Abdom Imaging 23:256–265 (1998)

Abdominal Imaging

The small renal mass: detection, characterization, and management

R. J. Zagoria, R. B. Dyer

Department of Radiology, Bowman Gray School of Medicine, Wake Forest University, Medical Center Boulevard, Winston-Salem, NC 27157, USA

With the widespread availability and use of cross-sectional imaging (computed tomography [CT], ultrasonography [US], and magnetic resonance ([MR] imaging), the detection of small renal masses has become commonplace [1–5]. Unfortunately, this improved ability to detect these previously unrecognized renal masses has caused some consternation for radiologists and referring physicians, because difficulty in classifying these masses may complicate management decisions. Once a small renal mass is detected, characterizing the lesion with a specific diagnosis is most important, because some of these masses are malignancies diagnosed at an early stage, and the single most important determinant in the prognosis of primary renal malignancy is the stage of the tumor at the time of treatment initiation [6]. Renal cell carcinoma (RCC) is resistant to both radiotherapy and chemotherapy [6]. Therefore, diagnosis at an early stage, when the tumor is surgically resectable, offers a patient the best chance for long-term survival. Alternatively, because nephrectomy is associated with a 5% perioperative mortality and a higher rate of morbidity [7], accurate characterization of benign renal masses may prevent unnecessary surgery. In this article, radiologic techniques for detection, characterization, and management of small renal masses are discussed.

Detection

The detection of small renal masses should be a high priority when imaging the kidneys. A significant proportion of these masses are malignant, and early detection offers the best hope for cure in these patients. Therefore, renal imaging techniques should be optimized for renal mass detection. For intravenous urography (IVU), optimal technique includes bolus injection of contrast material coupled with the use of tomography during the nephrogram phase. To improve tumor detection, nephrotomograms should be obtained in all urography patients with a history of hematuria and in patients 40 years old and older because the risk of RCC increases with increasing age, and RCCs are rare in persons younger than 40 years of age.

Optimal US technique requires the use of a transducer operating at least 3.5 MHZ, coupled with modern US techniques. The detection and characterization of small renal masses may be enhanced with color-Doppler and power-Doppler techniques because subtle vascular abnormalities may be detected in areas of otherwise unrecognizable gray-scale abnormality.

Renal masses are often detected incidentally during CT during scanning of patients referred without urologic symptoms [1–5]. In many cases, CT is performed only after the injection of intravenous contrast material, which will be adequate for visualization of detectable renal masses but suboptimal for mass characterization (Fig. 1). To avoid overlooking small renal lesions in all patients, including those without urologic symptoms, the CT examination of the kidneys should be planned to optimize renal mass detection. Collimation should be 10 mm or less, and for patients in whom a renal abnormality is specifically suspected, 5-mm scan collimation should be used. When helical CT is used, the kidney should be scanned early during the corticomedullary phase, which is usually imaged when scans are initiated at the level of the diaphragm 50–60 s after initiation of the power injection of contrast material. Imaging is repeated during the tubular nephrogram phase, with renal scanning initiated approximately 2 min later. This biphasic combination of scans improves the detection rate of renal masses with helical CT equipment [8]. Some small renal masses can go undetected if only the corticomedullary phase or only the tubular nephrogram phase is evaluated with helical CT [8].

MR imaging equipment and scanning capabilities vary greatly. To optimize the detection of small renal masses, high-field-strength MR imaging equipment

Correspondence to: R. J. Zagoria

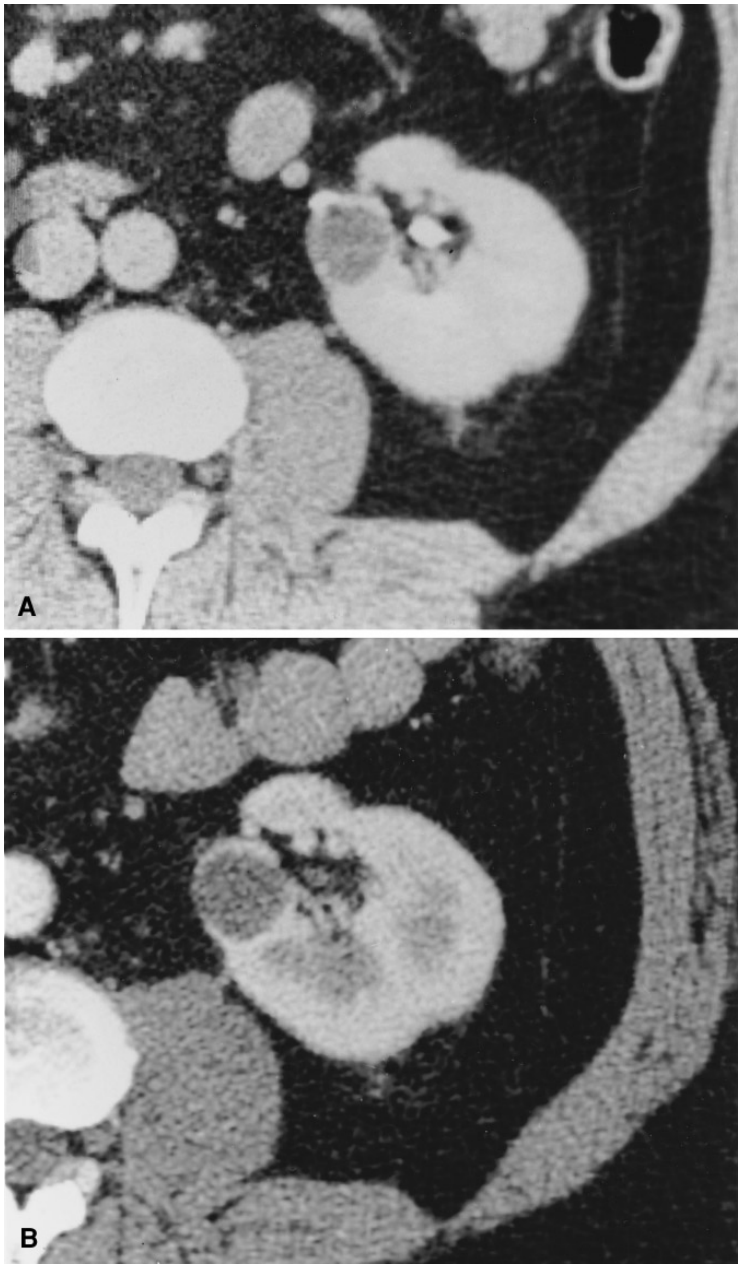


Fig. 1. One-centimeter left renal cyst adequately characterized only with very thin CT collimation. **A** A 1-cm well-circumscribed mass was detected in the medial portion of the left kidney on this contrast infused CT scan with 5-mm collimation. Sonography of this lesion was indeterminate due to the patient's large body habitus. This mass was felt to represent a small RCC. **B** A follow-up CT scan with 3-mm collimation done before (not shown) and after the intravenous injection of contrast material demonstrates that this mass is not only well circumscribed but also water density. The mass increased by only 4 HU with contrast infusion. This mass could be diagnosed definitively as a simple cyst only following very thin-section (3 mm) renal CT.

