21 Percutaneous Biopsy and Radiofrequency Ablation

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21.1 Introduction

Traditionally solid renal masses have been managed with open surgical resection, by either complete or partial nephrectomy. This management is based on the epidemiologic and imaging data of renal cell carcinoma which accounts for the majority of solid renal masses. The surgical approach is also based on the traditional belief that image-guided needle biopsy cannot adequately discriminate between renal cell carcinoma and the majority of benign masses. The management dilemma occurs when imaging alone cannot definitely classify the lesion as solid or when the lesion is small and incidentally detected on a CT performed for unrelated reasons. Similar management issues occur in patients with known primary extrarenal malignancy, when a renal mass is detected on CT. The diagnosis of these lesions with image-guided biopsy is often the basis on which the new nephron-sparing treatment procedures, including laparoscopic partial nephrectomy or image-guided radiofrequency ablation, can be performed. These less invasive procedures are associated with significantly less morbidity and shorter hospital stay, and nephron-sparing surgery, in selected cases, provides clinical outcomes similar to traditional nephrectomy. Pre-treatment investigation of some renal lesions with image-guided biopsy allows detection of benign tumors, locally advanced carcinoma, metastatic disease to the kidney, and benign lesions which are indeterminate by imaging criteria.

The characterization and treatment of renal neoplasms has gained importance with current increasing detection of incidental, localized, as well as advanced renal cell cancer (Chow et al. 1999).

In this chapter we discuss the role of image-guided biopsy and percutaneous radiofrequency ablation in the current management of focal renal lesions.

21.2 Percutaneous Biopsy

In the majority of cases the CT and MR imaging can characterize a renal lesion as solid or cystic. Most solid renal neoplasms are still treated with surgical removal, without a preceding biopsy. In the remaining lesions, the options include follow-

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up cross-sectional imaging, image-guided biopsy, or surgical management. With continued experience and improvements in the technique, image-guided biopsy has become a safe, accurate, and reliable method for the diagnosis of problematic cases (Caoili et al. 2002; Chow et al. 1999; Eshed et al. 2004; Mignon et al. 2001; Lee et al. 1991; Richter et al. 2000; Rybicki et al. 2003; Wood et al. 1999). The core biopsy results have been noted to modify therapeutic management in 38–41% cases and morbidity is low compared with surgery (Barriol et al. 2000; Wood et al. 1999). Metastases, lymphoma, and some cases of oncocytoma are examples of biopsy results that may preclude surgery.

21.2.1 Indications

Indications for renal biopsies include indeterminate focal lesions, which do not have all the imaging features of neoplasm; suspicion of metastases, lymphoma, angiomyolipoma (Figs. 21.1, 21.2), or oncocytoma; differentiation of transitional cell carcinoma from renal cell carcinoma; and complex cystic renal lesions (Fig. 21.3). Other indications include locally advanced renal lesion, renal transplant mass, history of tuberous sclerosis, poor surgical candidate, mass in a solitary kidney, and focal lesion in a patient with extrarenal malignancy (Hara et

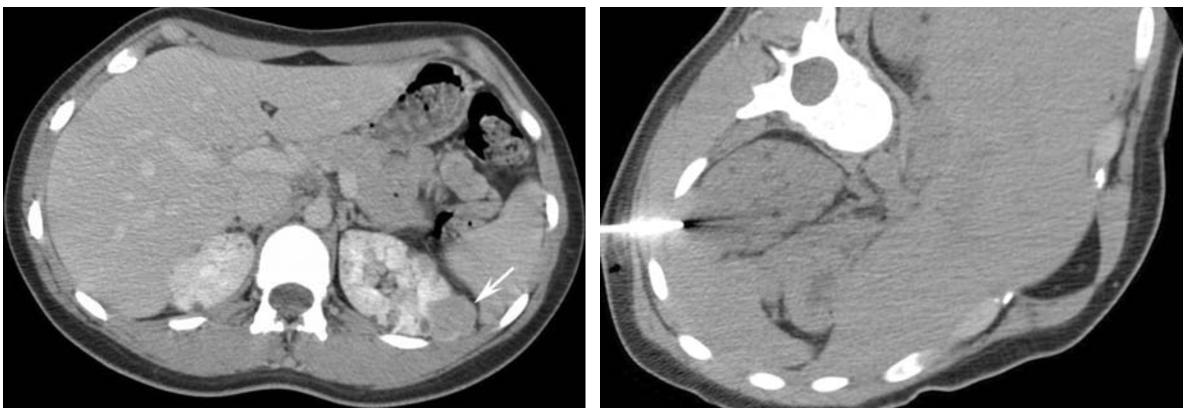

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Fig. 21.1a,b. Percutaneous biopsy of multiple fat-containing tumors in a 21-year-old woman. **a** Axial contrast-enhanced CT scan shows a soft tissue density mass (*arrow*) in the left kidney. There is no fat density seen in the mass. **b** Axial unenhanced CT scan obtained in oblique prone position shows the 17-G coaxial biopsy needle tip in the renal mass. The histopathological diagnosis was angiomyolipoma.

