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Editors

Oncologic Imaging
Urology

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Preface

Today's medicine is directing patient-centered multidisciplinary approach, and imaging is an integral part of it. In line with this direction, "Oncologic Imaging: Urology" is a book presenting oncological diseases of the urinary tract including renal tumors, urothelial tumors, prostatic tumors, tumors of the male genitalia, adrenal tumors, and retroperitoneal tumors.

This book was edited and written by specialists of urologic oncology in radiology, urology, pathology, nuclear medicine, and radiation oncology of the Seoul National University Hospital and the members of the Korean Society of Urogenital Radiology. We deeply appreciate all contributors named and unnamed for their works for this book. We hope this book is read by physicians of a variety of specialties who are interested in oncological diseases of the urinary tract.

Seoul, Korea — Seung Hyup Kim, MD
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Renal Tumors

1

Sun Ho Kim, Seung Hyup Kim, Byung Kwan Park, Keon Wook Kang, Kyung Chul Moon, Cheol Kwak, Young Ju Lee, and Jin Ho Kim

1.1 Introduction

Malignant renal cell tumor (renal cell carcinoma: RCC) is the most common malignant renal tumor, and the most common benign renal tumor is angiomyolipoma (AML). Malignant renal mesenchymal tumor (sarcoma) is rare. Other renal tumors include oncocytoma, metanephric adenoma, mixed epithelial and stromal tumor, rare mesenchymal tumors such as leiomyoma or hemangioma, nephroblastoma, and neuroendocrine tumors. Lymphoma and metastasis should be differentiated from these primary renal tumors.

Most renal masses are detected by ultrasonography (US), but computed tomography (CT) is considered as the dominant imaging modality for evaluating renal masses, especially for RCC in its staging and treatment planning. Some subtypes of RCC show typical CT finding and can be differentiated from other subtypes, which is important in planning treatment and expecting prognosis. Magnetic resonance imaging (MRI) is usually used in limited cases, in which US and CT fail to give sufficient information.

1.2 Detection

Although most renal masses are discovered incidentally, some tumors are detected during the work-up of patients' symptoms such as hematuria or flank pain. Most symptomatic tumors are large,

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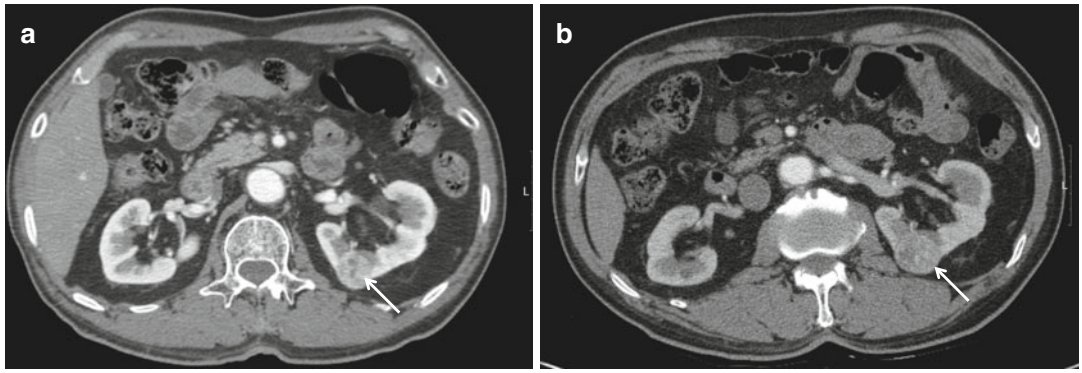

Fig. 1.1 Small RCC discovered incidentally on CT. (**a**) Contrast-enhanced CT shows a 2.4 cm-sized, hypervascular mass (*arrow*) in the left kidney. (**b**) The diameter of the mass increased as much as 2 mm during 2-year follow-up without metastasis. Clear cell RCC was confirmed after partial nephrectomy

but even small renal masses can cause significant symptom, and renin-producing juxtaglomerular cell tumor (reninoma) is an example. RCC with renal vein thrombus may be an underlying cause of scrotal varicocele, especially on the right side where the incidence is relatively rare.