should be employed in conjunction with fast scan sequences. Axial and either sagittal or coronal imaging of the kidneys should be performed in all cases. In equivocal situations, the use of intravenous gadolinium contrast medium with MR scanning improves lesion detection and characterization [9]. Even though MR imaging is comparable to CT for the detection of small renal masses, it does require significantly more time, at a greater expense, than does CT. Therefore, MR imaging is usually reserved for patients who cannot tolerate the intravenous injection of iodinated contrast material for optimal CT scanning. Otherwise, MR imaging has no proven advantage over CT for the detection of small renal masses.

Small renal masses, those 3 cm or less in diameter, are most commonly detected with cross-sectional imaging techniques. However, 52% of masses 2–3 cm in diameter can be detected with intravenous urography [10], a test commonly used in the evaluation of patients with hematuria and other urinary tract symptoms. Smaller renal masses will usually go undetected with intravenous urography. All renal masses larger than 15 mm in diameter should be detectable with CT scanning with 5-mm collimation and dynamic contrast material

enhancement [11]. With US, all renal tumors larger than 25 mm are detectable [11]. The sensitivity of renal US declines rapidly as lesion size decreases. Virtually no renal tumors 5 mm or smaller are detectable with US, and only one-fourth of renal masses 10–15 mm in diameter are detectable with US [11]. By comparison, CT detects 47% of renal tumors 5 mm or smaller and 75% of tumors 10–15 mm in diameter [11]. Similar studies with MR imaging have not yet been published, but most authorities agree that the sensitivity of MR imaging for the detection of renal masses is comparable to that of CT.

Renal mass characterization

Once small renal masses are detected, the task of characterizing them is of paramount importance. The radiologic approach to characterization of small renal masses depends on the mode of detection.

Mass detected with IVU

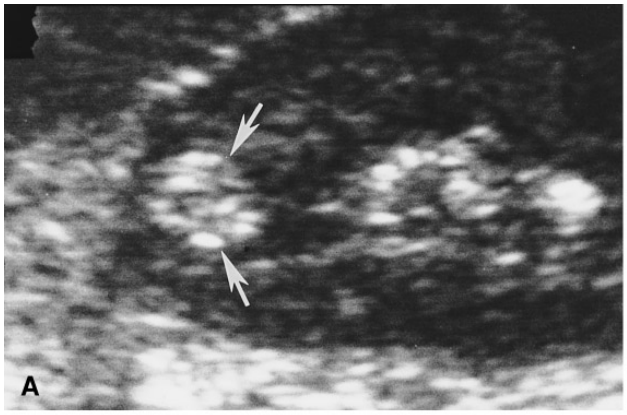
Although small renal masses can be detected with IVU, characterization of all of these renal masses should be pursued with other imaging techniques. With urography alone, only 76% of renal masses are correctly characterized as simple cysts or as solid, presumably malignant, renal masses [12]. This level of accuracy is unacceptable because readily available modalities such as US and CT markedly increase the accuracy of diagnosis. The most cost-effective approach to characterizing renal masses detected on IVU is to proceed with renal US [12], which characterizes most renal masses adequately as simple cysts, complex cysts, or solid renal masses. The solid masses and the complex cysts then require CT or MR imaging for further characterization and staging. Only one mass in five detected with IVU and then evaluated with renal US has indeterminant features requiring further imaging evaluation for diagnosis [12]. Lesions that do require further imaging because of indeterminant US features should be studied with CT or MR imaging tailored for renal mass characterization and staging. Both techniques should include 5-mm-thick scans through the kidney before and after the injection of intravenous contrast material. Once this sequence of imaging studies is completed, virtually all renal masses detected with IVU should be adequately characterized as either benign or probably malignant [12], and management decisions can proceed.

Mass detected with renal US

Many renal masses are first detected with renal US. In the vast majority of these masses, features are diagnostic of a simple renal cyst, and no further imaging evaluation is necessary. Approximately one in five renal masses cannot be adequately characterized [12] with renal US because of indeterminant features with this modality. These masses can be imaged with a complementary study, i.e., CT or MR imaging focused on renal mass characterization as described above. Combining US with CT or MR imaging results in accurate characterization of nearly 100% of renal masses greater than 10 mm in diameter [11, 12]. Neither US nor CT is reliable in characterization of renal masses 10 mm or smaller [11]. It should be emphasized that any renal mass that does not meet US criteria for a simple cyst requires further evaluation with CT or MR imaging. In particular, the hyperechoic renal mass, a pattern once thought typical of benign angiomyolipoma (AML), requires further evaluation to exclude a small RCC (Figs. 2, 3). Even though RCCs can appear hypoechoic, isoechoic, or hyperechoic with renal US, the single most common US appearance of a small RCC is that of a hyperechoic mass [13] (Fig. 3), often mimicking the appearance of AML. With CT or MR imaging, fat is detectable in nearly all AMLs (Fig. 2) [14, 15], thereby confirming the diagnosis. If fat is not detectable with an adequate CT or MR imaging examination, a solid mass should be presumed to be an RCC. Finally, gray-scale renal US can be augmented with Doppler and power Doppler US for improved characterization of small renal masses [16, 17]. Increased and aberrant vascularity in a renal mass strongly suggests malignancy, whereas benign lesions do not demonstrate findings of neoplasia on Doppler US [16]. Abnormal or questionable findings with Doppler US should always lead to further evaluation with renal CT or MR imaging.

