis

- The differential diagnosis of acute pyelonephritis is given in Table 2.2. Focal pyelonephritis causing a focal area of edema should be differentiated from various mass lesions, including a renal abscess, which usually appears more complex.

#### Pearls and Pitfalls

- It is difficult to exclude the diagnosis of acute pyelonephritis with imaging studies because IVP, CT, and ultrasound findings can be normal in up to 75 % of the cases.
- On ultrasound, abnormal echogenicity areas can occasionally be misinterpreted as mass lesions.
- Although renal infection can be localized by DMSA, it occasionally cannot be definitely distinguished from a sterile inflammation by using any kind of radiotracer.

### Acute Bacterial Renal Infection in Adults

#### General Information

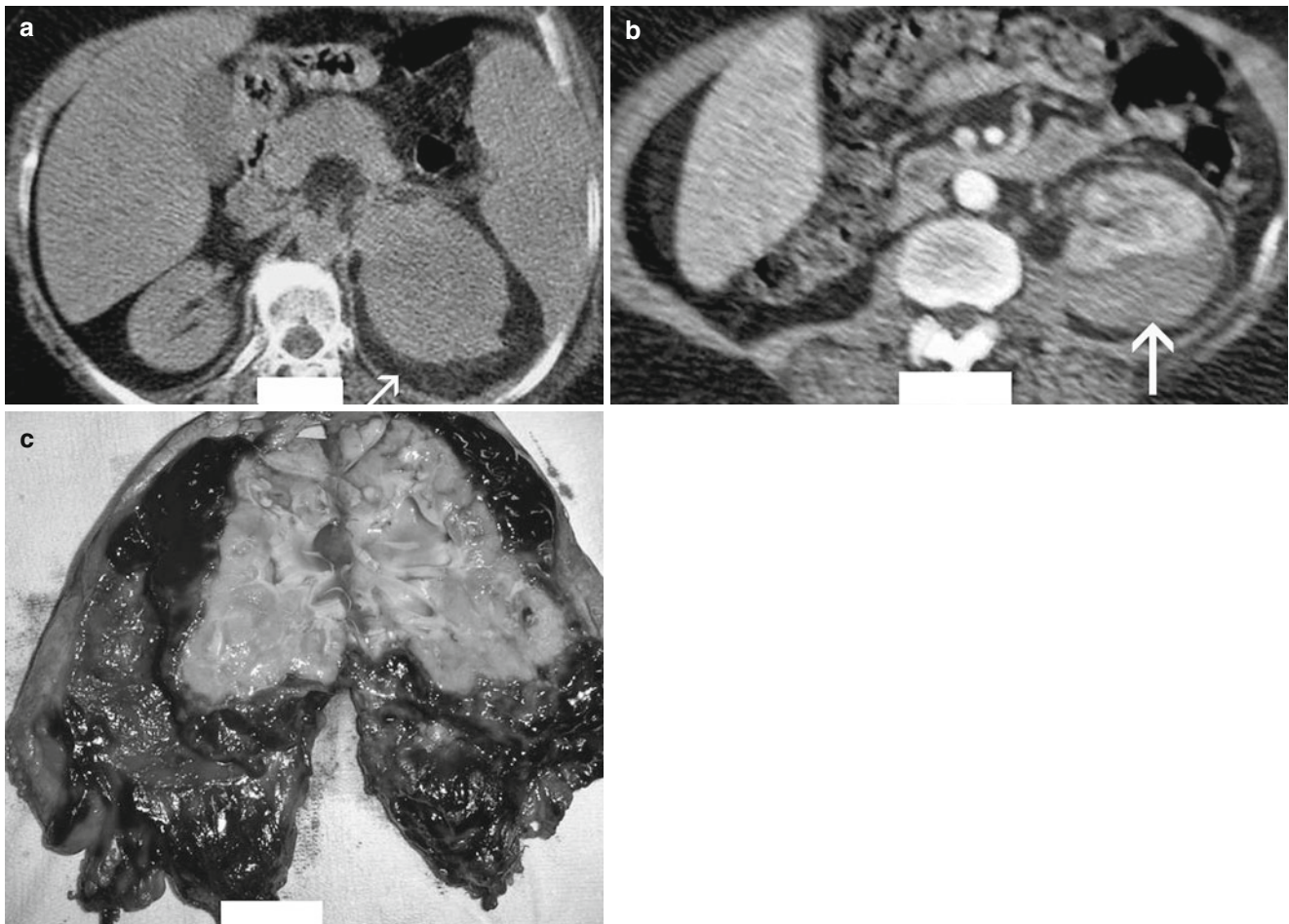
- The incidence of acute bacterial pyelonephritis (ABP) is high, with an increasing rate of hospitalization.
- In the United States, approximately 250,000 cases of ABP with more than 100,000 hospitalizations occur each year.

#### Imaging

##### Intravenous Pyelography

- The main role of IVP in the imaging of infection involves screening for obstruction, although this is now better demonstrated by other modalities.
- Only 25 % of cases of ABP will have positive IVP findings, including enlargement of the affected kidney, delayed contrast excretion, and compression of the collecting system.





**Fig. 2.3** Hemorrhagic acute pyelonephritis in a 45-year-old woman presented with left flank pain. (a) Nonenhanced CT scan demonstrates a low-attenuation collection in the left perirenal space (arrow). (b) Contrast-enhanced CT scan reveals a perirenal fluid collection with

mixed attenuation (arrow) and thickening of Gerota's fascia. Preoperative diagnosis was perirenal abscess. (c) Left nephrectomy revealed an acute pyelonephritis with perirenal hematoma

#### Ultrasound

- Sonographically, variable echotexture changes of the renal parenchyma have been described for ABP.
- They are in the form of hypoechoic lesions or to a lesser degree, hyperechoic foci.
- The former are attributed to edema, whereas the latter may be due to hemorrhage.
- Ultrasound can also be used to detect and monitor the progress of focal inflammatory masses.
- Thus, ultrasound is widely used either as a complement to the IVP or as a screening modality, which may or may not be followed by CT scan, depending on the findings.

#### Computed Tomography

- CT is considered the imaging modality of choice in the evaluation of patients with ABP.
- It is superior to both ultrasound and IVP in detecting morphologic and functional abnormalities, defining the extent of disease, and detecting the formation of renal subcapsular or perinephric abscess or hematoma (Fig. 2.3a–c).

- In hemorrhagic bacterial pyelonephritis, nonenhanced CT may demonstrate, on occasion, wedge-shaped or rounded areas with increased attenuation due to parenchymal bleeding.
- Nonenhanced CT is an excellent study for identifying calculi, gas formation, hemorrhage, parenchymal calcification, urinary obstruction, renal enlargement, and inflammatory masses.
- Typical findings of ABP after intravenous contrast administration include ill-defined, wedge-shaped lesions of decreased attenuation radiating from the papilla in the medulla to the cortical surface.
- These wedge-shaped lesions probably represent areas of poorly or nonfunctioning parenchyma due to vasospasm, tubular obstruction, and/or interstitial edema.
- The nonspecific appearance of a striated nephrogram in the excretory phase on CT comprises linear bands of alternating hyper- and hypoattenuation parallel to the axes of tubules and collecting ducts, corresponding to

**Table 2.3** Causes of striated nephrogram on CT

Acute pyelonephritis
Acute urinary obstruction
Renal vein thrombosis
Renal contusion
Hypotension
Medullary sponge kidney
Autosomal recessive polycystic kidney disease
Tubular obstruction (myoglobinuria)

obstructed tubules with intervening normal tubules, which is associated with stasis of contrast material in dilated ducts due to edematous renal parenchyma (Table 2.3).

### Pathology

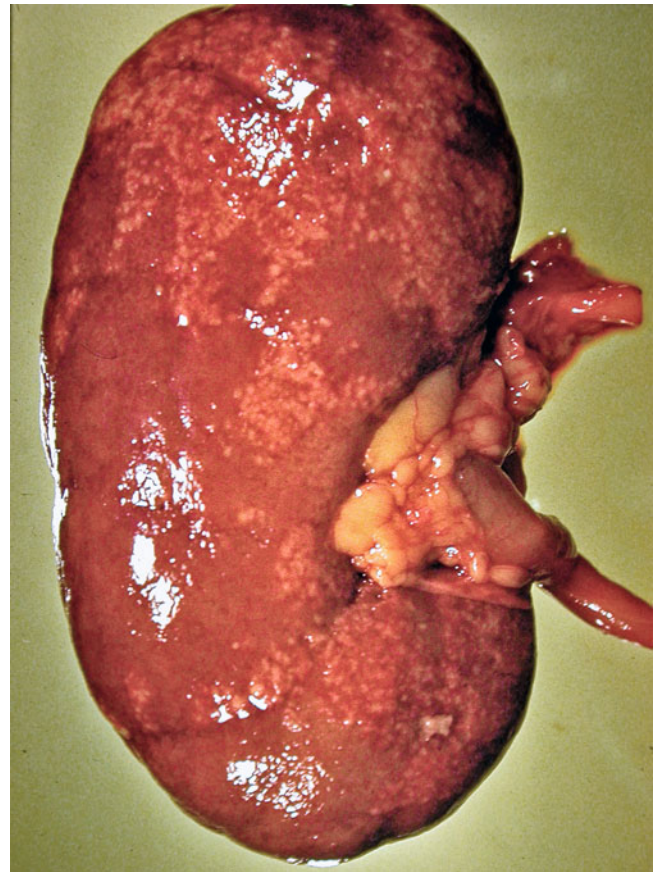
- Acute bacterial pyelonephritis results from an ascending infection that originates in the lower urinary tract.
- Grossly, the collecting system is thickened, with yellow-white abscesses located throughout the renal parenchyma. An abscess is composed of central necrosis, surrounded by a zone of preserved neutrophils, all of which is surrounded by dilated vessels and fibroblasts. Fibroblastic proliferations serve to organize and confine processes and cause adjacent structures to contract. Cortical abscesses may result in hematogenous spread, further seeding the kidney with microorganisms (Fig. 2.4).
- Histologically, the predominant finding is neutrophils; neutrophils are present in the interstitium and in the renal tubules (eventually forming white blood cell casts) (Fig. 2.5). In early infection, neutrophils and bacteria may be seen in the collecting ducts.

### Differential Diagnosis

- On CT, differential diagnosis for focal areas of hypoattenuation includes renal infarction, tumors (renal cell carcinoma), and scarring.
- The hypoattenuating areas associated with infarcts and tumors persist following antibiotic treatment, in contrast to those caused by ABP.
- Furthermore, scarring rarely occurs in adult patients.

### Pearls and Pitfalls

- On ultrasound, the combination of a hypoechoic area and a focal inflammatory bulge to the perinephric space may be misinterpreted as a neoplasm.
- On CT, streak artifacts during the excretory phase may give a false impression of abnormal nephrogram.
- The appearance of a “striated nephrogram” is not pathognomonic for ABP and can be seen in kidneys following renal trauma, in medullary sponge kidney and in autosomal recessive polycystic kidney disease (Table 2.3).



**Fig. 2.4** Acute pyelonephritis. Patient died of sepsis after inadvertent ligation of one ureter. The kidney is swollen and pale. Microabscesses are visible on the cortical surface (From MacLennan GT, Cheng L. Atlas of Genitourinary Pathology. New York: Springer; 2011. Reprinted with permission)

## Chronic Pyelonephritis

### General Information

- Chronic pyelonephritis is a chronic interstitial nephritis that may arise secondary to a host of etiologic causes, including recurrent infection, autoimmune diseases, calculous disease, and chronic obstruction.

### Imaging

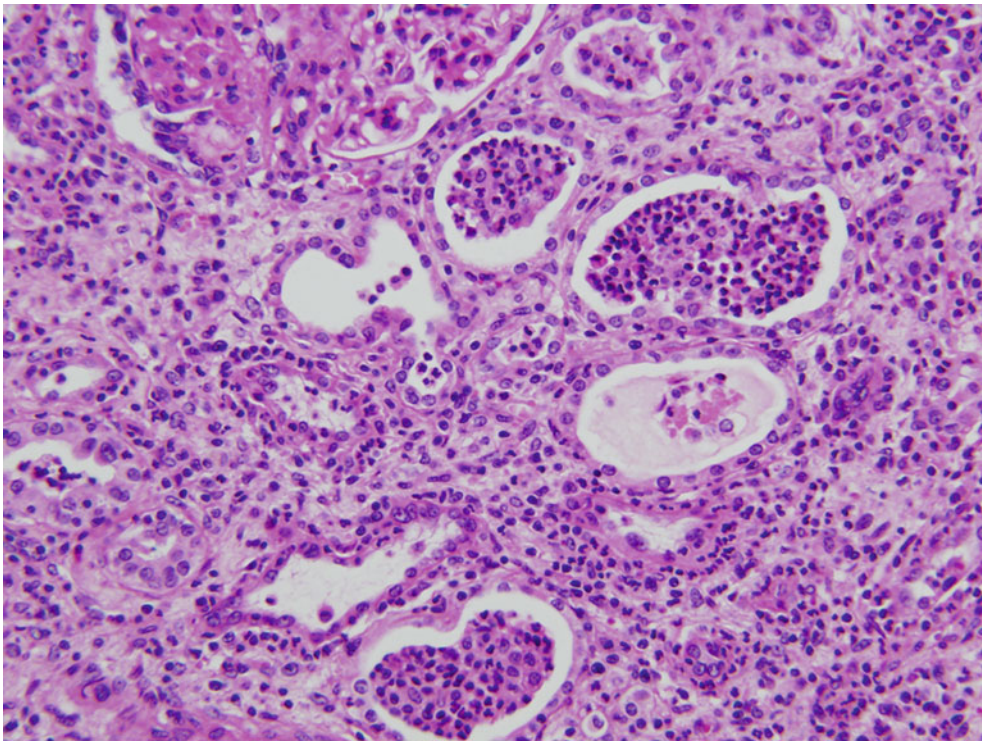
The imaging findings of chronic pyelonephritis are summarized in Table 2.4.

#### Intravenous Pyelography

- Renal size is usually decreased, unless chronic obstruction is present, in which case the renal size may be increased.
- Renal contour blurring.
- Cortical thinning.



**Fig. 2.5** Acute pyelonephritis. Abundant neutrophils are present in the interstitium and within renal tubules



**Table 2.4** Imaging findings in chronic pyelonephritis

Renal scarring
Renal atrophy
Cortical thinning
Hypertrophy of residual normal tissue
Caliceal clubbing
Dilatation of the calyceal system
Renal asymmetry

- Focal nonfunctional area in nephrogram phase.

Ultrasound

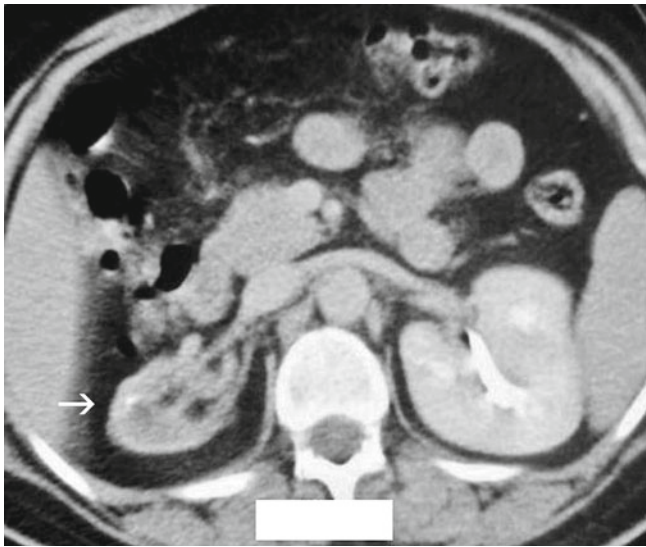
- Focal or diffuse cortical thinning
- Renal scar formation
- Distortion of renal contours

Computed Tomography

- The kidney is usually shrunken and has an irregular outer margin (Fig. 2.6).
- Renal scar formation presents as defect in the margin of the kidney between two calyces.
- Decreased contrast excretion on enhanced CT.
- Fibrotic distortion of the collecting system.