Most renal masses are detected on imaging performed for no or unrelated symptom. These masses are usually small, mostly smaller than 3 cm in diameter (Fig. 1.1). Some lesions are too small to characterize on imaging. Because most incidentally discovered renal mass (incidentaloma) is detected by US, the first step is the differentiation of these lesions from pseudotumor, a mass-like finding that mimics a neoplasm. The most common renal pseudotumor is congenital variations or anomalies such as a prominent column of Bertin and dromedary hump. Doppler US can be helpful in the differential diagnosis to show normal vascular pattern in these pseudotumors [1, 2]. Echogenic mass such as AMLs or small RCCs can be easily detected on US. 50 % of small RCC (<3 cm) can be detected by US. However, isoechoic masses, masses embedded totally in renal parenchyma, or masses located in polar regions are apt to be missed.

1.3 Characterization

1.3.1 US

Renal masses can be divided into solid and cystic lesions. Although it is well known that US is accurate in differentiating between cystic and solid renal masses, it is also known that often this differentiation is difficult. Sometimes a homogeneous solid renal mass may be difficult to differentiate from a simple renal cyst if it accompanies posterior sonic enhancement and edge shadowing. The diagnosis of a simple renal cyst can be made if a renal mass is round, well demarcated, and anechoic and accompanies posterior acoustic enhancement. If a renal mass does not meet these criteria but also does not appear as an overt RCC, it can be defined as an indeterminate renal mass and should be evaluated further. Indeterminate renal masses can be categorized into mainly cystic, mixed cystic and solid, and mainly solid renal masses, and the amount of solid portions is important in the suspicion of malignancy [1, 2].

Although the main role of US in renal masses is detection and CT or MRI is usually used for further characterization, US may be required to provide additional information of renal masses detected on CT or MRI. Technical advances in US including tissue harmonic imaging, Doppler US, and contrast-enhanced US (CEUS) increase the ability of US in characterizing renal masses (Fig. 1.2).

1.3.1.1 Solid Renal Mass

The most common solid renal tumor is RCC. Solid renal mass on US in adult should be considered as RCC unless strong evidence of other tumors is present. Differential diagnosis includes AML, oncocytoma, adenoma, lymphomas, metastases, and various benign mesenchymal tumors and sarcomas. A study showed that oncocytomas and