Mass detected with CT or MR imaging

Commonly, renal masses are first detected with CT or MR imaging of the abdomen performed for nonurologic symptoms. If the imaging features are typical for a simple cyst, i.e., water density content without enhancement and smooth thin margins, a simple cyst can be diagnosed without further imaging evaluation. In addition, fat detected within a solid renal mass indicates a diagnosis of AML [15], and no further imaging is necessary for characterization of the mass unless the imaging findings suggest that the fat is not intrinsic to the tumor but is perirenal fat that has been encompassed by an aggressive renal malignancy. Unfortunately, some small renal masses lack definitive CT features. In these cases, it is helpful to obtain thin scan sections (5 mm or thinner collimation) through the kidneys while the patient remains in the scanner. Ideally, scan collimation should be no greater than half of the cephalocaudal diameter of the renal mass to avoid partial-volume aver-



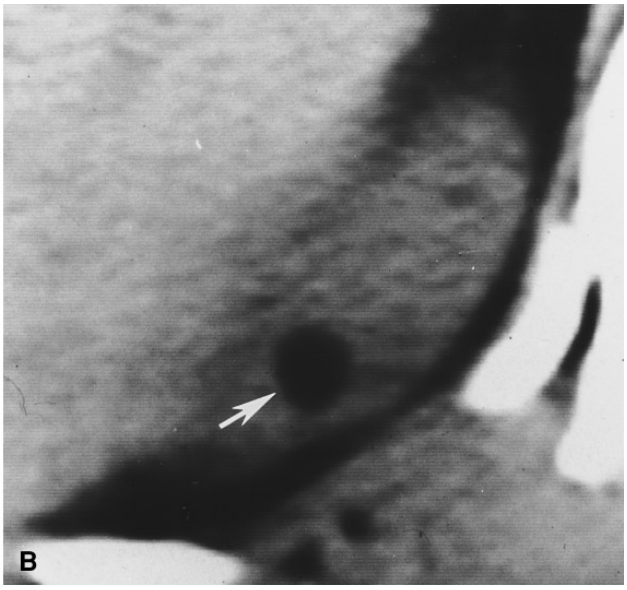
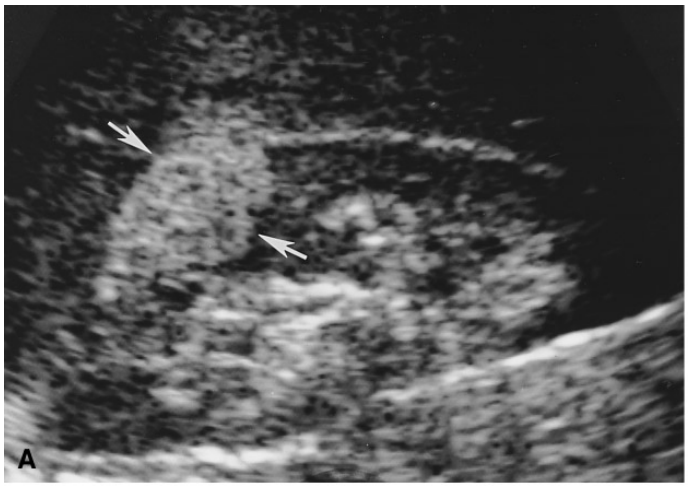


Fig. 2. US and CT of a small renal angiomyolipoma. **A** View of the upper pole of the right kidney from a sagittal renal US demonstrates a small hyperechoic mass (*arrows*). This mass requires further characterization with renal CT or MR. **B** Thin-section CT through the upper pole of the right kidney demonstrates a well-circumscribed fat-containing mass (*arrow*) in the upper pole of the right kidney. This finding confirms the diagnosis of angiomyolipoma.



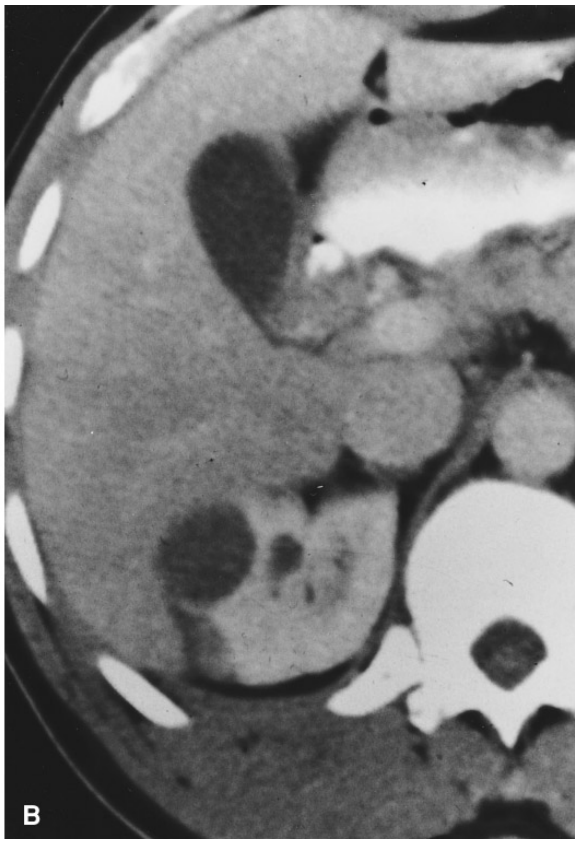


Fig. 3. Sonography and CT of a hyperechoic renal cell carcinoma. **A** Sagittal renal US of the right kidney demonstrates a markedly hyperechoic renal mass (*arrows*) in the upper pole. **B** Contrast-infused CT in this area demonstrates a well-circumscribed, homogeneous mass in the upper pole of the right kidney, corresponding to the area of US abnormality. Visual inspection of the CT suggests that this represents a simple cyst. However, US better demonstrates that this is a solid mass. Upon resection, this was found to be a well-differentiated RCC.

aging artifacts. After thin-section scanning, if features of a simple cyst (Fig. 1) or AML (Figs. 2, 4) can be confirmed, the imaging evaluation of these masses is complete. In practice, even with theoretically adequate thin-section scanning, partial-volume averaging may impede complete characterization of very small renal masses.