**Pathology**

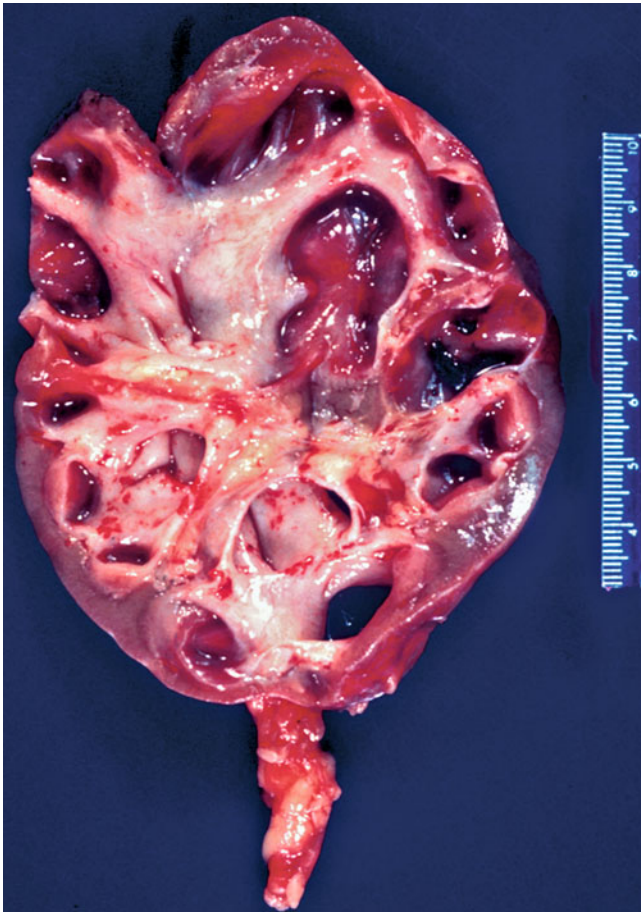
- Chronic pyelonephritis is a general term implying chronic interstitial renal infection due to long-standing obstruction or vesicoureteric reflux, resulting in loss of renal



**Fig. 2.6** Forty-year-old woman with recurrent pyelonephritis. Contrast-enhanced CT scan reveals severe parenchymal scarring of and decreased contrast excretion from the right kidney (arrow). The left kidney is normal

parenchyma, with scarring. Chronic pyelonephritis accounts for 5–15 % of cases of end-stage renal failure. Most patients are asymptomatic until hypertension or uremia develops.

- The gross findings in chronic pyelonephritis are variable. When the condition is obstruction related, the kidney may be large due to dilatation of the collecting system, and the



**Fig. 2.7** Chronic obstructive pyelonephritis. The renal damage in a setting of obstructed renal drainage results from pressure-related atrophy and chronic infection. This patient had long-standing distal ureteral obstruction. The renal pelvis and calyces are dilated, with flattening or obliteration of papillae and global thinning of renal cortex

cortical surface is distorted by irregular scars (Fig. 2.7). Beneath the scars, the renal cortex is thin, and the papillae are scalloped or obliterated, causing the affected calyces to appear dilated.

- Microscopically, chronic pyelonephritis consists of interstitial fibrosis, tubular atrophy, and sclerosis of glomeruli, often patchy in distribution (Fig. 2.8). The interstitial inflammation is mixed but is composed mainly of lymphocytes. Tubules usually contain eosinophilic material, a feature known as “thyroidization.” Arteries and arterioles commonly show fibrosis, mural hyalinization, and occlusion.

## Differential Diagnosis

- Several conditions involving the loss of renal parenchymal tissue such as infarction or papillary necrosis and fetal lobulation should be considered in the differential diagnosis of renal scarring.

## Pearls and Pitfalls

- On ultrasound, the limited depiction of calyces may preclude the distinction of a renal scarring in cases with chronic pyelonephritis.
- In chronic pyelonephritis, tubules usually contain eosinophilic material, a feature known as “thyroidization.”

## Vesicoureteral Reflux and Reflux Nephropathy

### General Information

- Vesicoureteral reflux (VUR) is described as the existence of retrograde urine flow from the bladder to the ureter and the upper urinary tract.
- This condition usually develops secondary to the primary abnormality of the vesicoureteral junction and may cause focal or diffuse acute and/or chronic pyelonephritis.
- The prevalence of VUR in asymptomatic children is less than 0.5 %, but VUR is seen in up to 50 % of children with UTIs. Renal damage, also termed “reflux nephropathy,” develops in only 10 % of the children with symptomatic UTI.

## Imaging

### Intravenous Pyelography

- IVP can demonstrate cortical contour deformity associated with a clubbed calix.
- In the past, IVP was the preferred diagnostic method in the demonstration of renal scarring and parenchymal function but was replaced by ultrasound and DMSA renal scintigraphy because of its low sensitivity in identifying these abnormalities, the nephrotoxic potential of contrast materials used, and the necessity for exposure to radiation.

### Voiding Cystoureterography

- The gold standard method for the evaluation of VUR is the conventional voiding cystoureterography (VCUG) (Fig. 2.9a).

- The international system of radiologic grading of vesicoureteral reflux has assigned five grades of reflux on VCUG:

Grade 0: Indicates no VUR

Grade 1: VUR that does not reach the renal pelvis

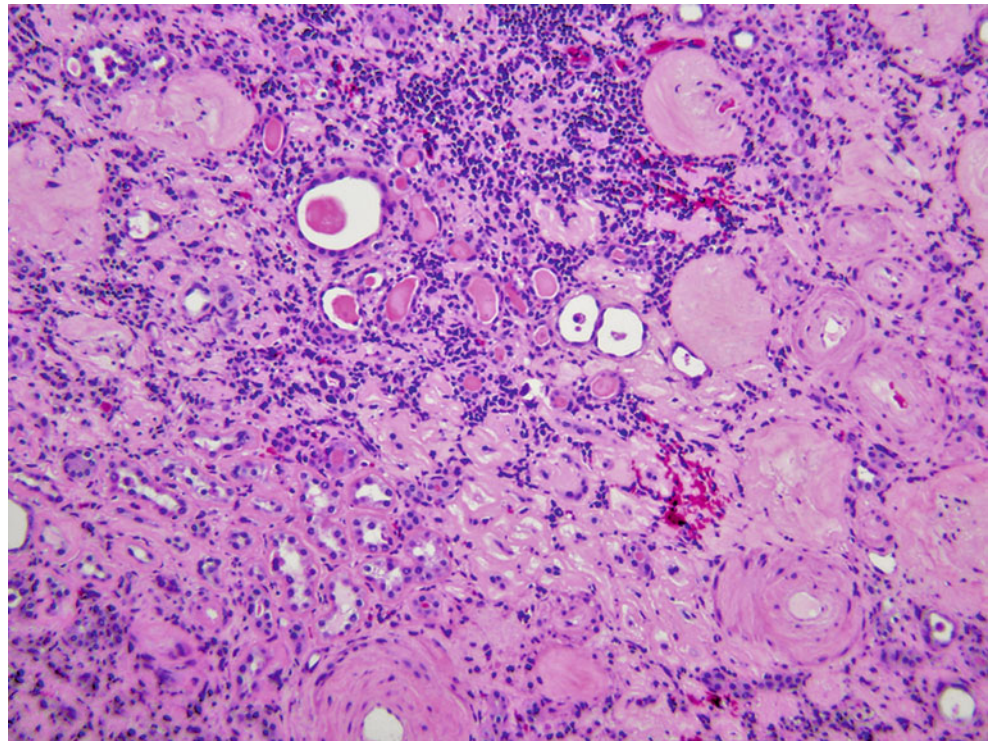
Grade 2: VUR extending to the renal pelvis without dilatation

Grade 3: VUR extending to the kidney with mild ureteral dilatation and mild to moderate pelvicalyceal dilatation

Grade 4: VUR extending to the kidney with moderate ureteral dilatation and complete obliteration of the sharp angles of all fornices



**Fig. 2.8** Chronic obstructive pyelonephritis. The glomeruli are sclerotic, the interstitium shows fibrosis and is infiltrated by lymphocytes, the tubules are atrophic and contain eosinophilic casts (thyroidization), and the blood vessels show intimal sclerosis and mural thickening



Grade 5: VUR extending to the kidney with a tortuous ureter and moderate dilatation of the renal pelvis to extreme dilatation of the entire upper urinary tract

- The sensitivity of VCUG depends on the severity of the VUR. It has been demonstrated that VCUG has 100 % sensitivity in the diagnosis of grade 4 and grade 5 VUR.

#### Ultrasound

- Ultrasound may be helpful for the detection of parenchymal damage and dilatation of the collecting system.
- Features of VUR that may be evident by ultrasound include diminished renal length and dilatation of the ureter, the renal pelvis, and the renal calyces.
- Ureteral dilatation was found to be the most helpful diagnostic feature in detection of the higher grades of VUR by ultrasound.
- Recently, it has been advocated that echo contrast-enhanced cystosonography may be useful in diagnosing, grading, and following up on patients with VUR.

#### Magnetic Resonance Imaging

- Multiplanar cross-sectional T1- and T2-weighted magnetic resonance imaging (MRI) combined with unenhanced 3D magnetic resonance urography (MRU) is potentially useful for morphological evaluation of the urinary system, without the hazards related to the use of intravenous iodinated contrast agents.
- In addition to morphological evaluation, contrast-enhanced MRU provides functional information about

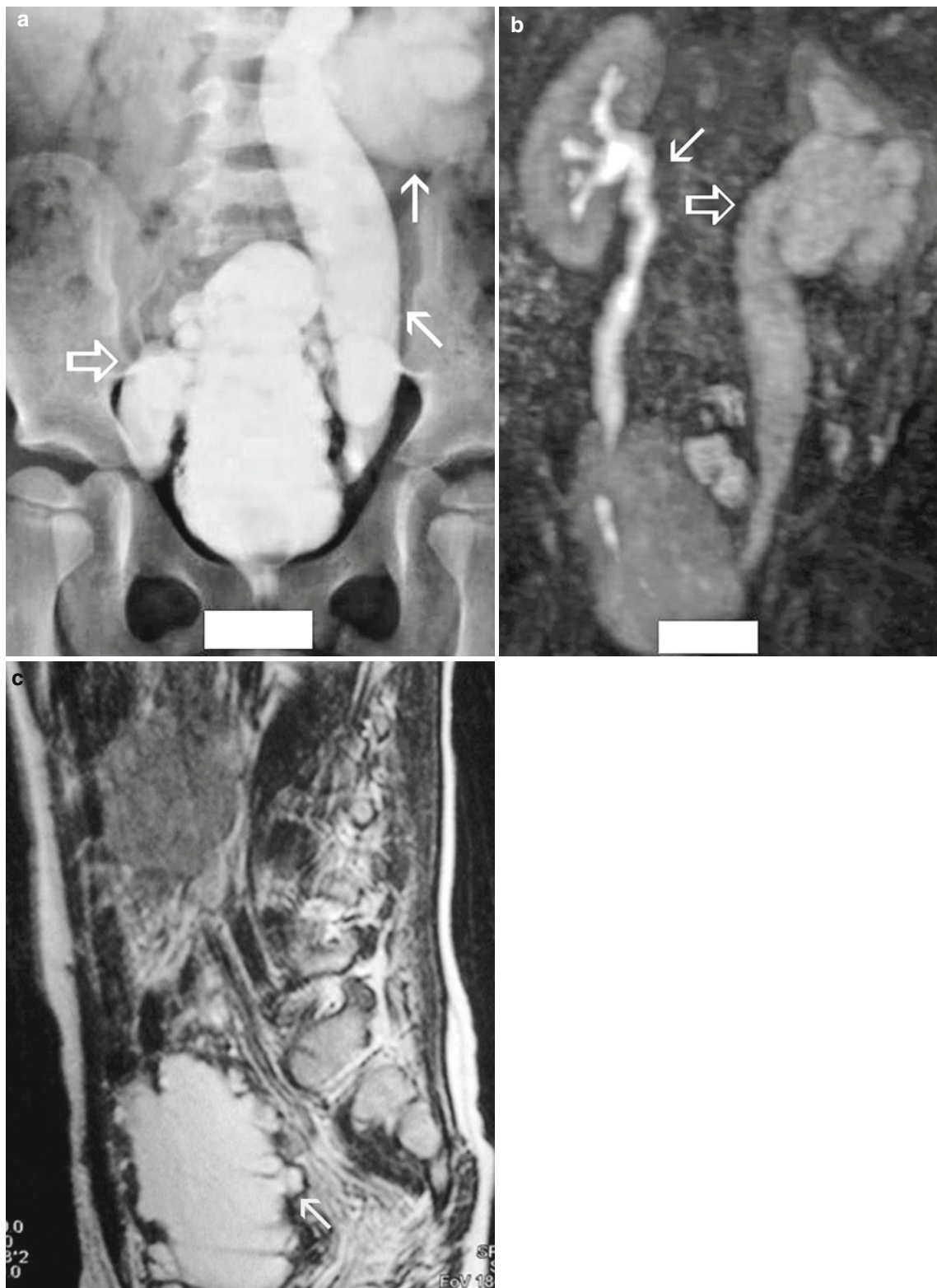
renal perfusion, concentration, and excretion of contrast agent (Fig. 2.9b, c).

- Gadolinium-enhanced T1-weighted excretory MRU may demonstrate the parenchymal scars and perfusion defects associated with reflux nephropathy.
- Probably, the greatest advantage of the use of this T1-weighted gadolinium-enhanced 3D-MRU technique is the visualization of the urinary tract of patients with impaired renal function.
- Unenhanced T2-weighted MRU technique allows excellent visualization of the urinary tract and is useful in patients with dilated collecting systems. However, a non-dilated urinary tract is either invisible or incompletely visualized with this technique, whereas excellent visualization is achieved with contrast-enhanced T1-weighted excretory MRU.

#### Nuclear Scintigraphy

- Direct radionuclide cystography with a  $^{99m}\text{Tc}$ -labeled agent (sulfur colloid, diethylenetriamine penta-acetate [DTPA], or pertechnetate) is a well-accepted alternative to fluoroscopic VCUG for screening asymptomatic children, for follow-up examination of children with vesicoureteral reflux (VUR), for postoperative evaluation after ureteral reimplantation, and for excluding VUR.
- $^{99m}\text{Tc}$ -labeled DTPA scintigraphy is more sensitive than VCUG in detection of VUR.
- DMSA renal scintigraphy has been found to be more sensitive than IVP in the evaluation of focal renal scars.





**Fig. 2.9** VUR and reflux nephropathy in 5-year-old boy with recurrent bladder infection. (a) Retrograde voiding cystourethrogram reveals marked dilatation of the left ureter and left renal pelvicaliceal system (arrows) representing reflux to the left kidney and trabeculations and multiple diverticula in the bladder (open arrow). (b) Coronal contrast-enhanced 3D T1-weighted gradient echo MRI demonstrates minimal

dilatation of the right collecting system (arrow) and severe hydronephrosis on the left collecting system (open arrow). (c) On sagittal contrast-enhanced T1-weighted gradient echo MRI, bladder diverticula (arrow) and diffuse bladder wall thickening secondary to cystitis are visualized excellently

## Pathology

- When chronic pyelonephritis is primarily reflux related, the affected kidney is usually small. Reflux nephropathy usually results from vesicoureteral reflux (a congenital disorder) combined with intrarenal reflux, thus allowing infection access to the renal parenchyma.
- The kidneys are small and contracted, with broad depressed sometimes saddle-shaped scars in the capsule (Fig. 2.10). There is loss of renal pyramids with dilated and thickened calyces, and the renal cortex overlying these areas is thinned. Renal parenchyma between scarred areas may be normal or hypertrophic.
- When these findings are present in a hypertensive patient known to have had long-standing VUR, the renal lesion is sometimes described as “Ask-Upmark kidney” (Fig. 2.11).
- The predominant histologic finding is an interstitial lymphoid infiltrate with extensive renal tubular atrophy. Residual tubules contain eosinophilic casts (thyroidization) (Fig. 2.12). Additional findings include glomerular and vascular sclerosis.