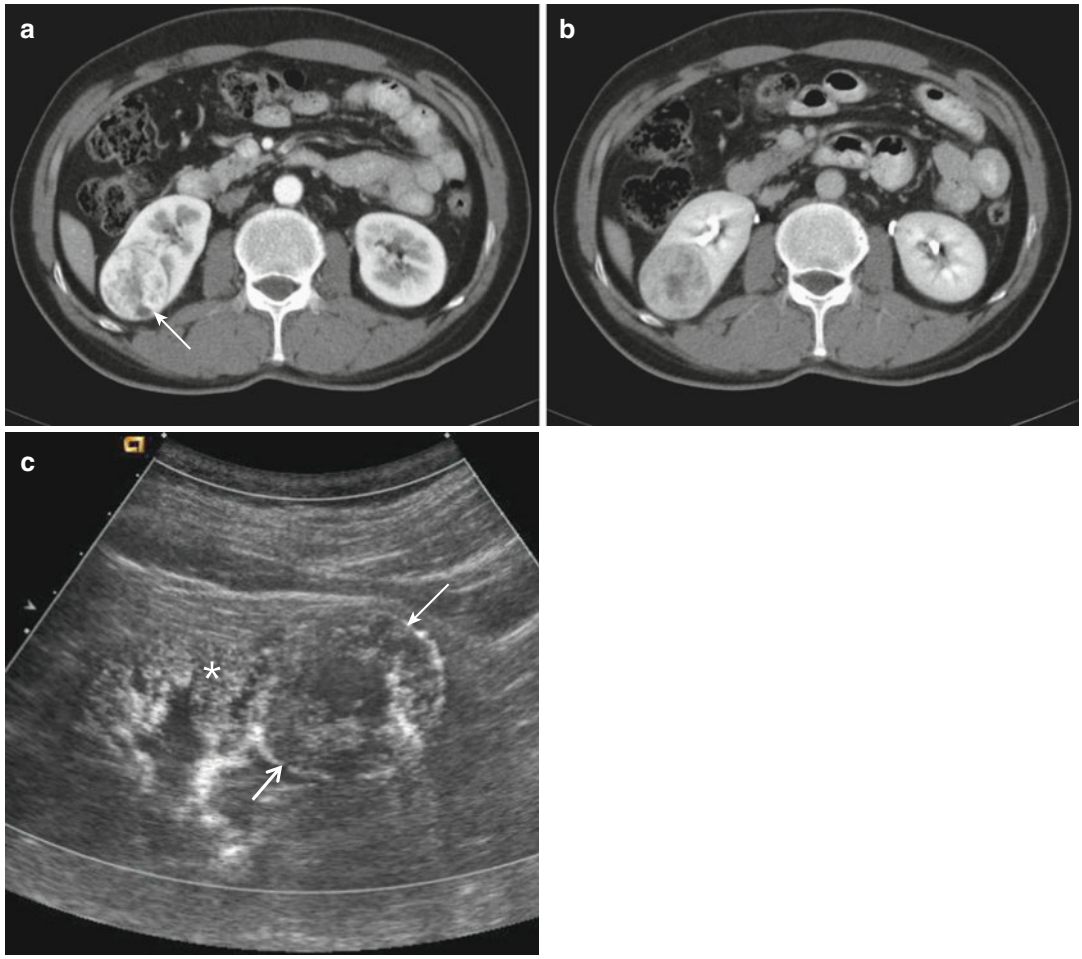

Fig. 1.2 Clear cell RCC. (**a**) Contrast-enhanced CT in corticomedullary phase shows a hypervascular mass (*arrow*) in the right kidney. The degree of the enhancement is similar to that of the renal cortex. (**b**) In nephrographic phase, the mass enhances less than the renal parenchyma. (**c**) Contrast-enhanced US shows early enhancement of the mass (*arrows*), similar to the renal cortex (*)

AMLs were almost all of benign masses (12.8 %) among 2770 solid renal masses that were surgically removed [3]. AML can show typical US findings such as bright high echo comparable to renal sinus fat (Fig. 1.3). Small RCCs are also usually hyperechoic but may show characteristic findings such as intratumoral cysts and hypoechoic rim (Fig. 1.4). Lymphomas and metastases may be differentiated by clinical settings, but other tumors usually show nonspecific US finding, and other imaging modalities such as CT or MRI are required for further characterization.

1.3.1.2 Cystic Renal Mass

Simple cyst is the most common renal mass detected incidentally. If a cystic mass does not show typical findings of a simple cyst on US, it should be considered a complicated cyst. In evaluating cystic masses based on US findings, internal echoes, septa, wall thickness, calcification, and mural nodularity are important in assessing the risk of malignancy.

Bosniak proposed a four-category classification system of cystic renal masses. Although it is based on CT findings, this classification is widely used also in US or MRI [4].

Bosniak I: Clearly simple cysts that have hairline-thin wall without septa, calcifications, or solid components. Hounsfield units (HU) of CT in the content is usually smaller than 20 (0–20), and does not enhance.