When masses are imaged with CT, careful evaluation of their attenuation coefficients should be obtained from the scans both before and after injection of contrast

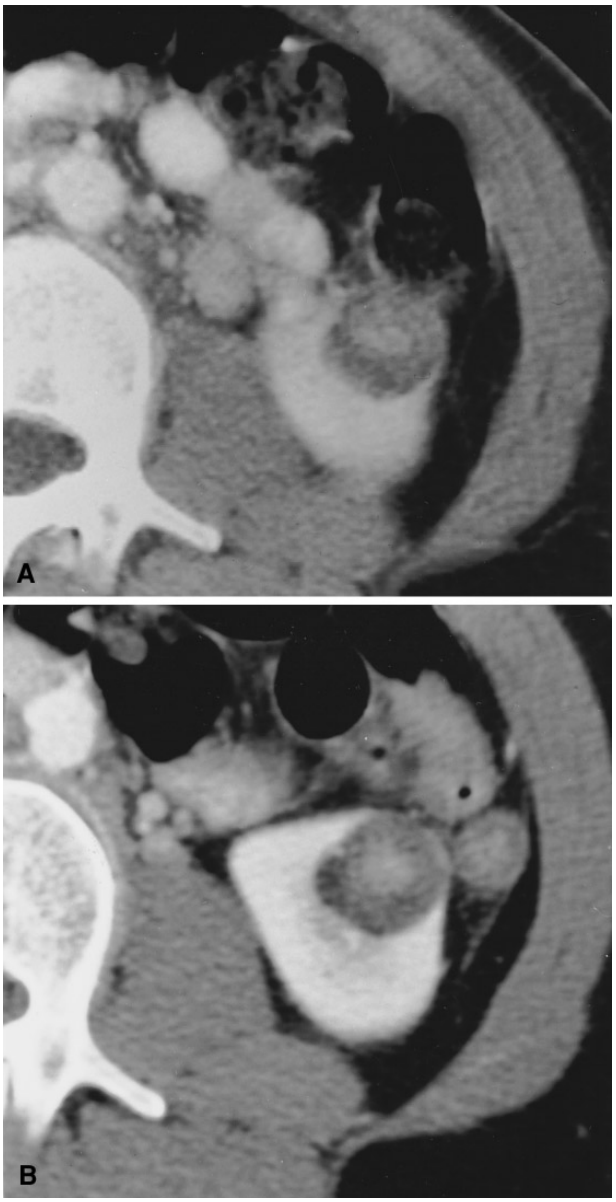


Fig. 4. Thin-section CT scanning to demonstrate fat in an angiomyolipoma. **A** This patient was scanned following a motor vehicle accident, and a 2-cm renal mass was detected using 7-mm collimation with helical CT. The imaging features of this mass clearly excluded a simple cyst, and it was felt to represent a malignancy. **B** A 3-mm-thick helical CT through this lesion clearly demonstrates that this is a fat-containing mass with focal high-density areas centrally. The high-density areas likely represent focal hemorrhage within this angiomyolipoma. Thin-section CT considerably improved our ability to characterize this lesion as a benign neoplasm.

material. Many small renal masses lack obvious aggressive features with visual inspection alone [18]. Although enhancement greater than 10 Hounsfield units (HU) is a standard cutoff for separating benign from malignant renal masses, up to 50% of renal masses with this level of enhancement are benign [19]. Alternatively,

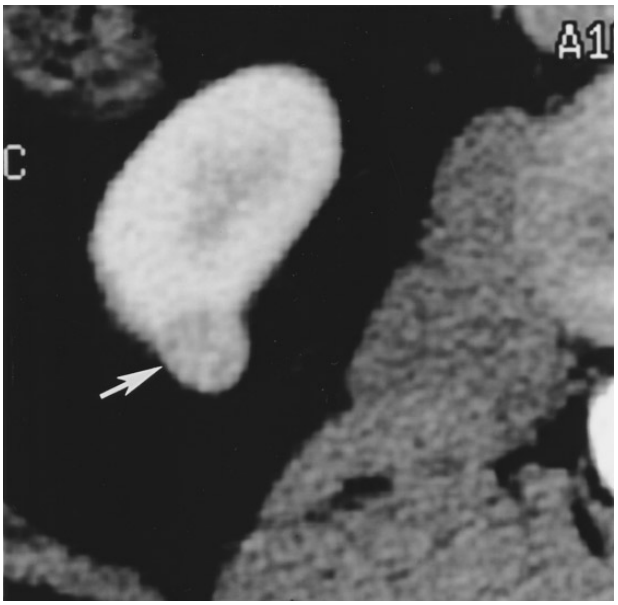


Fig. 5. Very small RCC demonstrated with CT. This 1-cm exophytic renal mass (*arrow*) was detected incidentally while scanning this patient for unrelated symptoms. The CT demonstrates a solid, markedly enhancing 1-cm renal mass. Because no fat is evident, this mass must be presumed to be an RCC. It was resected with partial nephrectomy, and this diagnosis was confirmed.

masses with enhancement greater than 20 HU after the injection of contrast material are nearly always malignant [19]. The majority of small RCCs appear solid or have mixed solid and cystic components. These lesions usually have relatively high attenuation values (>20 HU) on CT scans before contrast material infusion [19]. In addition, enhancement of most of these small RCCs is greater than 20 HU after the intravenous injection of contrast material (Fig. 5) [19]. Unfortunately, enhancement to a lesser degree is fairly nonspecific and can indicate either a benign lesion or a hypovascular neoplasm. Many of these lesions require surgical exploration for diagnosis. With helical CT, reformatting of the image slices with overlapping thin reconstruction may be useful to minimize partial-volume averaging artifacts. However, one study of this technique failed to demonstrate any advantage over standard thin-section CT for characterization of renal masses [19]. Helical CT does appear superior to conventional CT for fat detection in small AMLs [20].

Masses that appear predominantly cystic with CT may be classified according to the Bosniak system [21]. Bosniak's observations on cystic masses may be helpful in directing management decisions for these patients. With this system, a malignant lesion is diagnosed whenever the cystic mass contains enhancing solid components and irregular margins (class IV). Lesions that are complex, septated, or multiloculated cysts or contain nonenhancing solid components, calcifications that are