## Differential Diagnosis

- On VCUG, scarring from reflux nephropathy should be differentiated from scarring due to other etiologies such as parenchymal infarction.
- The deformed appearance of the calyx underlying the scar in reflux nephropathy may be a clue for the differential diagnosis.

## Pearls and Pitfalls

- Fetal lobation and other normal variants of renal development may be mistaken for renal scarring on ultrasound.
- With VCUG, misinterpretation may be possible, for example, the soft tissue of the bowel wall may infrequently simulate contrast in a ureter, or overlying stool and intestinal gas may obscure the kidney, precluding the diagnosis of lesser degrees of VUR.

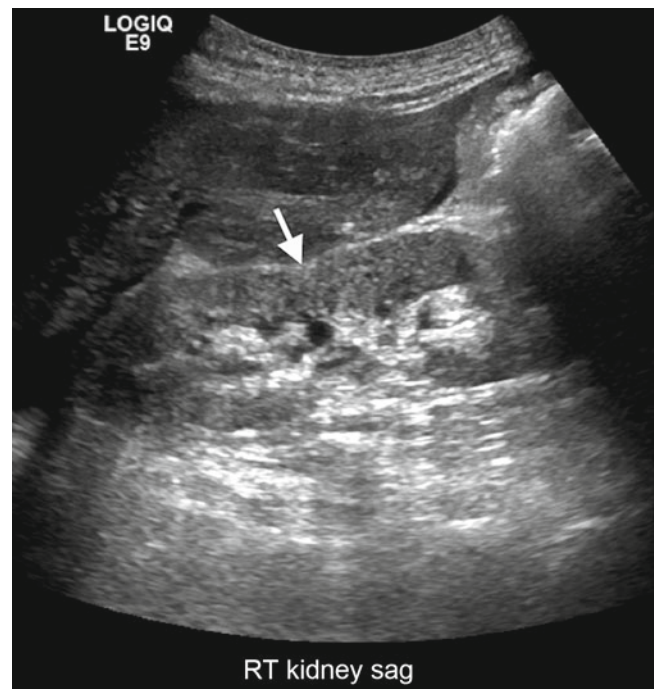
## HIV-Associated Nephropathy

### General Information

- The kidneys are affected in HIV-infected patients by a wide spectrum of entities including HIV-associated nephropathy, atypical infections, malignancy, and drug-related renal disease.
- The nephropathy may be the first manifestation of HIV infection and often precedes opportunistic infections.
- It is the leading cause of renal failure in HIV-positive patients.



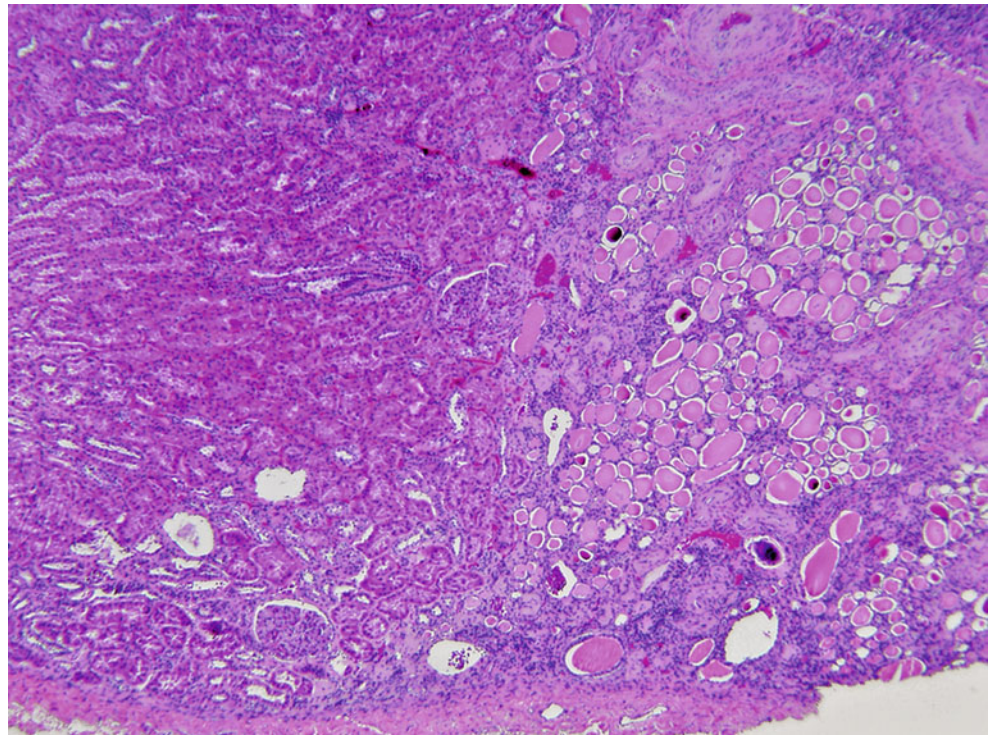
**Fig. 2.10** Reflux nephropathy. Some portions of renal cortex are relatively preserved; in the scarred areas, there is virtually no residual cortex. This is an example of an Ask-Upmark kidney, part of a clinical scenario including chronic urinary tract infections associated with vesicoureteric reflux, hypertension, and a small kidney with saddle-shaped scars



**Fig. 2.11** Ask-Upmark kidney. Gray-scale ultrasound demonstrates saddle shape of the kidney (arrow) secondary to scar formation from VUR



**Fig. 2.12** Reflux nephropathy. In this Ask-Upmark kidney, the renal tissue on the left is essentially normal, whereas on the right, in the area of scarring, glomeruli are absent, and the interstitium is fibrotic and infiltrated by lymphocytes. The tubules are atrophic and contain eosinophilic casts (thyroidization), and the blood vessels show intimal sclerosis



## Imaging

### Ultrasound

- On ultrasound, cardinal imaging findings for HIV-associated nephropathy include normal-sized or enlarged kidneys, increased echogenicity of the cortex, renal pelvicaliceal thickening, and loss of the fat appearance of the renal sinus.
- Renal biopsy provides the definitive diagnosis of the disease; the aforementioned imaging findings are only suggestive.
- Decreased corticomedullary differentiation and parenchymal heterogeneity are late findings of HIV-associated nephropathy.

### Computed Tomography

- CT findings include enlarged kidneys, a hyperattenuating medulla on the unenhanced scan, and a striated nephrographic appearance.
- Various opportunistic renal infectious agents such as *Pneumocystis jirovecii*, fungal organisms, and mycobacteria may affect the kidneys of patients with AIDS, giving rise to a wide spectrum of imaging findings with low specificity, such as renal cortical calcification, focal areas of increased echogenicity in the cortex and medulla, and focal microabscesses and hydronephrosis.
- The presence of renal calcifications and nephrocalcinosis may suggest HIV-associated infection despite not being specific for any specific pathogen.

- Non-Hodgkin lymphoma and Kaposi sarcoma are the most commonly encountered malignancies in patients with HIV infection.
- CT is the imaging modality of choice for the evaluation of all patients with lymphoma. Among the common patterns of renal involvement by the disease are multiple parenchymal masses, solitary lesions, direct extension from retroperitoneal adenopathy, perinephric disease, and nephromegaly.
- Likewise, renal involvement by Kaposi sarcoma associated with AIDS usually gives rise to nonspecific clinical or radiologic manifestations.
- Finally, certain antiretroviral agents such as indinavir and nelfinavir may cause the development of renal calculi.

### Magnetic Resonance Imaging

- On MRI, loss of corticomedullary differentiation and renal enlargement may be seen.

## Differential Diagnosis

- The combination of hyperechoic kidneys and a thickened pelvicaliceal system by ultrasound can imply a possible diagnosis of HIV-associated nephropathy. However, infection and acute tubular necrosis should be considered in the differential diagnosis.
- The presence of calcification and nephrocalcinosis may suggest HIV-associated infection despite not being specific for any specific pathogen.

## Pearls and Pitfalls

- An unusual pattern of nephrocalcinosis defined as “partial nephrocalcinosis” which involves the renal cortex and medulla asymmetrically has been described in patients with AIDS-related *M. avium-intracellulare* infection.

## Renal and Perirenal Abscess

### General Information

- Pyelonephritis leading to renal abscess is quite rare, with an incidence of 0.01 %. Although the vast majority of renal infections undergo resolution with effective antibiotic treatment, one of the complication of inadequately or untreated acute pyelonephritis is renal abscess.
- Renal abscess is more common in patients with conditions predisposing to infection, such as diabetes or other diseases associated with an immunocompromised status (Figs. 2.1, 2.13, and 2.14), as well as with urinary tract obstruction and/or renal stones.
- Renal abscess and pyonephrosis may result from hematogenous seeding of infection in immunosuppressed patients without any urinary obstruction. Furthermore, diabetes mellitus and immunosuppression may predispose patients to the development of an abscess (Fig. 2.15).
- Abscess may also result from interventional procedures, such as diagnostic cyst aspiration (Fig. 2.16a, b), or alcohol embolization of the kidney.

### Imaging

#### Plain Film Radiography

- Abdominal radiography typically demonstrates enlargement of the affected kidney.

#### Intravenous Pyelography

- IVP may reveal nonfunctional or faint opacification of the involved kidney, with focal pelvicalyceal dilatation or focal excretory defects.

#### Ultrasound

- Ultrasound demonstrates a round, thickened, or smooth-walled complex mass.
- At ultrasound, abscess is rarely anechoic (Figs. 2.1a and 2.13a), and it may have internal septation and loculations (Fig. 2.14a). These atypical findings are indistinguishable from those of infected or hemorrhagic cysts (Fig. 2.16a).

#### Computed Tomography

- CT is the best imaging method of determining extension of a renal abscess into adjacent structures.

- On precontrast CT scans, abscess may be a solitary mass or may appear as multiple, round, well-defined, and low-attenuation masses.
- After the administration of intravenous contrast agent, an abscess becomes more conspicuous due to enhancement (Figs. 2.1c, 2.13b, c, and 2.16b). Renal abscess may have an enhancing rim but does not enhance centrally.
- In some cases, Gerota’s fascia may be thickened, or perirenal extension of the abscess may be seen.
- Rupture of a renal abscess or an infected cyst through the renal capsule results in involvement of the perirenal space.
- Perirenal abscess may result from direct extension of peritoneal and/or retroperitoneal infection.

#### Magnetic Resonance Imaging

- On MRI, abscess presents a low or inhomogeneous signal intensity on T1- and T2-weighted images depending on the amount of protein, fluid, and cellular debris.

### Pathology

- Perinephric abscesses occur in the perinephric fat.
- They most commonly result from extension or rupture of a renal abscess or pyonephrosis; however, they can also occur secondary to surgery or transplantation (Figs. 2.17 and 2.18).
- The offending organisms may be demonstrable in the fluid aspirated from abscess cavity (Fig. 2.19).

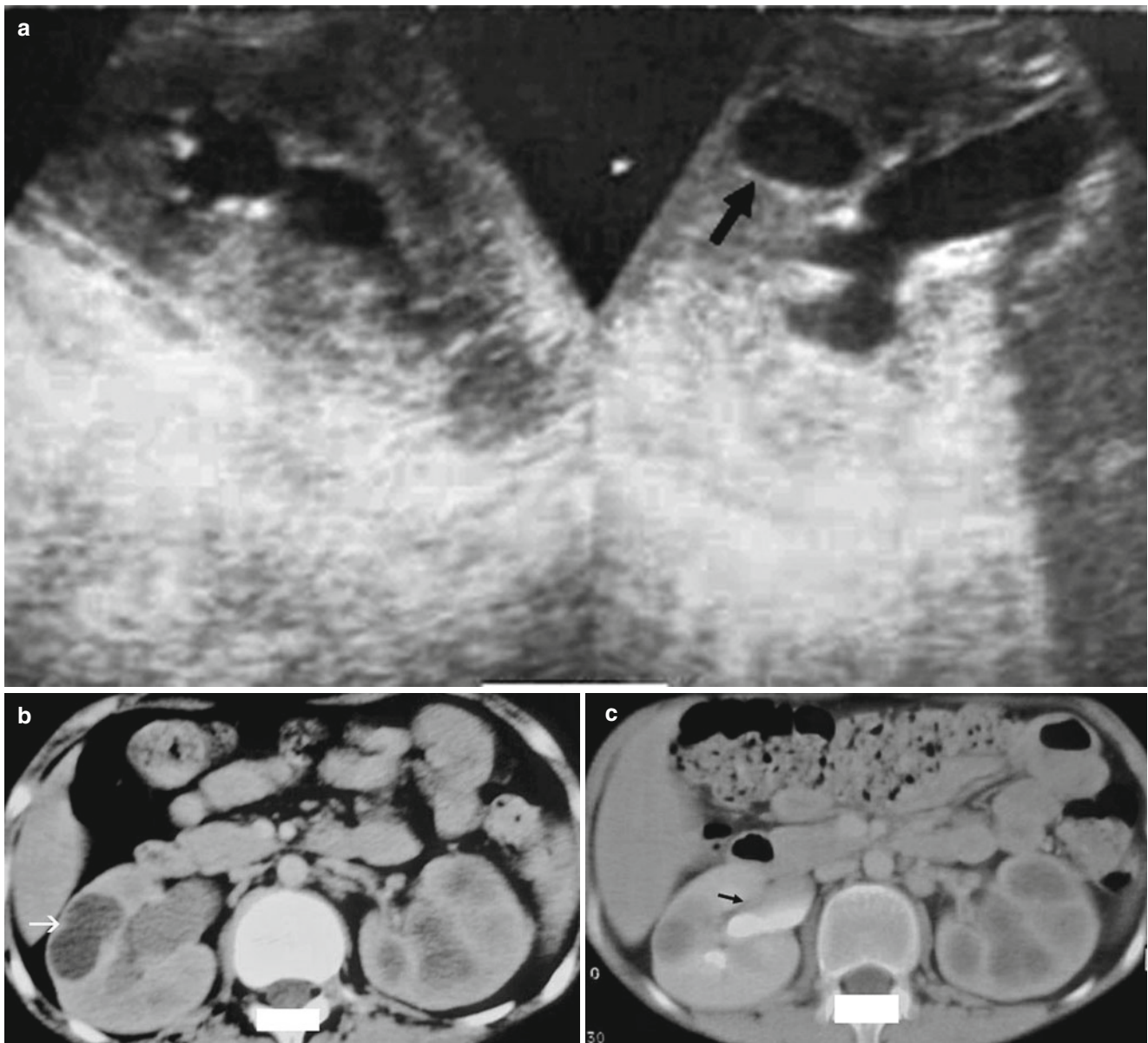
### Differential Diagnosis

- Renal abscesses should mainly be differentiated from a cystic renal cell carcinoma. The lack of vascularity on Doppler imaging may be helpful for the relevant differentiation.
- The differential diagnosis of perinephric abscesses includes perinephric fluid collections like urinoma, subcapsular and perirenal hematoma, renal lymphangiomatosis, pancreatic pararenal fluid collections, and transudate fluid associated with nephropathies.
- For perinephric urinomas, the history of trauma or the finding of an obstructing stone usually suggests the correct diagnosis. Extravasation of excreted contrast material can be depicted on delayed CT scans in patients with trauma to ureters.