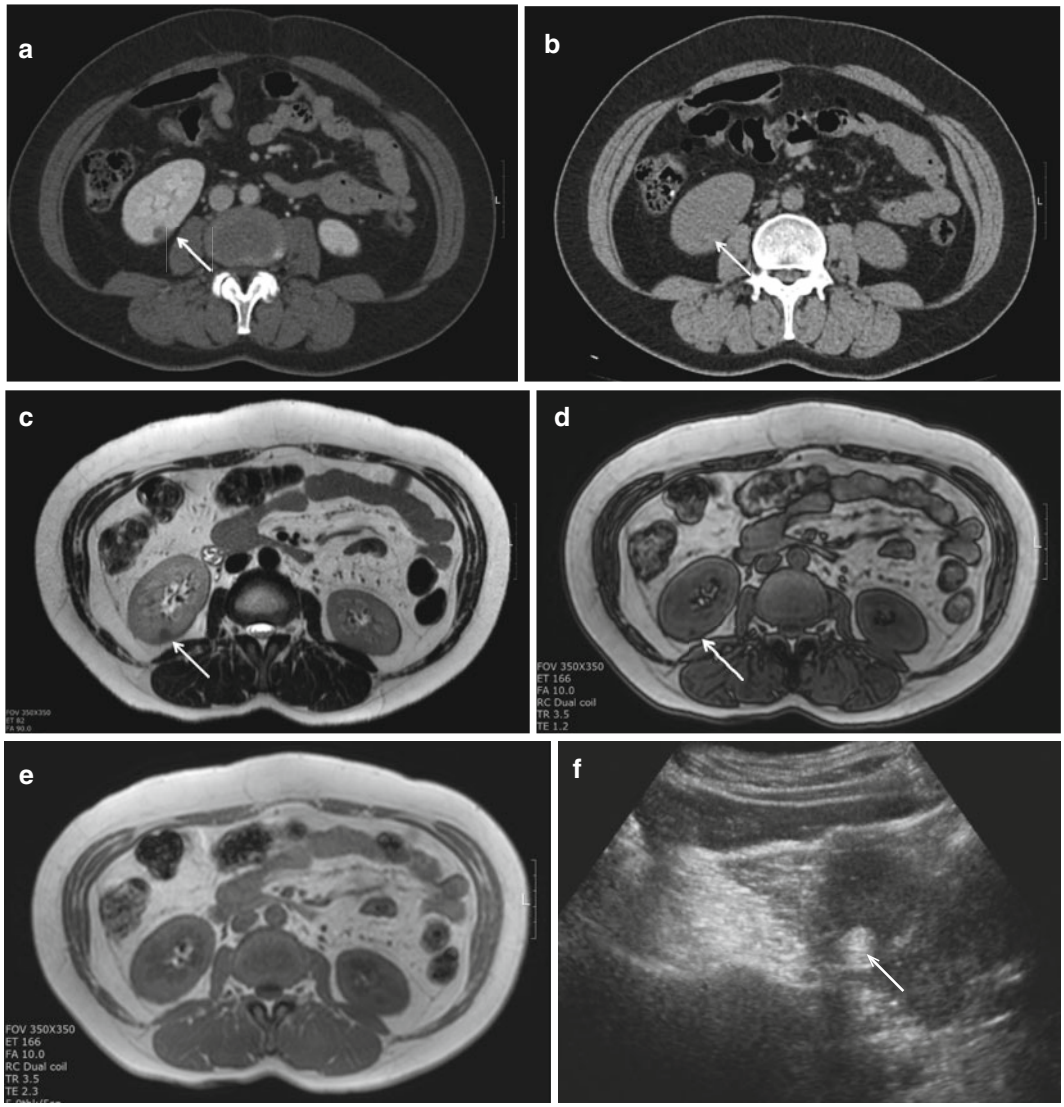

Fig. 1.3 AML. (**a**) Contrast-enhanced CT shows a small, poorly enhancing mass (*arrow*) in the right kidney. (**b**) Noncontrast CT shows subtle low attenuation in the mass (*arrow*). (**c**) The mass (*arrow*) shows low SI on T2-weighted MR image. (**d**, **e**) Small area of signal drop (*arrow*) is detected in the mass on out-of-phase T1-weighted MR image (**d**) compared with in-phase image (**e**). (**f**) The mass appears as a brightly high-echoic mass (*arrow*) on US

Bosniak II: Minimally complicated cysts with few, thin septa, or thin, fine calcification. The septa may be minimally thickened (Fig. 1.5).