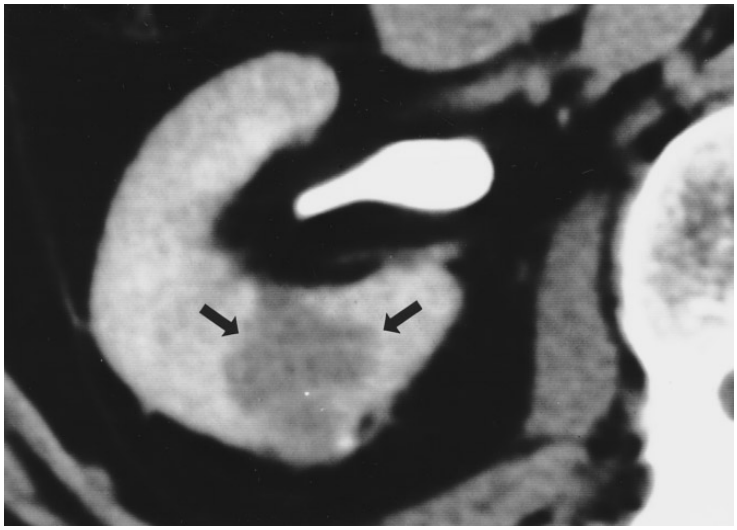


Fig. 6. Small RCC demonstrating aggressive features. This contrast-enhanced CT through the right kidney demonstrates a solid right renal mass (*arrows*). Although this mass is small (2 cm in diameter), its margins are irregular and there is an ill-defined mass–kidney interface. These imaging features suggest a more aggressive lesion. Radical nephrectomy was performed, confirming the lesion as a poorly differentiated RCC.

dense and irregular, or a combination of these features are suspicious for malignancy (class III). Typical high-density cysts that do not exhibit significant enhancement after infusion of contrast material, cysts with several thin septations, cysts with thin peripheral calcifications, or obviously infected cysts are classified as class II lesions and are considered benign. If multiple class II features are present (class IIF), then follow-up CT imaging is recommended in 6 months to confirm the benign nature of these lesions. If features remain indeterminant, several options are available. Renal US can be performed immediately and in most cases will lead to adequate characterization and diagnosis of masses that are indeterminant on CT examinations (Fig. 3). One study showed that approximately 12% of renal masses scanned with CT required renal US for complete characterization and diagnosis [12]. If US is not performed or is inadequate and if the initial CT or MR imaging examination was not tailored to the evaluation of renal masses, then the patient can be reexamined with CT or MR imaging on another day. On repeat scanning, contiguous 5-mm or thinner scans should be imaged before and after the injection of intravenous contrast material. In some patients, this approach will allow the confident diagnosis of a simple cyst, AML, or malignancy. If features remain indeterminant, options include follow-up surveillance renal imaging, percutaneous mass biopsy, or surgical exploration with mass excision.

Follow-up imaging has been advocated to characterize the aggressiveness of small renal masses [22–24]. This technique is usually reserved for patients who are poor operative candidates, who have small renal masses, or for those with small renal masses that are indeterminant, but likely benign, based on imaging features. Semiannual and annual renal CT is suggested for these patients [24]. With this technique, growth of lesions can be monitored and, supporters claim, there is little risk of advancement of tumor stage. With this approach, surgery would be recommended for tumors that exceeded 3 cm on follow-up imaging or those that develop more aggressive or characteristic imaging characteristics, because of the increased risk of developing advanced disease. Rapid growth or development of features such as marginal irregularity (Fig. 6) or evidence of extracapsular spread should lead to diagnosis of a malignant renal mass, and treatment should be undertaken as necessary. Studies have shown that if small RCCs have not metastasized at the time of diagnosis, then advanced stage and aggressive histology are very unlikely [22, 24]. These tumors usually grow less than 1 cm per year, and some are stable for prolonged periods without treatment [22, 24]. Unfortunately, RCCs are notorious for having a variable course. That is, RCCs may be stable for a prolonged period before inexplicably entering a phase of aggressive growth [6, 25]. In addition, once advanced disease, particularly lymphatic or hematologic metastases, develops, treatment is usually ineffective. Furthermore, tumor spread may go undetected, even with appropriate surveillance imaging. Lymph node metastases are found in 4% of normal-sized ($<$1 cm in diameter) regional lymph nodes in patients with RCC [26]. We have seen such a case where a patient with lymphoma had a 2-cm renal mass detected incidentally during staging. In conjunction with ongoing intensive therapy for the lymphoma, the renal mass was observed for 2 years without demonstrating any growth or evidence of spread. With the patient's lymphoma in remission nephrectomy was undertaken. Surgery demonstrated a 2-cm RCC with metastatic tumor in the regional lymph nodes. Even in retrospect, lymphadenopathy was not visible on the CT examinations. This case illustrates the potential hazard of a nonoperative

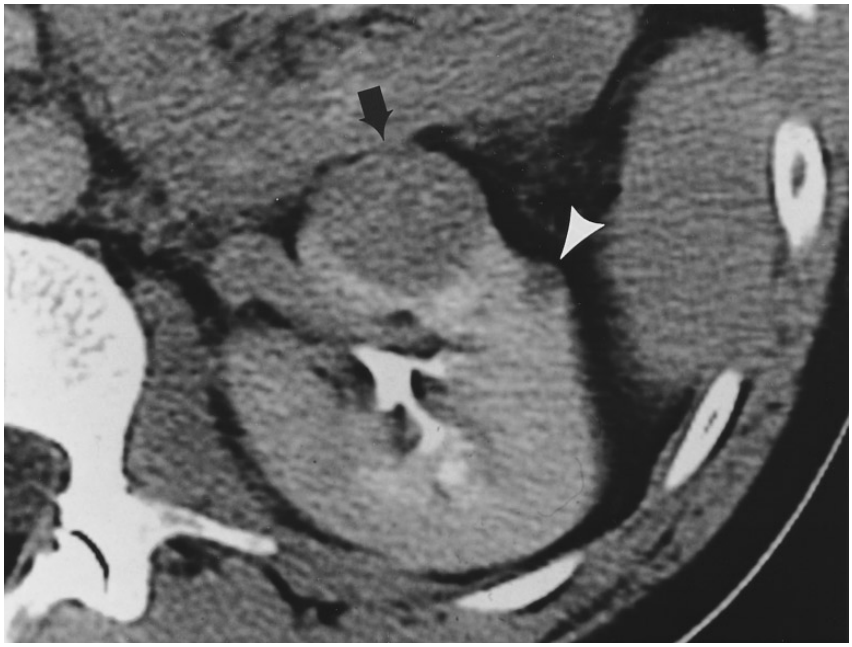


Fig. 7. Multiple small RCCs in a patient with von Hippel-Lindau disease. This contrast-infused CT through the kidney demonstrates a typical 2-cm RCC (*arrow*). This is a solid mass without any internal fat, typical of RCC. In addition, there is an 8-mm mass (*arrowhead*) located nearby in the kidney. This mass is too small to characterize based on its imaging features. However, due to this patient's high risk for developing multicentric RCC, both of these lesions were removed and proved to be RCCs.

imaging approach to the small renal mass. Therefore, a watchful-waiting approach should be used only in high-surgical-risk patients with small renal masses that do not appear benign, recognizing that there is a small, but definite, risk of advancement of disease during the period of surveillance.