### Pearls and Pitfalls

- Several conditions may cause diagnostic pitfalls because each of them may be misinterpreted as perinephric fluid collection. These conditions are:





**Fig. 2.13** Renal abscess and pyohydronephrosis in 18-year-old immunocompromised male with low-grade fever. **(a)** Ultrasound reveals an anechoic fluid collection with thin walls (*arrow*) and echogenic material within the collecting system. Early and late phase contrast-enhanced CT scans **(b, c)** demonstrate a nonenhancing renal mass with regular

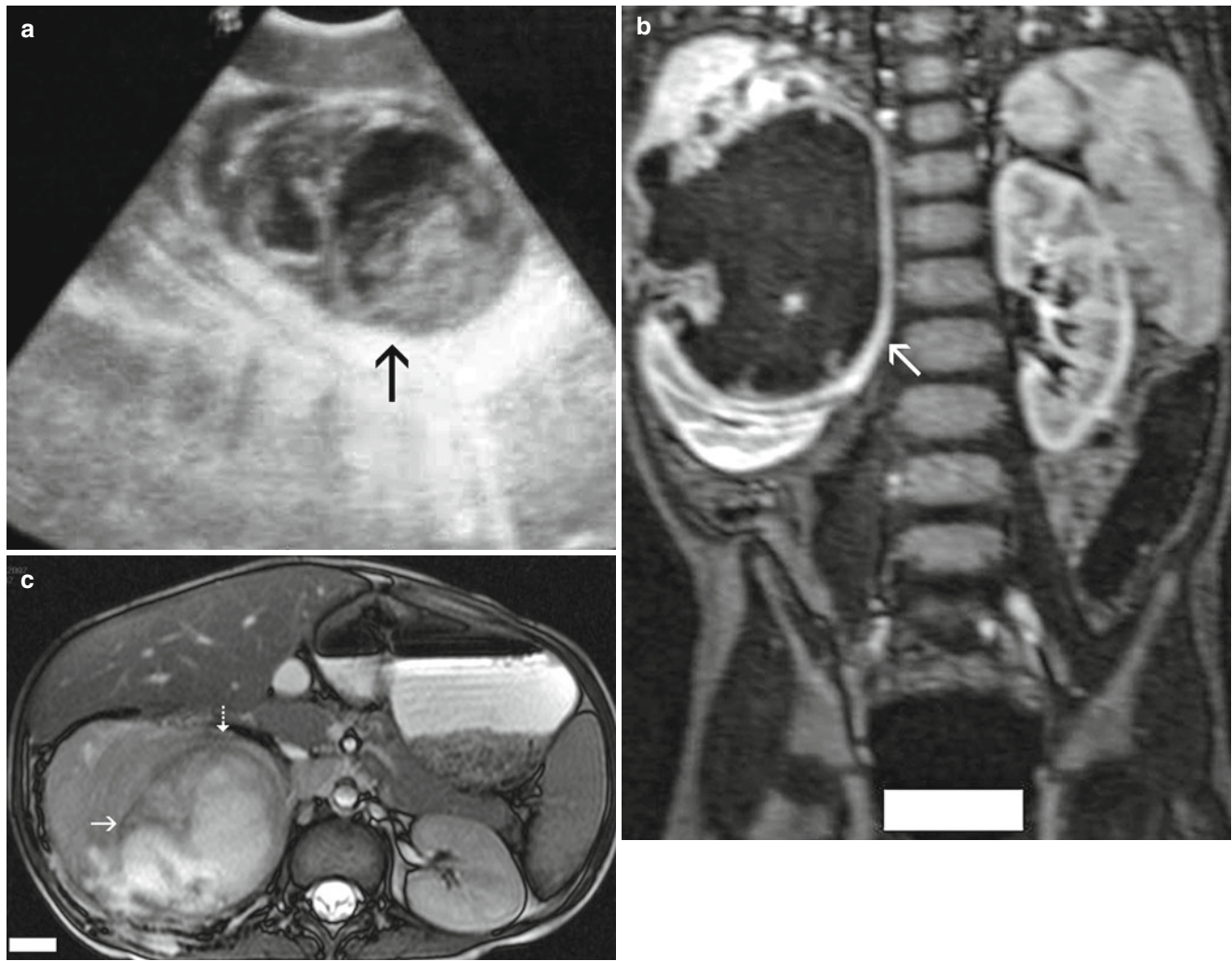
contour (*arrow*), corresponding to fluid collection defined in **(a)** and left hydronephrosis. Note contrast layering over the dense contrast material (*arrow*). All ultrasound and CT changes resolved after appropriate antibiotic therapy

- The hypoechoic rim at the periphery of infantile polycystic kidneys
- The peripheral hypoechoic rim surrounding a kidney
- Acute cortical necrosis
- Perirenal non-Hodgkin's lymphoma
- Retroperitoneal fibrosis
- Prominency of perirenal fat or thickened renal fascia causing a perirenal halo
- Breathing artifact on CT

## Pyonephrosis

### General Information

- Chronic suppurative infection in an obstructed kidney is called “pyonephrosis.”
- In pediatric patients, ureteropelvic junction obstruction, ureterocele, and ureteral ectopia are common causes of obstruction (Fig. 2.20).



**Fig. 2.14** Renal abscess in 5-year-old immunocompromised boy. (a) Ultrasound demonstrates a complex cystic mass with compression of the renal parenchyma (*arrow*). (b) Coronal contrast-enhanced 3D T1-weighted gradient echo image during early phase reveals the lack of enhancement confirming the cystic nature of the lesion (*arrow*).

(c) Axial T2-weighted MRI reveals a hyperintense mass compressing the parenchyma (*dashed arrow*). Renal outlines have become obscured secondary to the perirenal inflammatory process. Note the hypointense rim around the abscess cavity (*arrow*). The pathological diagnosis was renal abscess

- In adults, pyonephrosis is usually due to undiagnosed obstructive nephropathy, such as calculi, tumor, complicated pyelonephritis, strictures, or a congenital anomaly.

## Imaging

### Intravenous Pyelography

- IVP fails to demonstrate the collecting system in pyonephrosis, and it is seldom used for this purpose, except for surgical planning or postoperative assessment.

### Ultrasound

- Ultrasound is useful in early and accurate diagnosis of pyonephrosis.

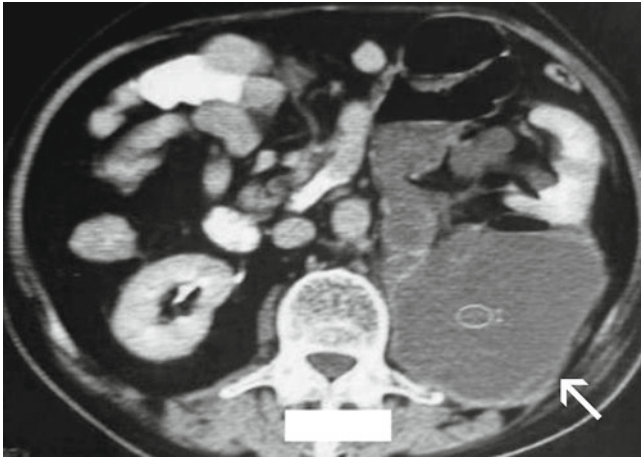
- The classic ultrasound finding in pyonephrosis is the presence of echogenic material in a dilated collecting system (Figs. 2.1a, b and 2.20). There may be fine echoes, fluid–fluid levels, and debris levels within the collecting system.

- Echogenic debris is the most reliable sign of pyonephrosis.

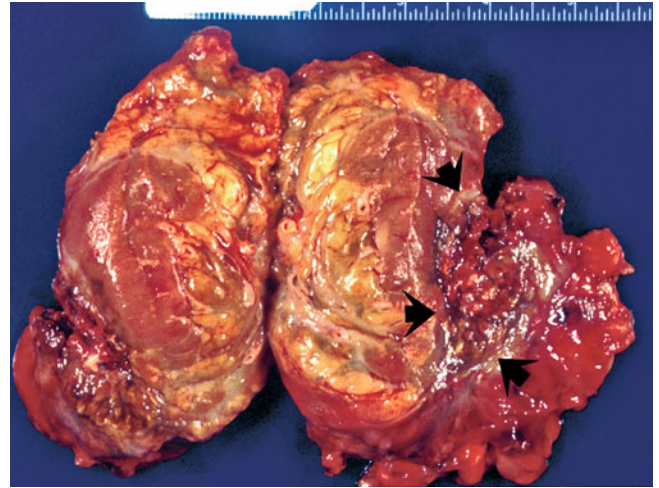
### Computed Tomography

- CT may be useful in evaluating adult pyonephrosis and in detecting the cause of obstruction, which may not be evident on ultrasound.
- CT scan can be performed without the use of intravenous contrast material, with an accuracy of 97 % in the detection of calculi in the urinary tract.
- Contrast-enhanced CT may be useful in demonstrating parenchymal and functional changes. It clearly

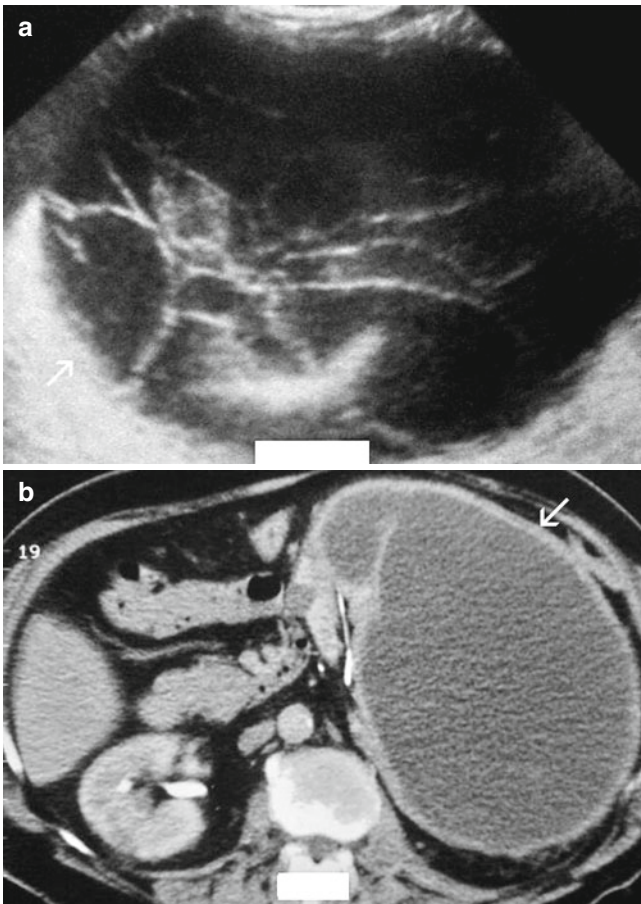




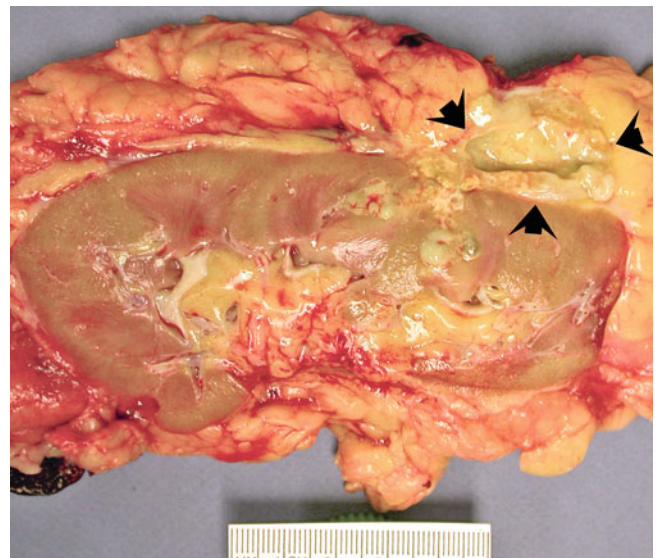
**Fig. 2.15** Perirenal abscess in 40-year-old diabetic woman with *Escherichia coli* in blood and urine cultures. Contrast-enhanced CT scan demonstrates a large perirenal abscess which displaces the left kidney (arrow)



**Fig. 2.17** Perirenal abscess, bacterial. Perirenal abscesses are composed of necrotic renal or perirenal tissue and loculated inflammatory exudate



**Fig. 2.16** Infected renal cyst in a 65-year-old man with left flank pain following several months of percutaneous cyst drainage. (a) Ultrasound reveals a large multilocated cystic lesion with thick wall and internal septations (arrow). (b) Contrast-enhanced CT scan shows that the attenuation of cystic lesion is slightly higher than water and that the lesion had an enhancing wall (arrow). Infected cyst was confirmed by nephrectomy



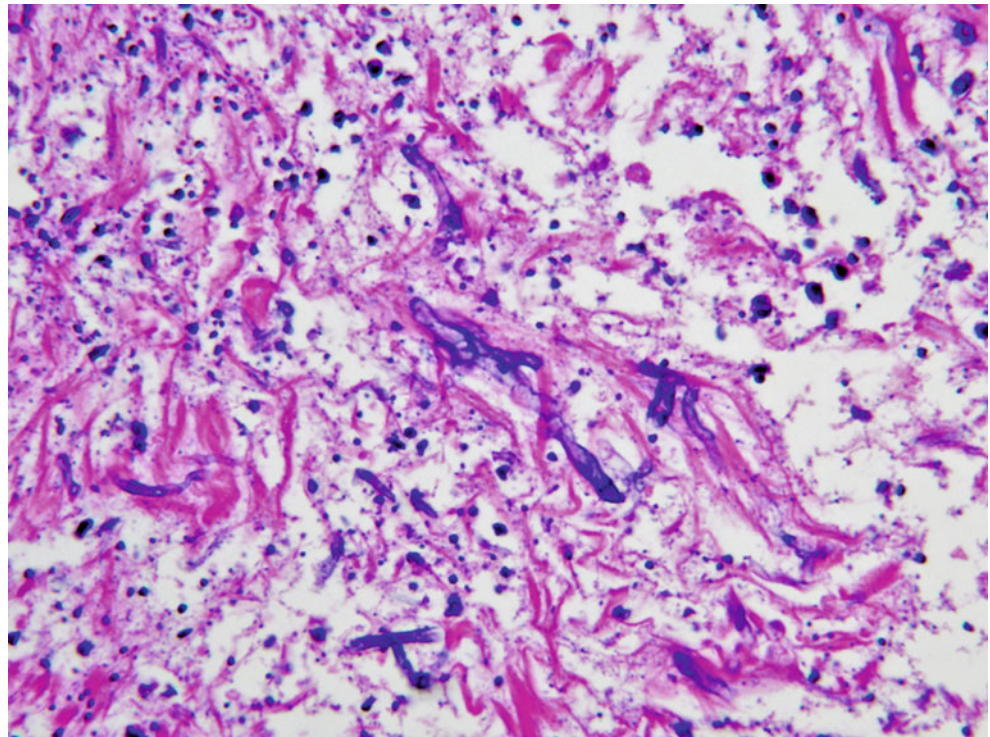
**Fig. 2.18** Perirenal abscess, fungal. This perirenal fungal abscess developed in a 64-year-old man who was immunosuppressed following liver transplant. Despite efforts at conservative management, nephrectomy was required. The abscess involves both renal parenchyma and perirenal fat (arrowheads) (Image courtesy of Stacy Kim, M.D.)

demonstrates thickening of the collecting system wall ( $>2$  mm), parenchymal or perinephric inflammatory changes, and dilatation or obstruction of the collecting system.

#### Magnetic Resonance Imaging

- MRU may show the presence of a fluid/fluid level within the dilated collecting system and is useful in establishing the severity of dilatation, the site, and the most likely cause of obstruction in pyonephrosis.