Bosniak III: More complicated cystic masses that contain thick or irregular walls or septa in which enhancement can be measured (Fig. 1.6).

Bosniak IV: Clearly malignant cystic masses that not only contain all the characteristics of Bosniak III lesions but also contain enhancing soft tissue components adjacent to, but independently of, the wall of septa. Most malignant complex renal cysts are cystic renal cell carcinomas (Fig. 1.7).

In Bosniak classification, the probability of malignancy is virtually 0 % for I and almost 100 % for IV. The problem in this classification is almost always the differentiation between II and III, because the criteria are apt to be subjective. In 1993, Bosniak added class IIF, which is a little bit more complicated than class II, but less than class III, and so needs close follow-up (Fig. 1.8).

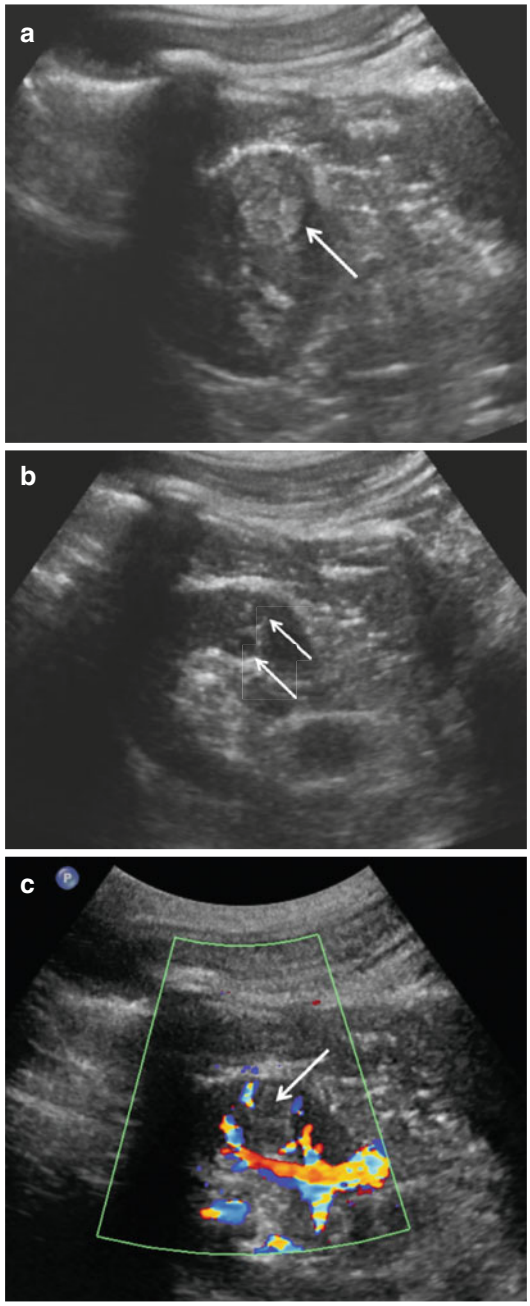

Fig. 1.4 US of small RCC. (**a**) About 2 cm-sized, high-echoic mass shows low-echoic rim (*arrow*). (**b**) Small cysts (*arrows*) are visible in the mass on another plane. (**c**) Increased vascularity is noted around the mass (*arrows*) on color Doppler US

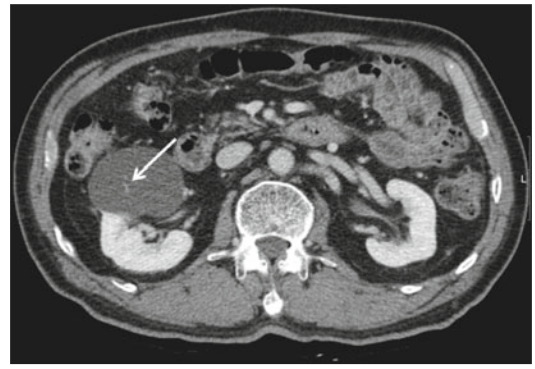

Fig. 1.5 Bosniak II cyst. Thin septal calcification (*arrow*) is noted on contrast-enhanced CT