We rarely employ percutaneous renal mass biopsy for the diagnosis of small renal masses. Although percutaneous renal mass biopsy is a safe procedure when performed under imaging guidance, results rarely affect management decisions. If the biopsy reveals frankly malignant tissue, then surgical excision of the mass is indicated. However, even if histologic findings are benign or indeterminant, the possibility of a renal malignancy must still be considered. One area of a renal mass may have benign features, whereas an adjacent area may contain malignant tissue [27]. Because only limited areas of the mass will be biopsied, benign histologic findings cannot be considered unequivocal evidence of a benign mass. In these cases, biopsy should be considered indeterminant, and surgery or surveillance imaging will be required.

The final option for evaluation of imaging-indeterminant small renal masses is exploratory surgery. A surgical approach that is being used more often is renal mass excision with partial nephrectomy. Frozen sections of the renal mass can be rapidly analyzed histologically. If the histologic findings indicate that the mass is benign, renal-sparing surgery can be completed. If histologic examination indicates that the mass was malignant, renal-sparing surgery can be completed if it is expected to be curative, or the surgeon can proceed to complete a radical nephrectomy.

Very small renal masses

Neither CT nor US is reliable in characterization of renal masses 10 mm or smaller in diameter. The overwhelming majority of these masses are simple cysts. In practice, these very small renal masses are routinely overlooked or presumed to be simple cysts if most CT features of a simple cyst are present, unless the patients are predisposed to the development of RCC or these very small renal masses are obviously not simple cysts. In patients with a high risk for RCC development, even benign-appearing renal masses should be considered suspicious for malignancy (Fig. 7). This group of patients includes those with von Hippel-Lindau disease and other patients with familial RCC patterns [6]. Some of the renal cysts in patients with von Hippel-Lindau disease contain occult foci of malignancy [28] and with time will develop imaging features typical of malignancy. Therefore, any renal mass detected in a von Hippel-Lindau patient should be evaluated thoroughly for malignant features. If such features are not apparent with careful imaging techniques, then close follow-up with CT scanning or MR imaging of the kidneys should be performed every 3–6 months to monitor these lesions.

Imaging after treatment

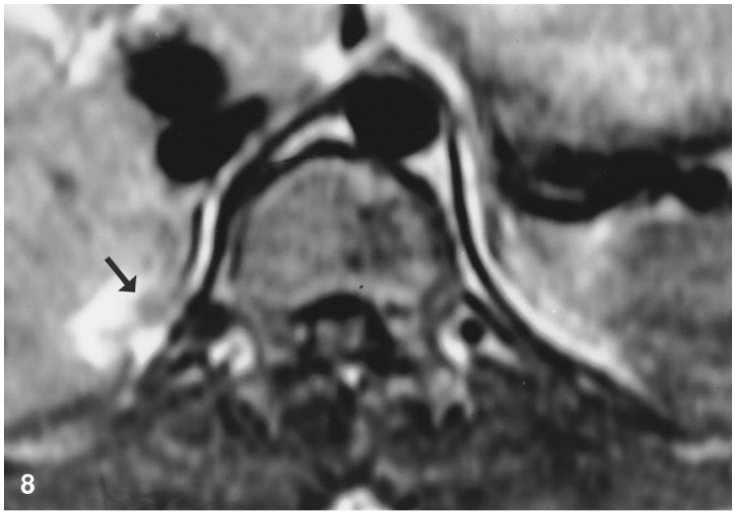
Small renal tumors can be resected with either standard radical nephrectomy or partial nephrectomy. Radical nephrectomy is the conventional therapy for RCC of any size in a patient with a normal contralateral kidney.

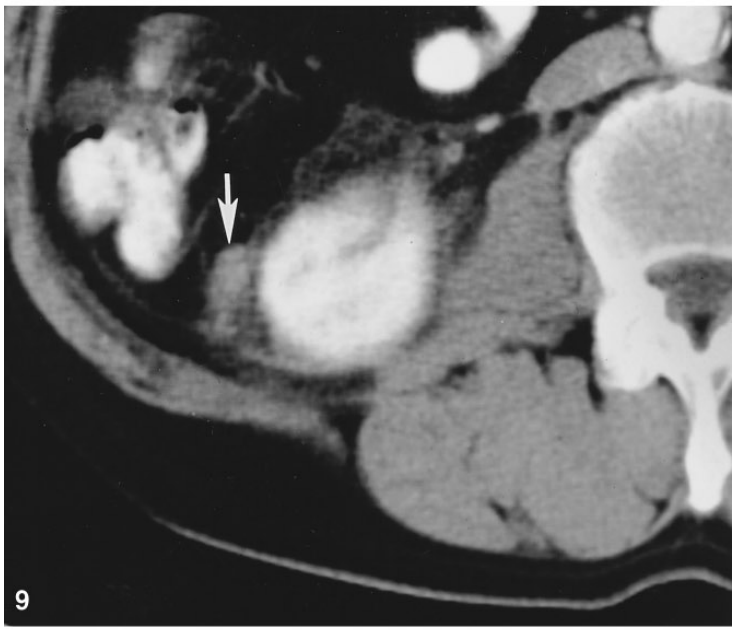
Absolute indications for partial nephrectomy include bilateral RCCs or unilateral RCC in an anatomic or functional solitary kidney [6, 29]. Partial nephrectomy is also favored in patients with risk factors for developing disease in the contralateral kidney. This group includes patients with hypertension, stone disease, diabetes mellitus, or von Hippel-Lindau disease [29]. In addition, many surgeons perform partial nephrectomies for RCC resection in patients whose contralateral kidney is normal and who have no known risk factors if the tumors are considered to be readily amenable to this form of surgical resection [29]. This includes tumors that are peripheral in location, away from the renal hilus, without evidence of lymph node disease or extension into the renal vein. The rate of local recurrence in the treated kidney is 2% or less [6], a rate similar to the rate at which asynchronous RCCs develop in the contralateral kidney after radical nephrectomy.