**Fig. 2.19** Perirenal abscess, fungal. Fungal organisms consistent with *Aspergillus* sp. were identified within the abscess cavity shown in Fig. 2.18



## Pathology

- In pyonephrosis, the kidney is largely replaced by a purulent collection of necrotic renal tissue and inflammatory exudate composed of acute and chronic inflammatory cells and edema fluid, forming, in effect, a contained abscess (Fig. 2.21).

## Differential Diagnosis

- The main differential diagnosis of pyonephrosis includes hydronephrosis.
- Ultrasound findings such as dilatation of the pelvicaliceal system, echogenic collecting system debris, and fluid–fluid levels within the collecting system may be helpful in distinguishing pyonephrosis from simple hydronephrosis.
- CT findings including renal pelvic wall thickness exceeding 2 mm, dilatation of the pelvicaliceal system, parenchymal or perinephric inflammatory changes, and layering of contrast material with the purulent fluid on excretory studies may also provide a correct diagnosis.
- MRI findings suggestive for pyonephrosis are similar to those seen at CT.

## Pearls and Pitfalls

- Rarely, a primary tumor of the upper collecting system, such as transitional cell carcinoma of the renal pelvis, may exhibit low-level echoes on ultrasound and may mimic pyonephrosis.

- Other clinical material, such as urine cytologic findings, may suggest the diagnosis of transitional cell carcinoma.
- Settlement or movement of debris within the lesion with changes in patient position, although observed infrequently, may enable the diagnosis of pyonephrosis.
- MRI may be helpful for the diagnosis in equivocal cases.

## Emphysematous Pyelonephritis

### General Information

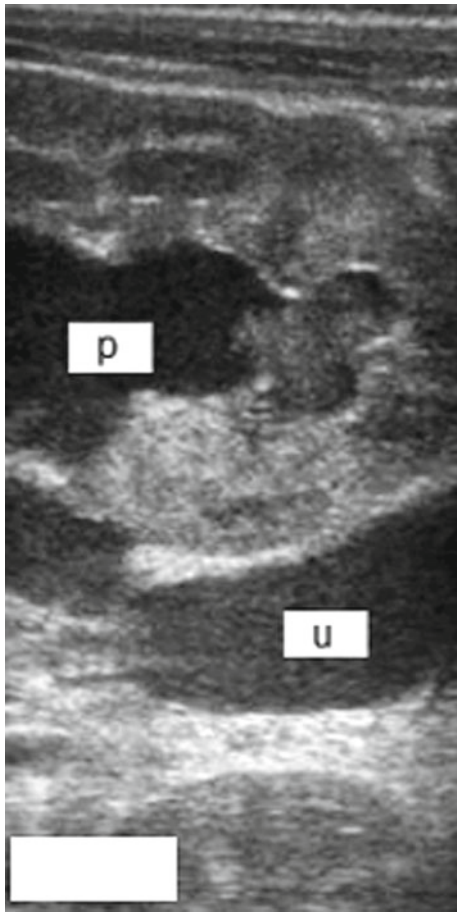
- Emphysematous pyelonephritis (EPN) is a life-threatening necrotizing infection of the kidneys characterized by gas formation within the renal parenchyma or the perinephric space.
- Up to 97 % of patients with EPN are diabetics; in contrast, EPN is quite rare in nondiabetics.
- The commonest infecting organisms include *Escherichia coli*, *Klebsiella pneumoniae*, and *Proteus mirabilis*. Women are affected twice as often as men.

## Imaging

### Plain Film Radiography

- Conventional radiography may demonstrate gas bubbles or abnormal gas collection within the renal fossa (Fig. 2.22a, b).





**Fig. 2.20** Pyonephrosis in 8-month-old boy with suspected upper UTI. On ultrasound, the dilated pelvicalyceal system is filled with echogenic material attributable to debris and organized pus in the renal pelvis and ureter due to ureterovesical junction obstruction (*p* renal pelvis, *u* ureter)

#### Intravenous Pyelography

- IVP may demonstrate a persistent nephrogram on the affected side secondary to delayed excretion of contrast agent.

#### Ultrasound

- Ultrasound demonstrates an enlarged kidney with high-amplitude echoes within the renal parenchyma and often with low-level posterior dirty acoustic shadowing, known as reverberation artifacts (Fig. 2.23a–c).
- Gas in the collecting system can be seen after certain interventional procedures, and it should not be confused with EPN.

#### Computed Tomography

- A CT classification scheme divides EPN into two types:
  - *Type I* is characterized by renal parenchymal destruction that manifests with either streaky or mottled areas of gas (Fig. 2.24). This is seen in 33 % of patients, and the associated mortality is approximately 68 %. Intra- or extrarenal fluid collections are notably absent.
  - *Type II* is characterized by bubbly or loculated gas within fluid collections in the renal parenchyma, collecting system, or perirenal space (Figs. 2.22b and



**Fig. 2.21** Pyonephrosis. The term “pyonephrosis” implies obstructed renal drainage, resulting in a contained abscess with varying degrees of renal parenchymal destruction. The collecting system contains abundant purulent material, and only a thin rim of residual renal tissue remains. This condition resulted from an obstruction at mid-ureter level; the etiology of the ureteral obstruction was indeterminate (From MacLennan GT, Cheng L. Atlas of Genitourinary Pathology. New York: Springer; 2011. Reprinted with permission)

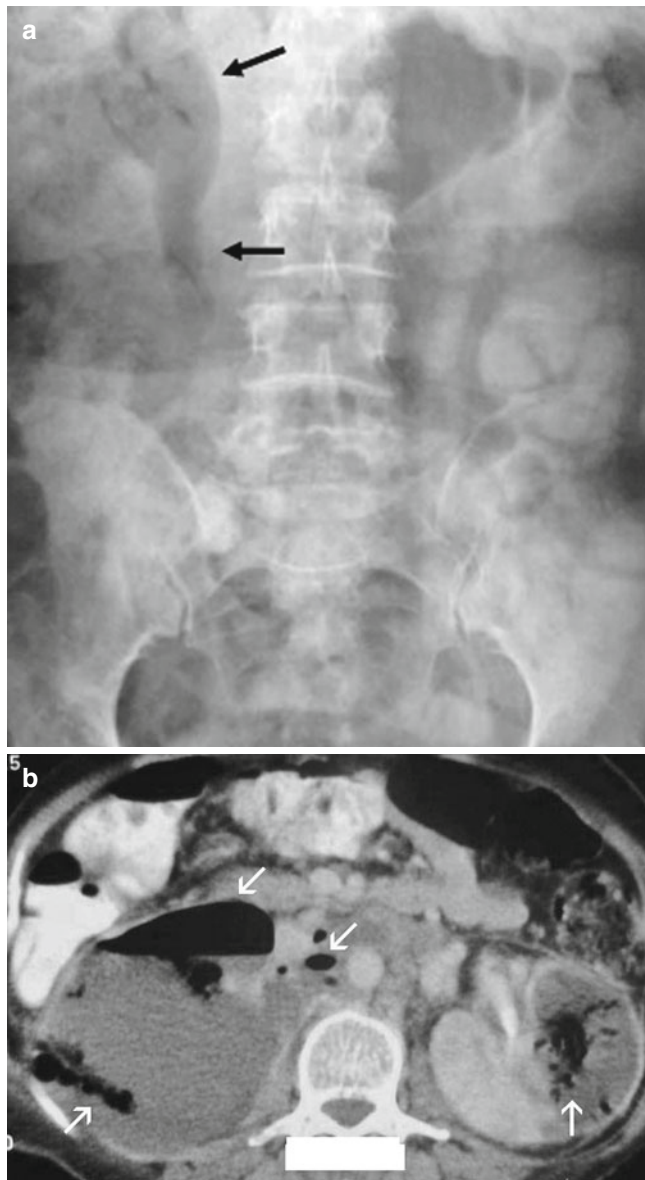
2.23c). This type is seen in 66 % of patients, and the mortality rate is approximately 18 %.

#### Pathology

- Emphysematous pyelonephritis is a rare life-threatening complication of acute pyelonephritis, usually of bacterial origin. It is associated clinically with diabetes mellitus and urinary tract obstruction.
- Abscesses are accompanied by renal papillary necrosis and cortical infarcts. Renal papillary necrosis refers to necrosis of portions of the medulla. There is a cystic appearance to the kidney secondary to gas formation (Fig. 2.25).
- Micro: Empty spaces lacking epithelial cell linings and distorting the parenchyma with areas of vascular thrombosis, ischemic necrosis, suppurative inflammation, and abscess formation.

#### Differential Diagnosis

- Retroperitoneal perforation of abdominal viscera
- Psoas abscess due to gas-forming organisms
- Reflux of air from the bladder
- Bronchorenal, enterorenal, or cutaneorenal fistulae
- Air in a focal renal abscess



**Fig. 2.22** Bilateral type 2 EPN with extensive parenchymal destruction in a 60-year-old diabetic woman. (a) IVP demonstrates lucent air which outlines the right pelvicalyceal system and the right ureter (arrows). (b) Contrast-enhanced CT scan reveals abscess with gas bubbles and fluid contents in the right collecting system and in bilateral renal parenchyma (arrows)

- A history of urologic intervention, such as nephrostomy insertion, or retrograde pyelogram

### Pearls and Pitfalls

- On ultrasound, gas within the kidney or renal pelvis may mimic renal calculi.

- The distal shadowing with reverberations and “dirty shadowing” of low-level echoes may be helpful for the differentiation of EPN from renal calculus.

## Xanthogranulomatous Pyelonephritis

### General Information

- Xanthogranulomatous pyelonephritis (XGP) is a rare form of chronic pyelonephritis, occurring most commonly in women, with a peak incidence in the fifth and sixth decades.
- Clinical symptoms are often vague, and laboratory findings are nonspecific.
- The classic urographic triad in XGP consists of:
  - Unilaterally decreased/absent renal excretion
  - Staghorn calculus (70 %)
  - Poorly defined mass or diffuse renal enlargement

### Imaging

#### Intravenous Pyelography

- May demonstrate an enlarged nonfunctional kidney with staghorn calculi.

#### Ultrasound

- On ultrasound, the kidney is usually enlarged, with multiple hypoechoic or anechoic areas corresponding to dilated calyces and areas of parenchymal destruction.
- Central echogenic foci representing staghorn calculus may be seen. In focal XGP, ultrasound findings are nonspecific, and it is not possible to differentiate this from a renal abscess or necrotic and/or cystic renal cell neoplasm.

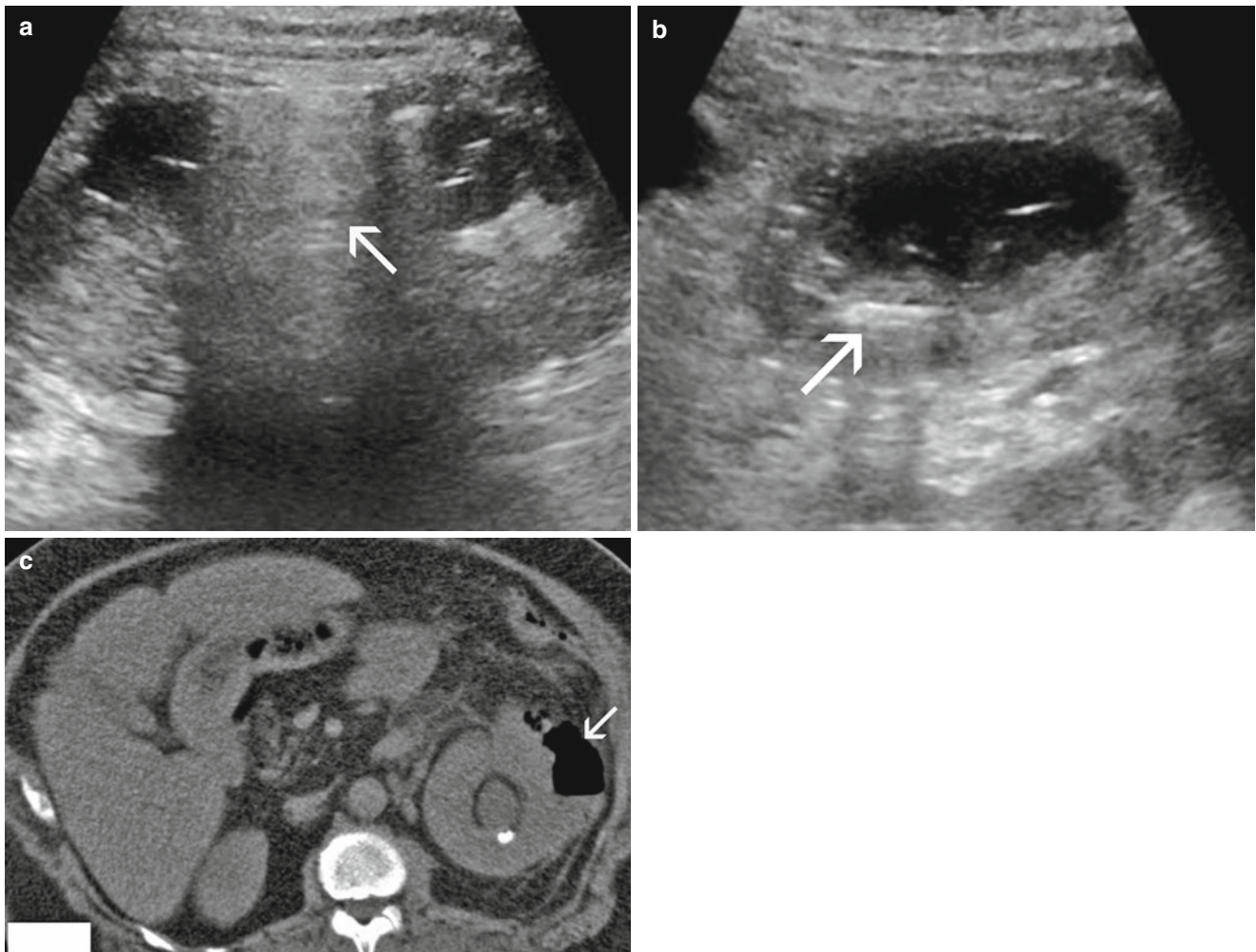
#### Computed Tomography

- CT is more informative than ultrasound in the evaluation of XGP.
- CT findings of diffuse XGP are listed in Table 2.5.
- In diffuse XGP, the inflammatory process may involve the perinephric space, the adrenal gland, the ipsilateral psoas muscle, and/or the subdiaphragmatic area (Fig. 2.26a–d).
- In focal XGP, a focal mass of low attenuation with rim enhancement is seen on CT, often associated with calculus (Fig. 2.27).

#### Magnetic Resonance Imaging

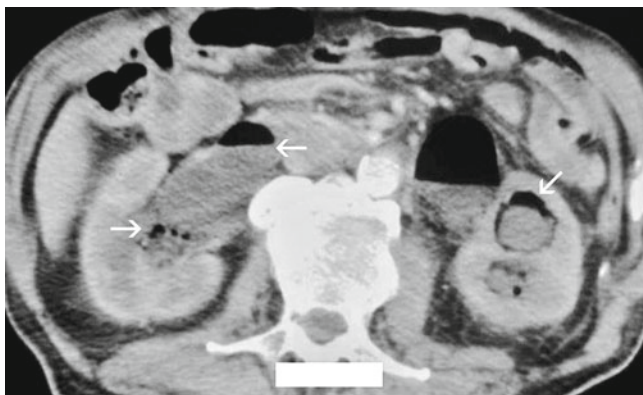
- MRI is valuable for diagnosing XGP and is extremely sensitive for identifying the lipid-laden xanthogranulomatous tissues (Fig. 2.26b–d).
- MRI is less accurate in diagnosing focal XGP with a limited component of lipid-laden macrophages.
- Pseudocystic masses with thick septa of XGP have low signal intensity in T1-weighted images and high signal





**Fig. 2.23** Type 1 EPN in a 50-year-old diabetic woman. Ultrasound (a, b) reveals echogenic foci with “dirty” shadowing in the left kidney (arrow in a). Acoustic shadowing represents stone in the left pelvis

renalis (arrow in b). (c) Unenhanced CT scan demonstrates multiple parenchymal gas collections in the left kidney (arrow)



**Fig. 2.24** EP in a 45-year-old diabetic woman. Unenhanced CT scan demonstrates air bubbles within the renal collecting system and ureter and moderate hydronephrosis bilaterally (arrows)

intensity on T2-weighted images, compared with the renal parenchyma.