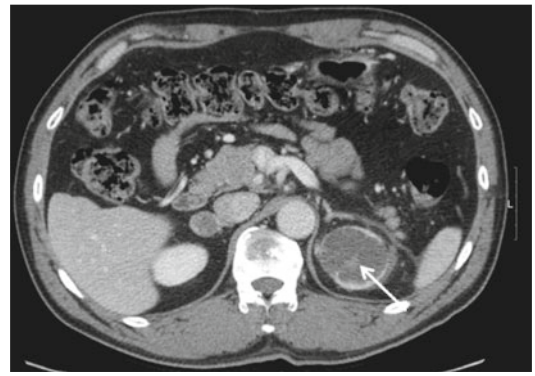

Fig. 1.6 Bosniak III cyst. Irregular wall and nodular thickening of a septum (*arrow*) is visible on contrast-enhanced CT. This cyst turned out to be cystic nephroma after surgery

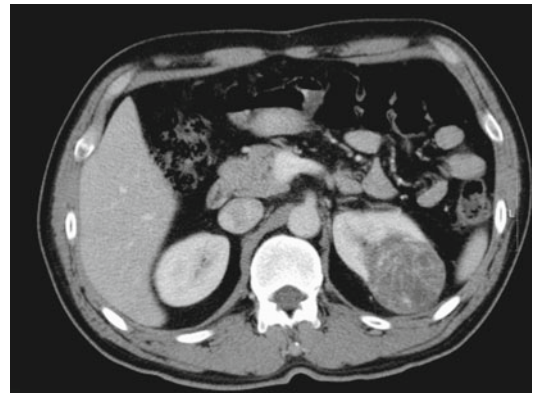

Fig. 1.7 Bosniak IV cyst. A complex cystic lesion in the left kidney shows multiple irregular septa with enhancement on contrast-enhanced CT. Multilocular cystic RCC was the pathologic diagnosis

Malignant risk of Bosniak IIF and III lesions is known as 5–10 % and 40–60 %, respectively [5]. A recent study retrospectively evaluated the outcome of Bosniak IIF and III cysts and reported higher malignancy rate (25 %) in IIF lesions and similar rate (54 %) in III lesions. However, in this study, resected Bosniak IIF

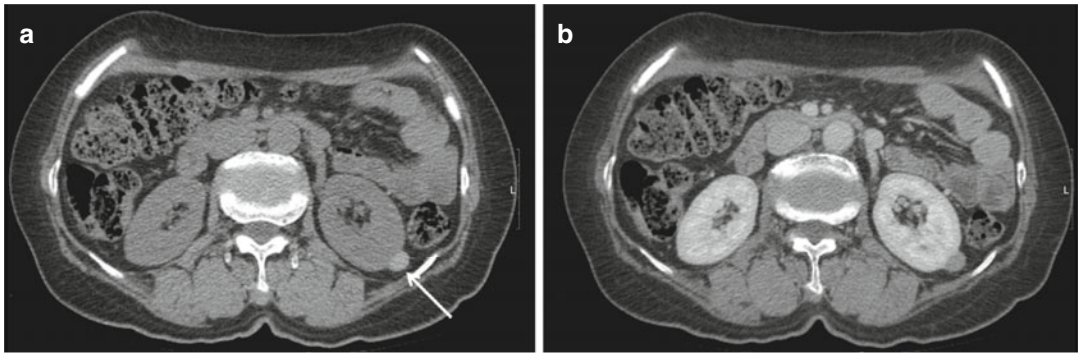

Fig. 1.8 Bosniak IIF cyst. (**a**). Noncontrast CT shows a hyperattenuating nodule (*arrow*) in the left kidney. (**b**). This nodule shows no definite enhancement on contrast-enhanced CT, suggesting hemorrhagic cyst

lesions were highly selected in patients with a high number of risk factors associated with malignancy: a history of primary renal malignancy, coexisting Bosniak IV lesion, and/or solid renal neoplasm [6].