Because patients with RCC are often treated with partial nephrectomy, radiologists should be aware of considerations for follow-up imaging of these patients. In 1–3% of patients with a solitary RCC, an asynchronous contralateral RCC will develop. In patients with predisposing factors for RCC development, including von Hippel-Lindau disease, long-standing renal insufficiency, clear-cell RCC with translocation between chromosome 3 and chromosome 6 or 8, or hereditary multifocal papillary RCC, the percentage is considerably higher. In all of these high-risk patients and in those with a solitary RCC, at least semiannual and then annual renal CT should be preformed for surveillance. Patients without hereditary predisposition for RCC development can be followed up with renal CT annually for an initial surveillance period of 5 years after tumor resection. In addition to evaluation of the contralateral kidney for the development of asynchronous RCC, follow-up should include close monitoring of the operative bed. For stage I and stage II RCC, local recurrence is uncommon; fewer than 5% of patients have such recurrences after radical nephrectomy [6]. However, up to 25% of patients develop distant metastases after nephrectomy [6]. Therefore, the lung bases, liver, skeletal system, and lymph nodes should be carefully evaluated on every follow-up CT scan in a patient with a history of RCC. In addition, in assessing the renal bed in patients who have undergone nephrectomy, care must be taken to understand the extent of surgery when evaluating residual soft tissue. Adrenalectomy, once a standard component of radical nephrectomy, is now considered optional by many surgeons treating RCC because the ipsilateral adrenal gland is involved with RCC in only 4% of these patients [30]. Involvement of the adrenal gland is usually detected easily with preoperative CT or MR imaging. Therefore, an unaffected adrenal gland may be preserved after nephrectomy (Fig. 8), and its presence should not be misinterpreted as a pathologic mass in the renal bed. In addition, scar tissue may develop in the surgical bed after either partial or radical nephrectomy. Confluent areas of fibrosis (Fig. 9) can mimic recurrent RCC. Follow-up imaging or CT-guided biopsy may be necessary to distinguish postoperative fibrosis from recurrent tumor in these patients. Finally, on occasion, perinephric fat may be used to fill a renal surgical defect (Fig. 10) after tumor excision. In these cases, postoperative imaging can demonstrate what appears to be intraparenchymal fat mimicking an AML [31]. This finding should be recognized as an expected postoperative appearance rather than as interval development of an AML.

Summary

Renal masses 3 cm or smaller in diameter are detected commonly. Fortunately, the overwhelming majority of these lesions are simple cysts. With current technology, in many cases it may be easier to detect than to characterize definitively the very small lesion. Once lesions are detected, efforts should be made to characterize them as thoroughly as possible. Such efforts should routinely include CT or MR scans obtained both before and after contrast material infusion, which are tailored for the evaluation of renal masses. Attenuation coefficients of all renal masses should be evaluated on both preenhancement and postenhancement CT images. If the baseline units exceed 20 HU, thin collimation (3 mm or 5 mm) should be used to minimize partial-volume artifacts. A mass with a baseline attenuation of less than 20 HU without significant enhancement and lacking atypical features is a cyst that requires no further evaluation. Fat within a small renal mass indicates a benign angiomyolipoma. Lesions smaller than 10 mm in diameter are likely to be diagnostically indeterminant on the basis of imaging characteristics alone because it is difficult to avoid some artifactual elevation of the attenuation coefficients in these very small masses. However, in practice, minor attenuation elevation alone, without a visible solid-tumor component in a small renal mass, can be presumed to result from partial-volume averaging artifact in a cyst, except in high-risk patients. For larger masses, if a lesion is predominantly cystic but fails to meet strict CT criteria for a simple cyst, sonography should be used for further evaluation. If the lesion is detectable with sonography and characteristics indicate a simple cyst, then evaluation of this lesion is complete. If atypical features remain or if US demonstrates evidence of RCC, then surgery or follow-up imaging should be pursued. Imaging-indeterminant lesions 1.5 cm or smaller in diameter can be followed with surveillance imaging, unless they exhibit obvious imaging features of malignancy, i.e., enhancing solid components. Larger lesions may be excised or followed with





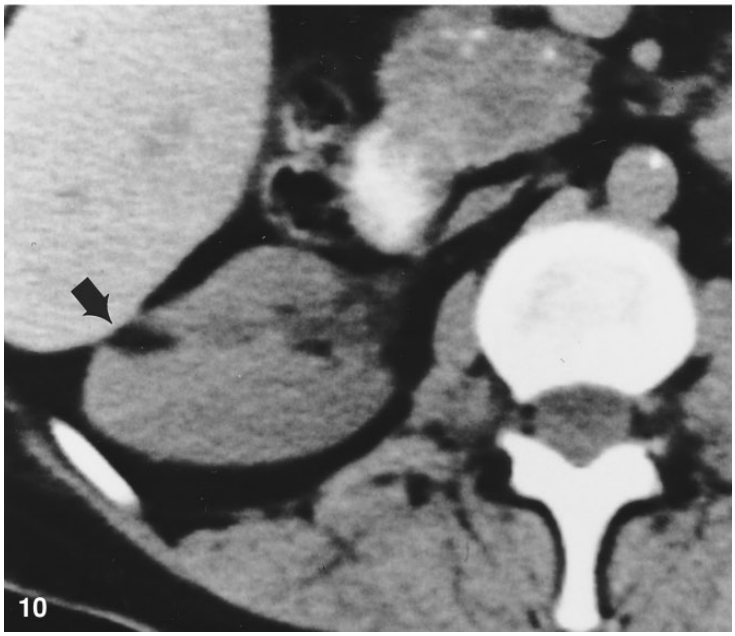


Fig. 8. MR of adrenal gland retained following nephrectomy for renal malignancy. This T1-weighted MR image demonstrates residual soft tissue (*arrow*) at the cephalad aspect of the right perinephric space. This patient had undergone radical nephrectomy 6 months prior to this imaging study. These 5-mm-diameter soft tissue nodules have been stable over prolonged surveillance and may represent the right adrenal gland, which was spared during surgery. The retained adrenal gland can easily be mistaken for tumor recurrence, but one should be aware that the adrenal gland is often spared with radical nephrectomy.

Fig. 9. Perinephric scarring following partial nephrectomy, which mimics local tumor recurrence. This contrast-enhanced axial CT through the lower pole of the right kidney demonstrates a discrete 1-cm-diameter soft tissue nodule (*arrow*) adjacent to the right kidney. This perinephric nodule developed adjacent to the area where an RCC had been excised 7 months prior to this CT. The development of this soft tissue mass suggested postoperative scarring or tumor recurrence. CT-guided needle biopsy of this perinephric lesion revealed benign fibrosis without evidence of tumor recurrence.