- Diffuse XGP may show a wide range of signal intensities on MRI, due to the heterogeneous composition of the chronic suppurative renal inflammation.

### Pathology

- The process may be diffuse, segmental, or focal. In the diffuse form of this entity, the kidney is completely obstructed, most commonly by a staghorn calculus.
- Grossly, the collecting system is thickened, with yellow-white nodules present in the renal pyramids (Fig. 2.28). The process begins with suppurative inflammation in the pelvis and adjacent sinus fat, with the cortex, perinephric fat, and retroperitoneal tissue potentially becoming involved.



**Fig. 2.25** Emphysematous pyelonephritis. This term denotes gas bubble formation in the renal parenchyma or perirenal tissues; it is often accompanied by abscess and cortical infarcts. This kidney is from a teenaged diabetic female who died of urosepsis. Tiny gas bubbles are visible within the purulent infiltrates in the renal cortex (From MacLennan GT, Resnick MI, Bostwick DG. Pathology for urologists. Philadelphia: Saunders; 2003, with permission)

**Table 2.5** Computed tomography findings of diffuse xanthogranulomatous pyelonephritis

Enlarged nonfunctioning kidney
Staghorn or solitary calculus filling the pelvis renalis
Caliceal and/or pelvic dilatation
Multiple nonenhancing cystic masses filled with pus and debris
Rim enhancement with contrast medium administration
Calcifications within the masses
Low-attenuation areas of lipid-rich xanthogranulomatous tissue within the masses
Absence of renal stone
Small, contracted kidney
Abundant perirenal fat tissue

- Histologically, there is a zonal pattern within the xanthogranulomatous nodules and thickened areas. The central zone is composed of necrosis and neutrophils. This area is admixed with/surrounded by foamy histiocytes (Fig. 2.29). The outermost zone is composed of fibroblasts.

## Differential Diagnosis

The differential diagnosis may include infiltrative renal masses, such as:

- Transitional cell carcinoma
- Renal cell carcinoma
- Lymphoma
- Nonneoplastic pseudotumoral conditions such as renal or perirenal abscess
- Pyonephrosis

- Renal tuberculosis (TB)
- Focal or diffuse nephritis
- Fungal infection

The definitive diagnosis must be confirmed by surgery.

## Pearls and Pitfalls

- Gas is rarely seen and may be misinterpreted as pyonephrosis or EPN.

## Renal Hydatid Cyst Disease

### General Information

- Hydatid disease, mainly caused by *Echinococcus granulosus*, frequently involves the liver (60 %) and lungs (25 %); renal involvement occurs only in 3 % of cases.
- The kidney is involved primarily by hydatid disease via the systemic circulation, but secondary involvement by spread from a hydatid cyst in an adjacent organ is possible.

### Imaging

Imaging findings of renal hydatid cyst are summarized in Table 2.6.

#### Plain Film Radiography

- Radiography may show a soft tissue mass in the kidney area with amorphous and/or curvilinear wall calcification, although similar calcifications may be seen in other renal lesions, including simple cyst, hematoma, XGP, and renal cell carcinoma.

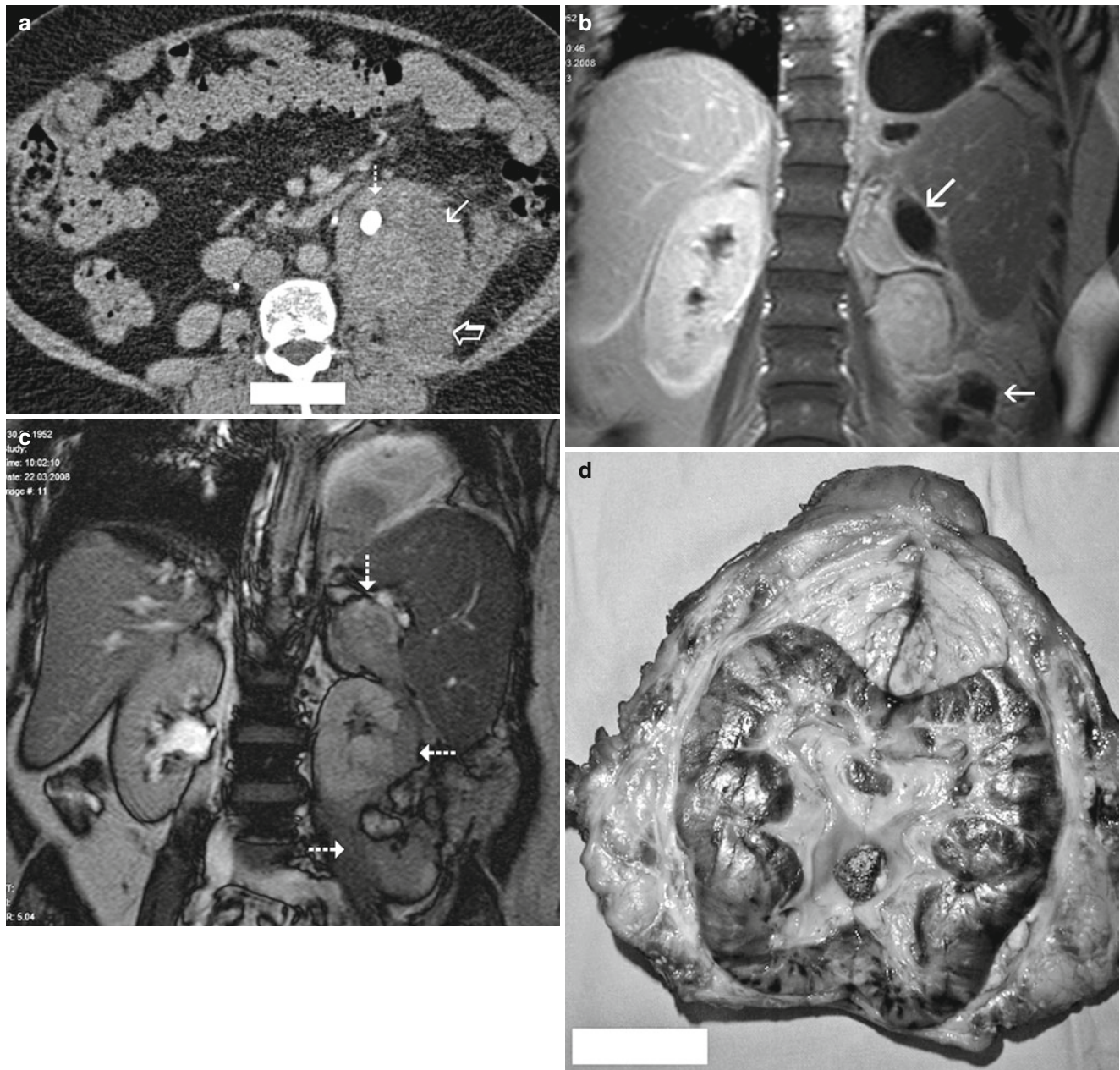
#### Intravenous Pyelography

- IVP may show a rounded soft tissue shadow with curvilinear calcifications, signs of compression of the pelvicalyceal system, and ureter or nonfunctioning kidney.
- If the cyst ruptures into the renal collecting system, IVP may show filling defects, due to daughter cysts in the pelvicalyceal system, or it may disclose the presence of an irregular mass with or without urinary obstruction and a nonfunctioning kidney.

#### Ultrasound

- Various ultrasound appearances of hydatid cysts have been described by Gharbi.
- In the Gharbi classification, a Type I echinococcal cyst appears as a well-defined anechoic lesion on ultrasound and is indistinguishable from a simple cystic lesion (Fig. 2.30a). Multiple echogenic foci due to “hydatid sand” may be seen in the cyst by repositioning of the patient.





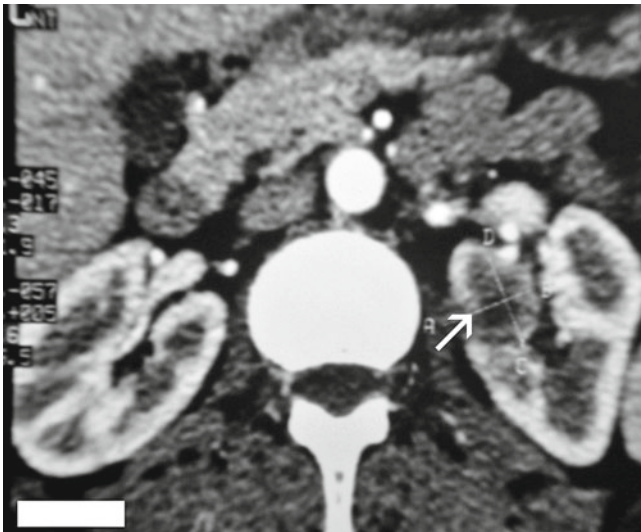
**Fig. 2.26** Diffuse XGP in a 40-year-old diabetic woman. (a) Contrast-enhanced CT scan demonstrates diffuse enlargement of the nonfunctioning left kidney with calculus (*dashed arrow*) and subcapsular fluid collection (*arrow*) and diffuse inflammatory process extending from the left kidney into the left perirenal and left posterior pararenal space (*open arrow*). Coronal contrast-enhanced 3D T1-weighted gradient echo sequence image (b) and coronal true fast imaging with steady-

state precession (FISP) sequence (c) reveal the nonfunctioning left kidney and the fluid-filled areas in the left perirenal and subdiaphragmatic regions (*arrows*). (d) Macroscopic specimen revealed a stone in the left renal pelvis. The renal pelvis and calyces are surrounded by inflamed tissue and infected fluid collections corresponding to xanthogranulomatous inflammation

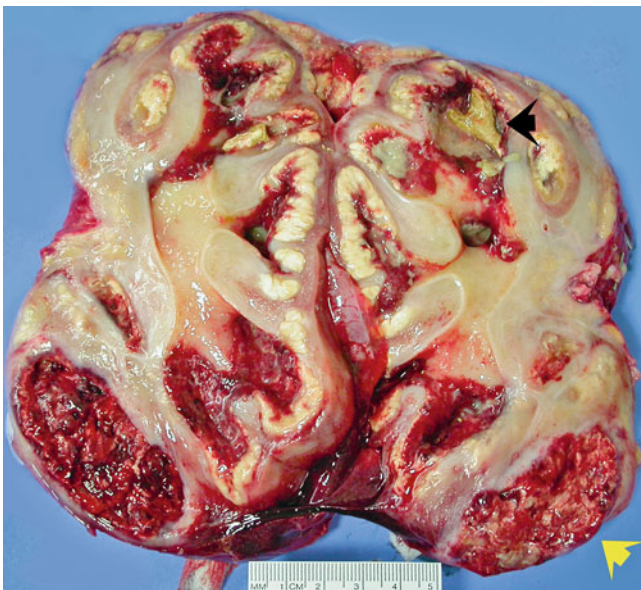
- The findings in cases of Type II echinococcal cyst are generally specific and characteristic for echinococcal disease. In these lesions, floating and detached membranes or daughter cysts that are pathognomonic for hydatid disease may be seen in the cyst (Fig. 2.31a).
- Complete detachment of the membranes inside the cyst has been referred to as sonographic water-lily sign because

of its similarity to the radiographic water-lily sign in pulmonary cysts.

- Both Type II and Type III lesions (multivesicular) are almost pathognomonic for hydatid disease (Fig. 2.31a).
- Type IV and Type V lesions demonstrate heterogenous solid appearances with a combination of liquid and solid cystic contents.



**Fig. 2.27** Contrast-enhanced CT scan of a 51-year-old female patient showing a focal mass of low attenuation with rim enhancement in the left kidney (arrow) which was histopathologically proven to be a focal XGP. Note that the lesion is not associated with any calculus (Courtesy of Ugur Toprak, MD, Ankara, Turkey)



**Fig. 2.28** Xanthogranulomatous pyelonephritis. This is typically a renal calculus-associated inflammatory process that may be difficult to distinguish radiologically from a renal neoplasm. The cut surface exhibits multiple gray-white to yellow nodules. The papillae are blunted, and a staghorn calculus (black arrow) is present. The inflammatory process often extends into the perirenal and sinus fat (yellow arrow) (Image courtesy of Douglas Hartman, M.D.)

- Type V lesions demonstrate calcifications in the cyst wall and generative membranes.

#### Computed Tomography

- On CT, the contents of a closed simple (intact) unilocular cyst are homogenous, with a density close to that of water (10 HU) (Fig. 2.30b).

- Calcification of the cyst wall or internal septa is easily demonstrated on CT (Fig. 2.31b).
- CT may reveal detachment of the generative membranes from the ectocyst, which gives the pathognomonic appearance of a ruptured cyst.
- On CT, the presence of daughter cysts is pathognomonic of renal cystic hydatid cyst (Figs. 2.31b and 2.32a).

#### Magnetic Resonance Imaging

- MRI diagnosis of intact unilocular renal hydatid cysts is based on demonstration of a relatively thick cyst wall (Fig. 2.30c).
- Although cyst wall calcification is more clearly demonstrated on CT, MRI is superior in demonstrating hydatid cyst morphology and the exact extent of the disease (Figs. 2.30c, 2.32b, c, 2.33, and 2.34a–c).
- On T1-weighted images, the parasitic cyst wall is isointense relative to the fluid in the cyst and appears on T2-weighted images as a low-signal-intensity rim surrounding the homogeneous high signal intensity cyst contents (Figs. 2.30c and 2.32b).
- On MRI, intact renal unilocular hydatid cyst may show homogeneous hypointense signal on T1-weighted images and homogeneous hyperintense signal on T2-weighted images.
- Perforated hydatid cysts exhibit detached generative membranes.
- The membranes are seen as floating structures within the cyst and appear dark on both T1- and T2-weighted images (Figs. 2.33 and 2.34a–c).

#### Pathology

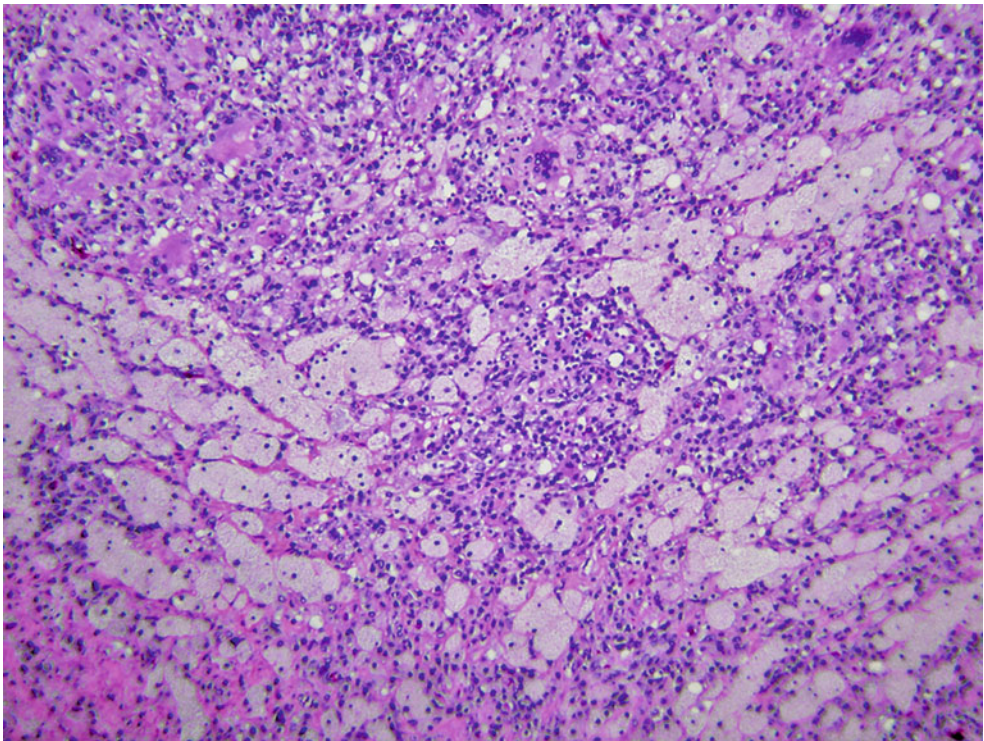
- Gross: Large multiloculated cyst containing numerous hydatid cysts (daughter cysts).
- Micro: The cysts are enveloped by a fibrous pseudocapsule and may be empty or contain scolices with evident hooklets. The daughter cysts have an outer layer of laminated chitin.