1.3.1.3 Doppler US and Contrast-Enhanced US

Color Doppler US (CDUS) or power Doppler US (PDUS) can be helpful in evaluating indeterminate renal masses by depicting vascularity in the mass (Fig. 1.4). Increased vascularity in a renal mass can suggest malignancy, whereas the absence of flow signals may suggest high likelihood of benign lesion. However, the presence of flow signals in the septa of a cystic mass does not always indicate malignancy, because benign neoplasms such as cystic nephroma or even nonneoplastic cysts may show flow signals in the septa. Flow signals on CDUS or PDUS should be confirmed by using spectral Doppler US, because artifacts may mimic flow signals.

Contrast-enhanced Doppler US can increase the detection of intratumoral vascularity compared to CDUS and PDUS. Recent development of contrast-enhanced harmonic US imaging has provided for a better assessment of the vascular morphology and the enhancing patterns of renal tumors, such as early enhancement and washout of RCC, in contrast to delayed and prolonged enhancement of AML (Fig. 1.2). Ultrasound contrast agents are strictly intravascular and not excreted by or retained in kidneys, so that they can be used in patients with renal failure or urinary obstruction, unlike CT or MRI. Because CEUS is very sensitive for vascularity, it is especially useful in the differential diagnosis of hypovascular renal tumors or the detection of blood flow in the septa of complex renal cysts, even if enhancement on CT is equivocal [7]. A study showed higher sensitivity of CEUS in the diagnosis of hypovascular renal tumors compared with contrast CT (94.4% vs 88.9%) [8]. In a prospective study comparing CEUS with CT in the assessment of complex renal cysts, CEUS was proved to be appropriate for renal cyst classification with the Bosniak system, and complete concordance between CT and CEUS was observed regarding the need for surgery [9]. Another study demonstrated the superiority of CEUS as compared to grayscale US and to CT for the diagnosis of complex renal cysts [10].

1.3.2 CT

1.3.2.1 Unenhanced CT

Renal cysts show low attenuation (0–20 HU) on CT images regardless of contrast enhancement, but hemorrhagic cysts may show higher attenuation on unenhanced CT. These high-attenuation cysts should be categorized as Bosniak IIF, and follow-up is required (Fig. 1.8). Complicated cysts may show septal or wall calcifications, and close comparison with contrast-enhanced images should be made to differentiate from enhancing part. Solid RCCs usually show attenuation similar to surrounding renal parenchyma. However,