Fig. 10. CT of fat filling a surgical defect and mimicking renal angiomyolipoma. This CT scan demonstrates a small focus of fat (*arrow*) in the right renal parenchyma. This patient has von Hippel-Lindau disease and previously underwent partial nephrectomy. The site of tumor excision was packed with fat, leading to this CT appearance. Fat is sometimes used to fill the surgical bed when partial nephrectomy is performed.

surveillance imaging in patients who are at increased risk for surgical complications because of coexisting life threatening illnesses. It should be recognized that imaging specificity for these small lesions is not 100%. Up to 10% of solid renal masses are benign oncocytomas or angiomyolipomas lacking CT-detectable fat [21, 32]. Some lesions are complicated cysts or metastatic disease [32]. These will be indistinguishable from malignancies even with optimal imaging.

Acknowledgments. We are indebted to Karen Watson, Donna Garrison, Ph.D., and Terry Poovey for their assistance in preparing this manuscript.

References

1. Smith SJ, Bosniak MA, Megibow AJ, et al. Renal cell carcinoma: Earlier discovery and increased detection. *Radiology* 1989;170:699–703
2. Amendola MA, Bree RL, Pollack HM, et al. Small renal cell carcinomas: resolving a diagnostic dilemma. *Radiology* 1988;166:637–641
3. Aso Y, Homma Y. A survey on incidental renal cell carcinoma in Japan [abstract]. *J Urol* 1992;147:340–343
4. Sweeney JP, Thornhill JA, Grainger R, et al. Incidentally detected renal cell carcinoma: pathological features, survival trends and implications for treatment. *Br J Urol* 1996;78:351–353
5. Rodríguez-Rubio FI, Díez-Caballero F, Martín-Marquina A, et al. Incidentally detected renal cell carcinoma. *Br J Urol* 1996;78:29–32
6. Motzer RJ, Bander NH, Nanus DM. Renal-cell carcinoma. *N Engl J Med* 1996;335:865–875
7. Skinner DG, Colvin RB, Vermillion CD, et al. Diagnosis and management of renal cell carcinoma: a clinical and pathologic study of 309 cases. *Cancer* 1971;28:1165–1177
8. Bosniak MA, Rofsky NM. Problems in the detection and characterization of small renal masses. *Radiology* 1996;198:638–641
9. Semelka RC, Hricak H, Stevens SK, et al. Combined gadolinium-enhanced and fat-saturation MR imaging of renal masses. *Radiology* 1991;178:803–809
10. Warshauer DM, McCarthy SM, Street L, et al. Detection of renal masses: sensitivities and specificities of excretory urography/linear tomography, US and CT. *Radiology* 1988;169:363–365
11. Jamis-Dow CA, Choyke PL, Jennings SB, et al. Small (≤3-cm) renal masses: detection with CT versus US and pathologic correlation. *Radiology* 1996;198:785–788
12. Einstein DM, Herts BR, Weaver R, et al. Evaluation of renal masses detected by excretory urography: cost-effectiveness of sonography versus CT. *Am J Roentgenol* 1995;164:371–375
13. Yamashita Y, Ueno S, Makita O, et al. Hyperechoic renal tumors: anechoic rim and intratumoral cysts in US differentiation of renal cell carcinoma from angiomyolipoma. *Radiology* 1993;188:179–182
14. Bosniak MA. Angiomyolipoma (hamartoma) of the kidney: a preoperative diagnosis is possible in virtually every case. *Urol Radiol* 1981;3:135–142
15. Bosniak MA, Megibow AJ, Hulnick DH. CT diagnosis of renal angiomyolipoma: the importance of detecting small amounts of fat. *Am J Roentgenol* 1988;151:497–501
16. Kier R, Taylor KJW, Feyock AL, et al. Renal masses: characterization with Doppler US. *Radiology* 1990;176:703–707
17. Kuijpers D, Jaspers R. Renal masses: differential diagnosis with pulsed Doppler US. *Radiology* 1989;170:59–60
18. Zagoria RJ, Wolfman NT, Karstaedt N, et al. CT features of renal cell carcinoma with emphasis on relation to tumor size. *Invest Radiol* 1990;25:261–266
19. Silverman SG, Lee BY, Seltzer SE, et al. Small (≤3-cm) renal masses: correlation of spiral CT features and pathologic findings. *Am J Roentgenol* 1994;163:597–605
20. Silverman SG, Pearson GD, Seltzer SE, et al. Small (≤3 cm) hyperechoic renal masses: comparison of helical and conventional CT for diagnosing angiomyolipoma. *AJR* 1996;167:877–881
21. Bosniak MA. The current radiological approach to renal cysts. *Radiology* 1986;158:1–10
22. Bosniak MA. Observation of small incidentally detected renal masses. *Semin Urol Oncol* 1995;13:267–272
23. Curry NS. Small renal masses (lesions smaller than 3 cm): imaging evaluation and management. *Am J Roentgenol* 1995;164:355–362
24. Bosniak MA. The small (≤3.0 cm) renal parenchymal tumor: detection, diagnosis, and controversies. *Radiology* 1991;179:307–317
25. Curry NS, Schabel SI, Betsill WL. Small renal neoplasms: diagnostic imaging, pathologic features, and clinical course. *Radiology* 1986;158:113–117
26. Studer UE, Scherz S, Scheidegger J, et al. Enlargement of regional lymph nodes in renal cell carcinoma is often not due to metastases. *J Urol* 1990;144:243–245
27. Numata M, Momose Y. Renal cell carcinoma: oncocyte type. *Am J Kidney Dis* 1989;14:53–55
28. Choyke PL, Filling-Katz MR, Shawker TH, et al. Von Hippel-Lindau disease: radiologic screening for visceral manifestations. *Radiology* 1990;174:815–820
29. Polascik TJ, Pound CR, Meng MV, et al. Partial nephrectomy: technique, complications and pathological findings. *J Urol* 1995;154:1312–1318
30. Kozak W, Höltl W, Pummer K, et al. Adrenalectomy—still a must in radical renal surgery? *Br J Urol* 1996;77:27–31
31. Papanicolaou N, Harbury OL, Pfister RC. Fat-filled postoperative renal cortical defects: sonographic and CT appearance. *Am J Roentgenol* 1988;151:503–505
32. Levine E, Huntrakoon M, Wetzel LH. Small renal neoplasms: clinical, pathologic, and imaging features. *Am J Roentgenol* 1989;153:69–73