#### Differential Diagnosis

- Sonographically, a Type I hydatid cyst may be indistinguishable from a simple renal cyst, but a double contour thick wall, involvement of other organs, or a history of living in endemic regions strongly favors the diagnosis of hydatid cyst.
- On CT, enhancement of the wall of the cyst with contrast helps in differentiating hydatid cyst from simple renal cyst or abscess.



**Fig. 2.29** Xanthogranulomatous pyelonephritis. There is a polymorphous assortment of inflammatory cells, including neutrophils centrally, with a broad zone of large pale lipid-laden macrophages, plasma cells, eosinophils, and lymphocytes and sometimes multinucleated giant cells, as in this case. There is usually a fibrous reparative reaction at the periphery of the inflammatory nodules



**Table 2.6** Sonographic appearance of hydatid cysts in Gharbi classification

Type I – Well-defined, purely anechoic lesions that may be indistinguishable from simple renal cysts. Multiple echogenic foci due to hydatid sands may be seen in the cyst
Type II – A focal or diffuse detachment of the inner germinal layer results in a floating membrane inside the cyst
Type III – Multiseptated cysts with multiple daughter cysts
Type IV – Heterogeneous solid appearance with infolded membranes and internal echoes
Type V – Solid appearance calcifications in the cyst wall and germinative membranes

- The “rim sign” on MRI corresponding to low-signal-intensity cyst wall is also helpful for differentiating unilocular hydatid cysts from simple renal cysts, although this sign has also been described in hepatocarcinoma, amoebic liver abscess, adenoma, and hematoma.
- The diffuse and bilateral nature of polycystic kidney disease is helpful in distinguishing this entity from Type III hydatid cysts.
- On CT, the presence of daughter cysts is a helpful in distinguishing Type 3 hydatid cysts from simple renal cysts, renal abscess, and cystic renal cell carcinoma.
- The heterogenous appearance of Type IV lesions may be difficult to distinguish from infected renal cysts, abscesses, pyonephrosis, hydronephrosis, and neoplasms.
- CT may be useful in the diagnosis of Type IV hydatid cysts with a “pseudotumor” appearance.

## Pearls and Pitfalls

- The Gharbi classification is used in classifying hydatid cyst disease.
- Postoperative imaging findings should not be misinterpreted as a recurrence.

## Renal Malakoplakia

### General Information

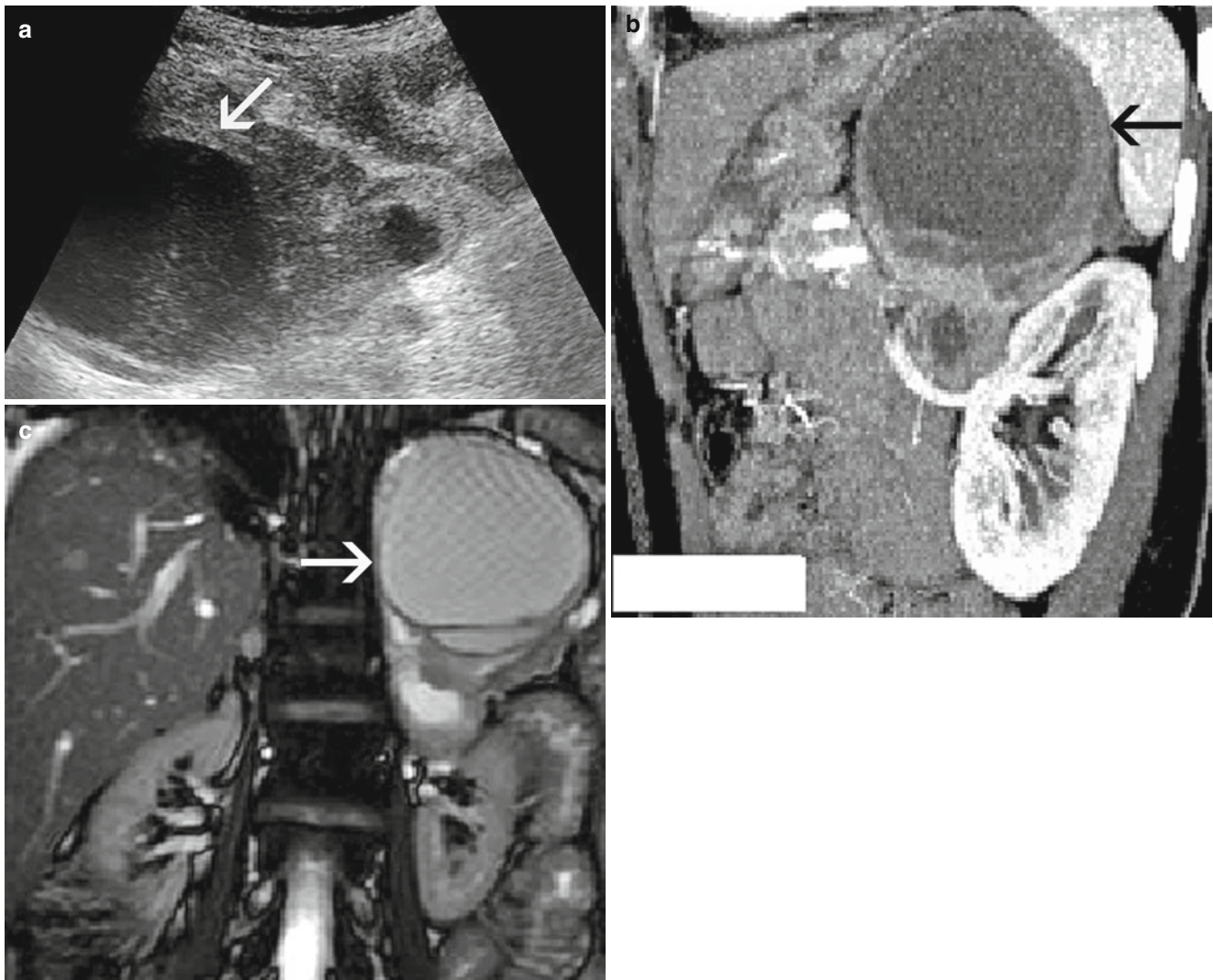
- Malakoplakia is a rare granulomatous inflammatory disease associated with chronic coliform infections caused by abnormal macrophage function.
- Fewer than 200 cases of renal malakoplakia have been reported in the literature so far.
- Clinically, it is most often accompanied by fever, flank pain, or a palpable flank mass.

### Imaging

- The imaging findings of malakoplakia are nonspecific and can often mimic other lesions, such as renal neoplasms; therefore, the diagnosis is typically made only after surgical intervention.

#### Plain Film Radiography

- Usually reveals the presence of an enlarged kidney.



**Fig. 2.30** Thirty-year-old woman with renal hydatid cyst. (a) Ultrasound demonstrates a large, unilocular cyst with a well-defined contour and thick wall (*arrow*) with inflammatory reaction adjacent to the cyst. (b) A sagittal oblique maximum intensity projection CT reconstruction image of the left kidney shows an intense enhancement of the cyst wall (*arrow*). (c) T2-weighted MRI reveals a large unilocular cyst containing high-intensity fluid and having a low-intensity rim “pericyst” (*arrow*)

struction image of the left kidney shows an intense enhancement of the cyst wall (*arrow*). (c) T2-weighted MRI reveals a large unilocular cyst containing high-intensity fluid and having a low-intensity rim “pericyst” (*arrow*)

#### Intravenous Pyelography

- On IVP, one or both kidneys are large, with smooth contours and with diminished or absent function.
- Filling defects in the collecting system with calyceal distortion due to foci of malakoplakia have been described.

#### Ultrasound

- Ultrasound demonstrates distortion and compression of the central echo complex by well-defined masses with variable echogenicity.
- Ultrasound findings may be observed unilaterally or bilaterally.

#### Computed Tomography

- CT may show nonspecific masses or an enlarged kidney with poor contrast uptake.

- Nonenhancing areas in the kidney may be seen in contrast-enhanced CT.

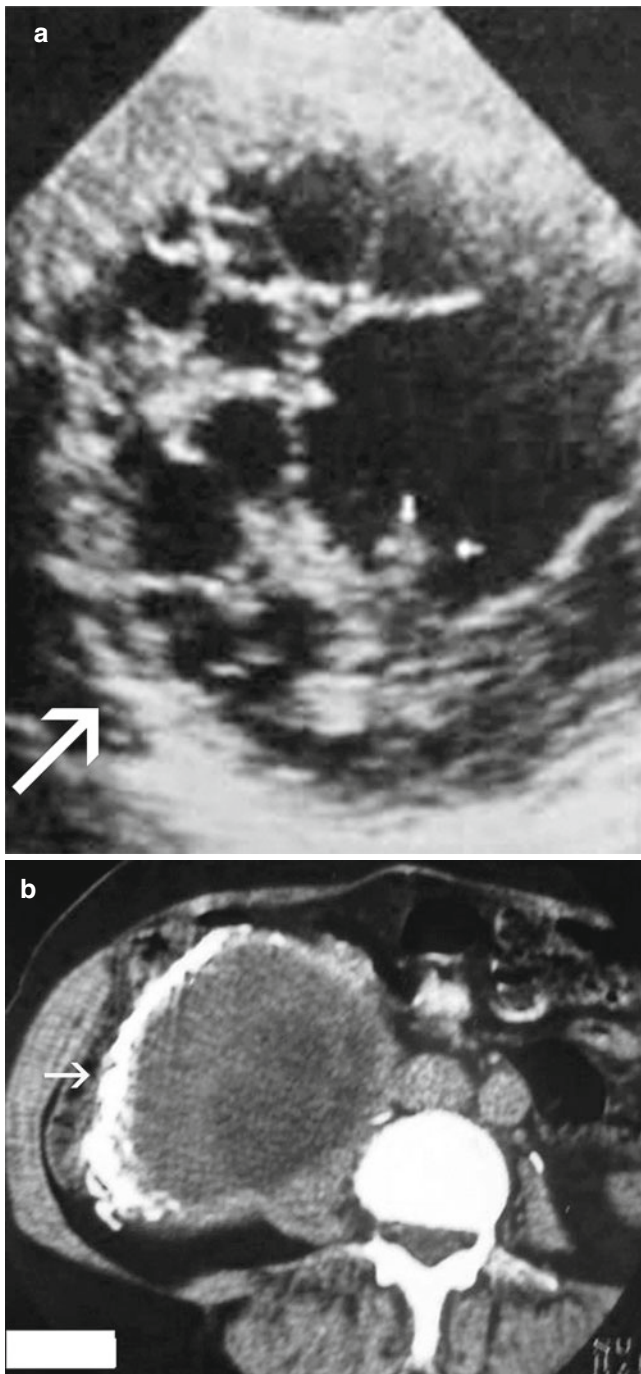
#### Magnetic Resonance Imaging

- Irregularly contoured kidneys with multiple 1- to 2-cm poorly defined nodules.
- Nodules have low signal intensity on T1- and T2-weighted MRI sequences.

### Differential Diagnosis

- XGP (unilaterality and the presence of upper tract calculi are more in keeping with XGP than with malakoplakia)
- Localized abscesses
- Lymphoma
- Multifocal primary or metastatic tumors

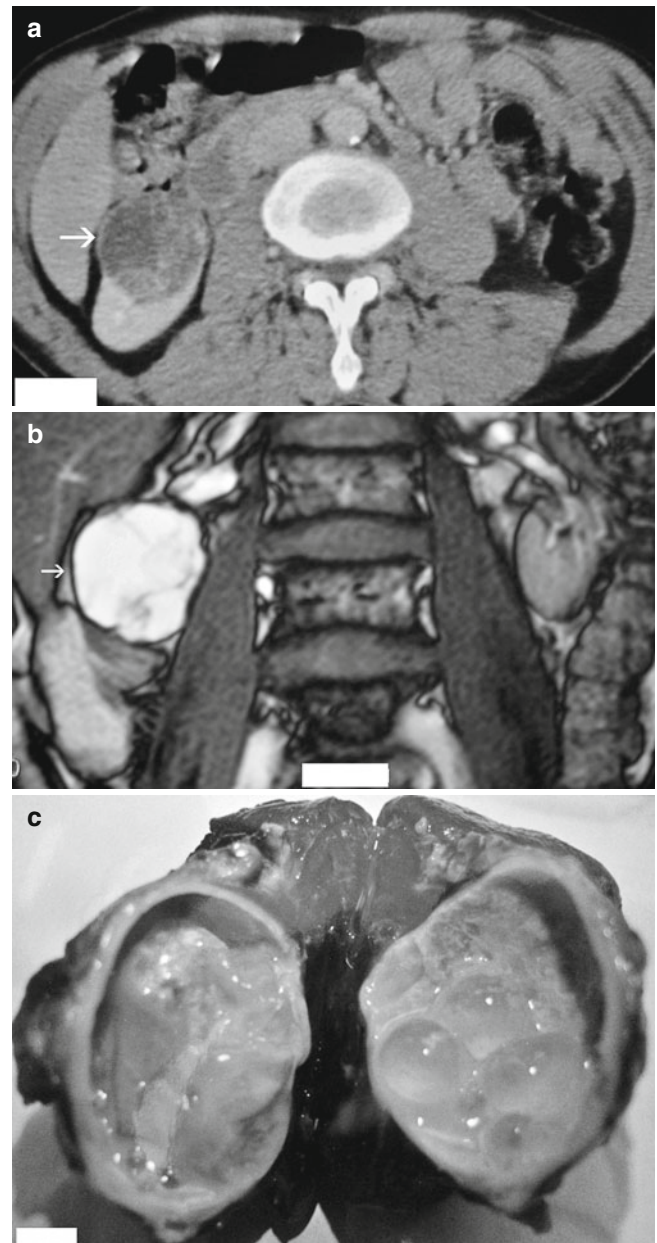




**Fig. 2.31** Thirty-five-year-old woman with renal hydatid cyst. (a) Ultrasound demonstrates a multilocular cyst in the right kidney (*arrow*). (b) Contrast-enhanced CT scan reveals multilocular appearance due to numerous daughter cysts. Note curvilinear calcification of the cyst wall (*arrow*)

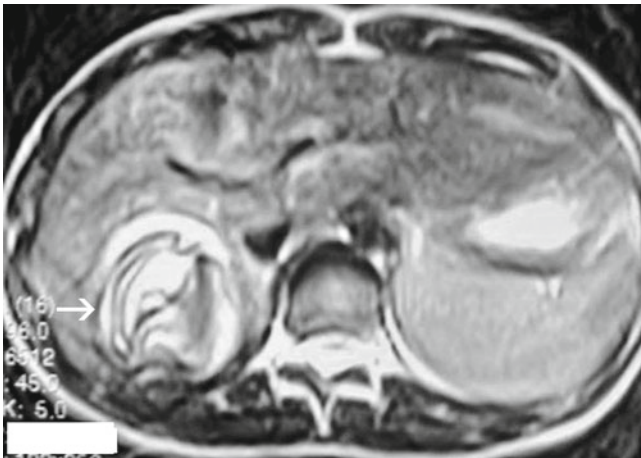
### Pathology

- Malakoplakia is a chronic granulomatous disease usually resulting from recurrent urinary tract infections in middle-aged women. It is an uncommon disorder that most often involves the urinary bladder but very rarely occurs in the upper tracts.