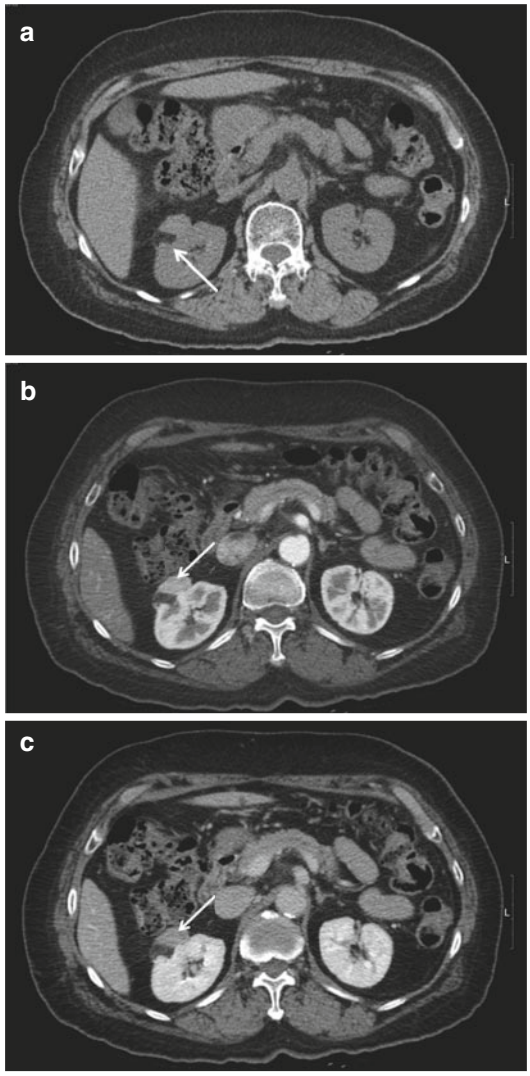

Fig. 1.9 AML. (**a**) Noncontrast CT shows fatty component (*arrow*) of a mass in the right kidney. (**b**, **c**) Nonfatty component of the mass (*arrow*) enhances well in corticomedullary phase (**b**) and shows persistent enhancement in nephrographic phase (**c**)

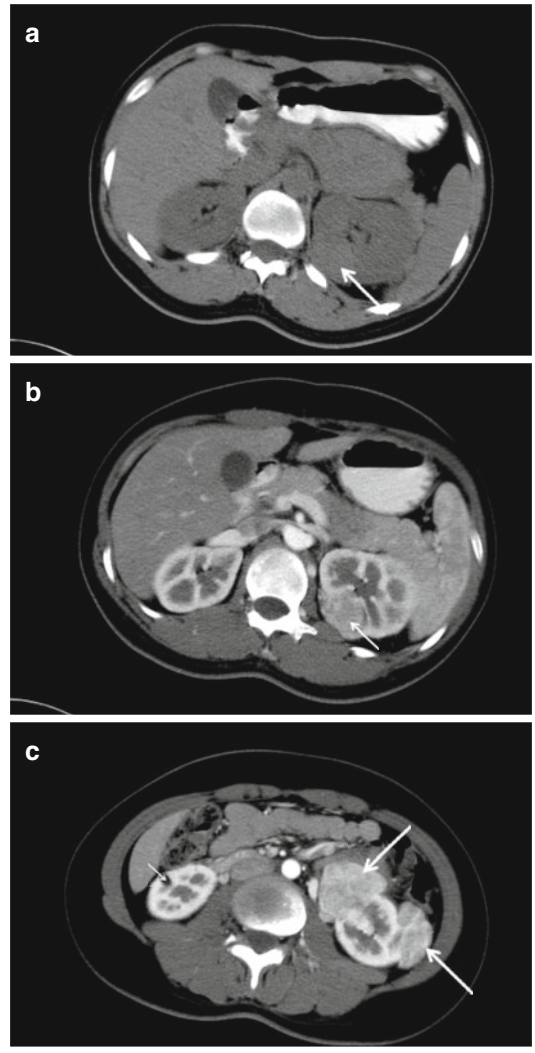

Fig. 1.10 Multiple AMLs in tuberous sclerosis. (**a**) Noncontrast CT shows a hyperattenuating mass (*arrow*) without detectable fatty component in the left kidney. (**b**) This mass (*arrow*) shows heterogeneous enhancement on contrast-enhanced CT. (**c**) Other AMLs (*arrows*) are also found in bilateral kidneys. Note fatty component of an AML (*small arrow*) in the right kidney

the attenuation becomes heterogeneous in large tumors due to hemorrhage or necrosis. Calcifications in a renal mass may suggest malignancy, because RCCs can contain calcifications but AMLs do not. AMLs usually show higher attenuation than RCCs on unenhanced CT and contain low-attenuation part comparable to fat (Fig. 1.9). However, 5 % of AMLs do not contain enough fat to be detected on CT (Fig. 1.10). In these fat-free or fat-deficient AMLs, the analysis of the shape and the enhancement pattern of the mass may be clues for the differentiation.

A recent study with 193 pathologically proven RCCs reported that all RCCs contained substantial noncalcified regions that measured 20–70 HU in ROI attenuation on unenhanced CT. Therefore, indeterminate renal lesions on unenhanced CT measuring within this range warrant further