**Fig. 2.32** Forty-year-old man with renal hydatid cyst. (a) Contrast-enhanced CT scan demonstrates a lobulated cystic mass with enhancement located on the right kidney (*arrow*). The cyst wall is not apparent. (b) On coronal T2-weighted MRI, a low-signal-intensity peripheral rim of capsule (*arrow*) and daughter cysts are well demonstrated. In this image, hydatid cyst is demonstrated much better than on CT. (c) Macroscopic specimen revealed the hydatid cyst containing numerous daughter cysts

- In this entity, the renal parenchyma and pelvis are coated with multiple yellow-brown soft plaques.
- The plaques are composed of large eosinophilic histiocytes (von Hanseman histiocytes), many of which contain basophilic cytoplasmic inclusions (Michaelis–Gutmann bodies) (Fig. 2.35). The inclusions represent



**Fig. 2.33** Thirteen-year-old girl with ruptured right renal hydatid cyst. On T2-weighted MRI, detached germinative membranes in hydatid fluid (arrow) are seen

incompletely digested bacilli and can be highlighted with the PAS stain and special stains for calcium (von Kossa) and iron.

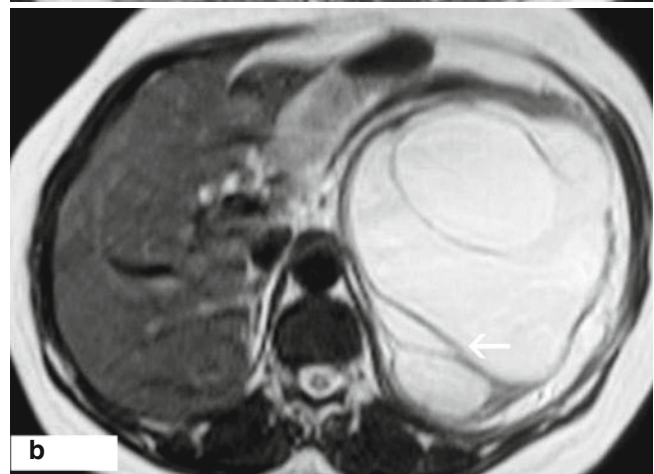
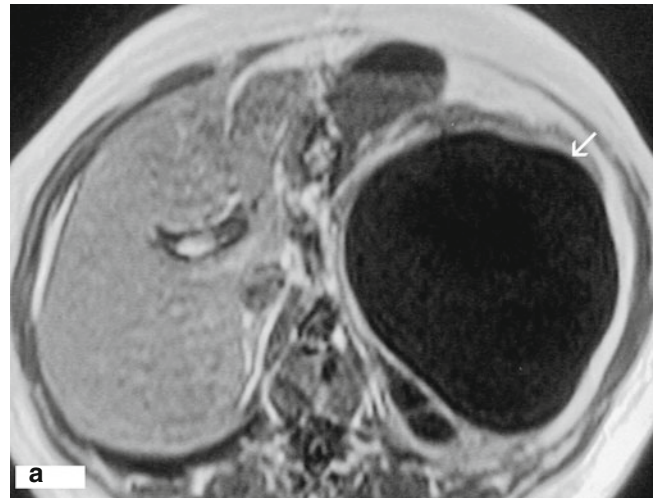
### Pearls and Pitfalls

- The radiological appearance of renal malakoplakia, depending on the pattern of involvement, is usually nonspecific.
- The malakoplakia nodules have low signal intensity on T1- and T2-weighted MRI sequences.
- The plaques are composed of large eosinophilic histiocytes (von Hanseemann histiocytes), many of which contain basophilic cytoplasmic inclusions (Michaelis–Gutmann bodies).

## Renal Tuberculosis

### General Information

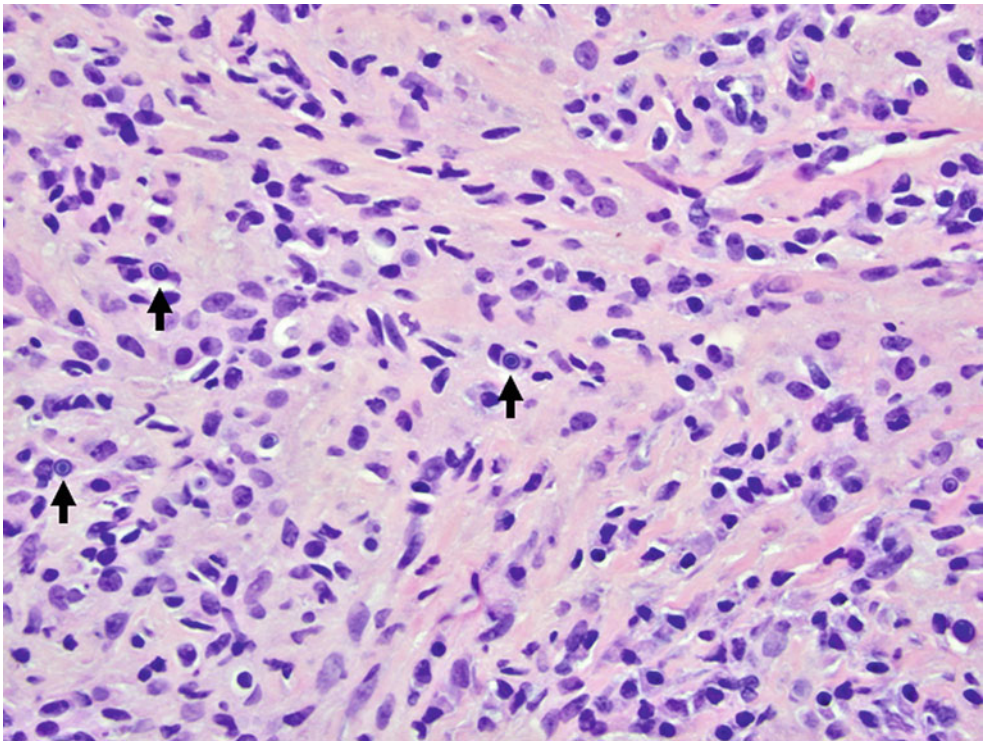
- Genitourinary involvement by tuberculosis (TB) develops in approximately 8 % of patients with pulmonary disease.
- Less than 50 % of patients with renal TB have a known history of TB.
- Abnormal radiographic findings typical of pulmonary TB are present in only 50 % of patients with renal TB, and only one-half of these patients show signs of active TB.



**Fig. 2.34** Thirty-year-old woman with a ruptured renal hydatid cyst. (a) T1-weighted MRI reveals a low-signal-intensity mass in the left kidney (arrow). Cyst wall is isointense relative to cyst contents. On T2-weighted MRI (b, c), the detached germinative membranes (arrow in b) are shown much better than on T1-weighted MRI. Daughter cysts (arrow in c) are identified within the mother cyst. Note both detached membranes and pericyst are of low intensity



**Fig. 2.35** Malakoplakia. Microscopic picture demonstrating eosinophilic histiocytes and Michaelis–Gutmann bodies (arrows)



**Table 2.7** Imaging findings of renal tuberculosis

Intravenous pyelography
Calcified parenchymal masses
Irregularity of the caliceal contour
Stricture formations in infundibula and renal pelvis
Ultrasound
Mass lesions with variable echogenicity
Necrotic areas of caseation
Calcifications
Computed tomography
Punctate, curvilinear, lobar, or diffuse calcifications in renal parenchyma and pelvis renalis
Caliectasis
Strictures of infundibulum and renal pelvis
Hydronephrosis
Parenchymal scarring

## Imaging

Imaging findings of renal TBC are summarized in Table 2.7.

### Intravenous Pyelography

- IVP may show calcified parenchymal masses and irregularity of the caliceal contour due to necrotizing papillitis.

- Development of infundibular, pelvic, or ureteral strictures is a common finding and is nearly pathognomonic of TB.

### Ultrasound

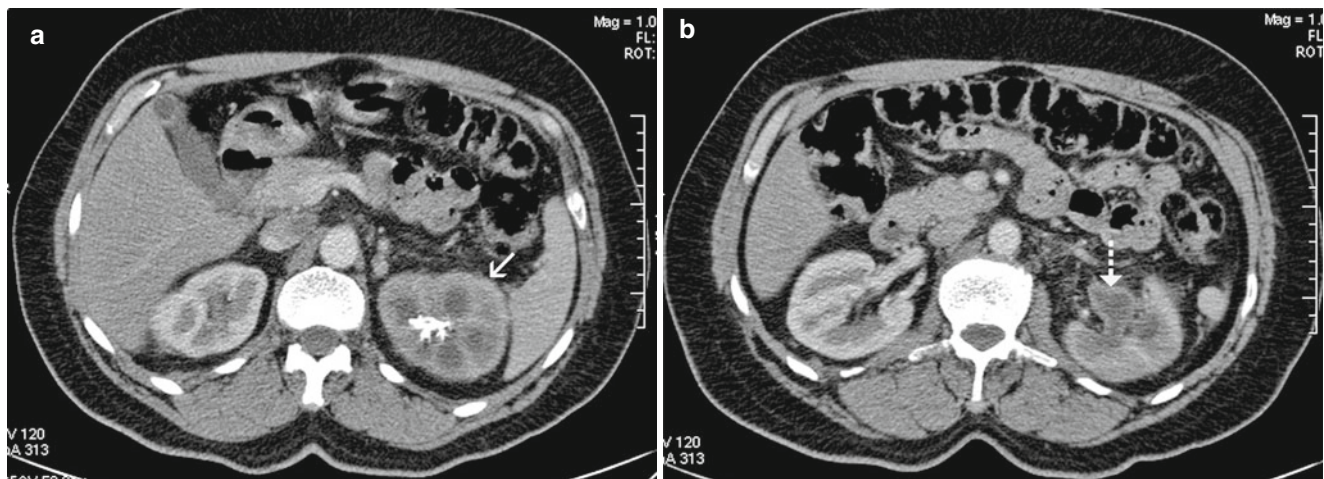
- Tuberculous granulomas in the renal parenchyma may appear as masses of variable echogenicity, with or without areas of caseous necrosis and calcifications.

### Computed Tomography

- CT is more sensitive than other methods in detecting renal calcifications, which are present in 50 % of the patients.
- Renal calcifications show various patterns: punctate, curvilinear foci, lobar disruption, and calcifications of the entire renal parenchyma and renal pelvis.
- The most common findings on CT are caliectasis, strictures of the infundibulum, renal pelvis and ureter, generalized hydronephrosis, and parenchymal scarring (Fig. 2.36a, b).
- The end result may be a “putty kidney,” composed of residual calcified nonfunctional renal tissue.

## Pathology

- In tuberculosis, the kidneys become infected by the hematogenous spread of mycobacteria, most often *M. tuberculosis*, resulting in the formation of multiple caseating granulomas (Fig. 2.37).
- Most patients are middle aged with no clinically apparent pulmonary disease.



**Fig. 2.36** Renal tuberculosis. Contrast-enhanced axial CT scans (a, b) in nephrographic phase in a 61-year-old man with left renal tuberculosis. (a) Enlarged left kidney has asymmetrically delayed parenchymal enhancement with amorphous parenchymal calcifications (arrow).

(b) Hydronephrosis and thickening of renal pelvic wall (dashed arrow) are evident in the left kidney (Courtesy of Nevzat Karabulut, MD, Denizli, Turkey)



**Fig. 2.37** Renal tuberculosis (*M. chelonae*). This explanted transplant kidney had become infected with *M. chelonae*, a rapidly growing mycobacterium most often found in skin, soft tissue, or postoperative wound infections. The pale gray-tan structure is a tuberculous perirenal abscess, which necessitated nephrectomy

- Caseating granulomas are composed of central necrosis and epithelioid histiocytes, surrounded by lymphocytes, giant cells, and fibroblasts (Fig. 2.38). The mycobacteria can be highlighted by special stains for acid-fast bacilli.

## Differential Diagnosis

- Chronic pyelonephritis.
- Papillary necrosis.
- XGP.
- Medullary sponge kidney.
- Renal cell carcinoma.
- Transitional cell carcinoma.
- Multiplicity of abnormal findings favors for the diagnosis of renal TB.
- The disease should be considered in the differential diagnosis, when findings consistent with chronic renal inflammatory disease are detected in the presence of peri-ureteric or peripelvic fibrosis.

## Pearls and Pitfalls

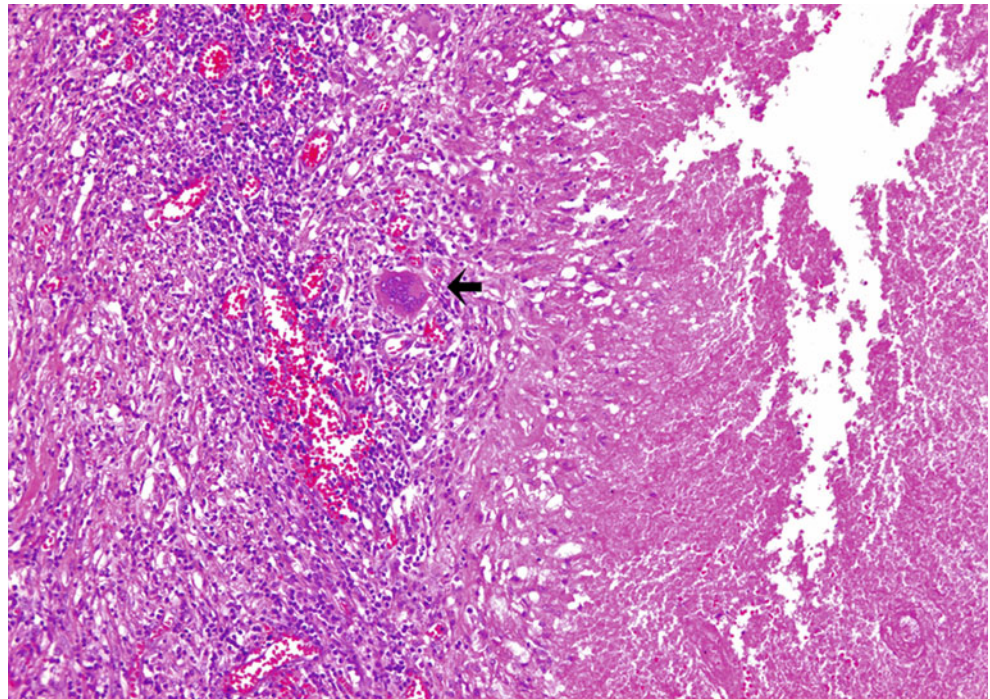
- Normal urographic findings are detected in approximately up to 15 % of patients presenting with active renal TB.
- Development of infundibular, pelvic, or ureteral strictures is a common finding and is nearly pathognomonic of renal TB.

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**Fig. 2.38** Renal tuberculosis (*M. tuberculosis*). This patient had a previous well-established history of pulmonary tuberculosis. Patient developed a renal mass which proved to be a tuberculous granuloma, with central caseating necrosis and peripheral scarring. Central necrosis is at right, and granulomatous inflammation and fibrosis are evident at left. A multinucleated giant cell is noted (arrow)



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