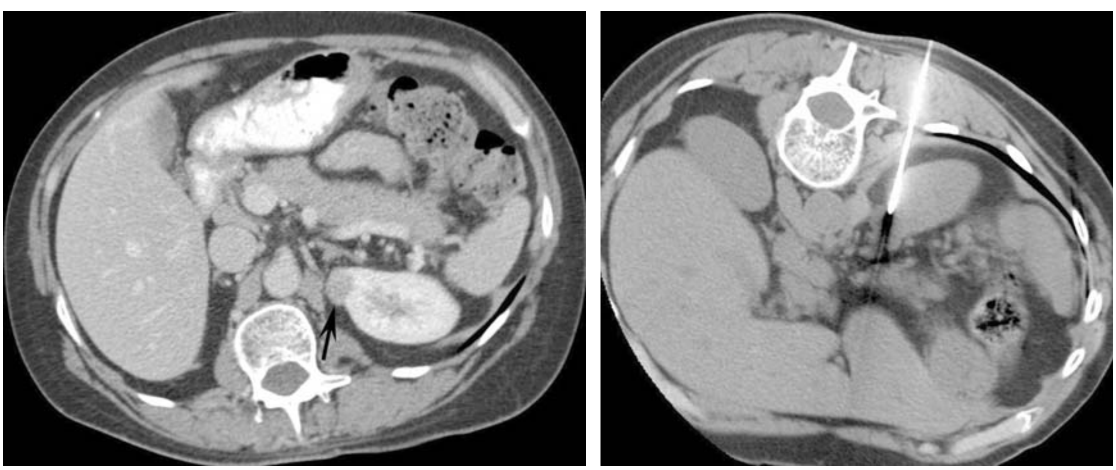

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Fig. 21.2a,b. Percutaneous biopsy of soft tissue density tumor in a 61-year-old woman. **a** Axial contrast-enhanced CT scan shows a soft tissue density, exophytic mass (*arrow*) arising from the left kidney. **b** Axial unenhanced CT scan in prone position shows the 18-G needle tip in the mass. The histopathological diagnosis was angiomyolipoma.

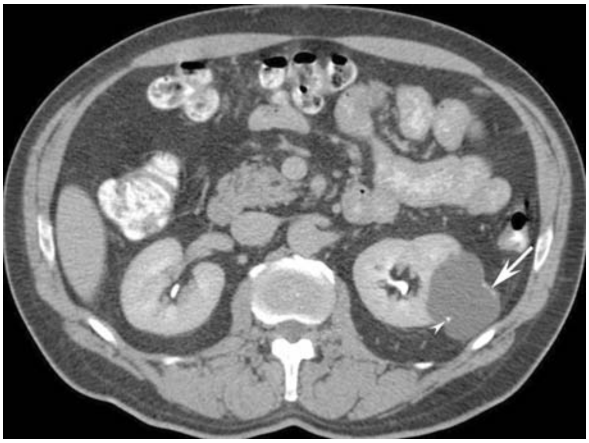
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Fig. 21.3a-c. Percutaneous aspiration of cystic renal lesion in a 62-year-old man. **a** Axial contrast-enhanced CT scan shows a cystic lesion with focal thickening (*arrow*) in the lateral wall and a focus of calcification (*arrowhead*) in the medial wall. **b** Axial unenhanced CT scan in prone position shows a 20-G aspiration needle tip seen in the cystic renal lesion. **c** Contrast injection into the cyst does not demonstrate any focal intracystic solid component. The cytological analysis was negative for malignant cells.

al. 2001; Lechevallier et al. 2000; Mignon et al. 2001).

Although the traditional treatment of Bosniak category-III lesions is surgery, approximately 40% of these lesions are benign. Identification of these patients by percutaneous biopsy can obviate unnecessary surgery for patients with benign lesions (Harisinghani et al. 2003).

21.2.2 Technique

Image-guided renal mass biopsy procedures can be performed using CT, ultrasound (US) or, less commonly, fluoroscopic guidance. The majority of focal renal biopsy series reported in the recent literature were performed under CT guidance. In obese patients CT guidance provides better renal visibility than US (Lee et al. 1991). Ultrasound has the advantage of real-time guidance and lack of ionizing radiation and the biopsy results are comparable to those of CT guidance. Ultrasound guidance provides satisfactory results in renal biopsies for patients with and without focal renal lesion (Arenson 1991; Juul et al. 2004).

The biopsy needle used for renal biopsies is typically 18-G and the number of specimens obtained varies from two to five. An 18-G biopsy needle gun passed through a 17-G coaxial needle has the advantage of allowing multiple biopsies by providing a track for the core needle to be placed into the mass (Fig. 21.4). The 18-G core biopsy more often yields diagnostic results than a smaller-caliber needle (Johnson et al. 2001; Rybicki et al. 2003).

In our department, the patient lies in lateral decubitus or prone position. Under image guidance the 17-G coaxial biopsy needle is placed at the edge or within the renal mass. Following this, the 18-G biopsy needle is used to obtain multiple cores. We also obtain multiple fine-needle aspiration samples using a 22-G needle, inserted through the 17-G coaxial needle. Post-procedural CT is obtained after removal of the biopsy needle to evaluate for possible complication.

Another renal biopsy technique is transjugular renal biopsy which has been used for renal biopsy in patients under evaluation for renal dysfunction (Cluzel et al. 2000; Jouet et al. 1996; Mal et al. 1990; Mal et al. 1992; Rychlik et al. 2004; Thompson et al. 2004). This technique should be considered in patients with significantly high risk of bleeding, most often related to anticoagu-

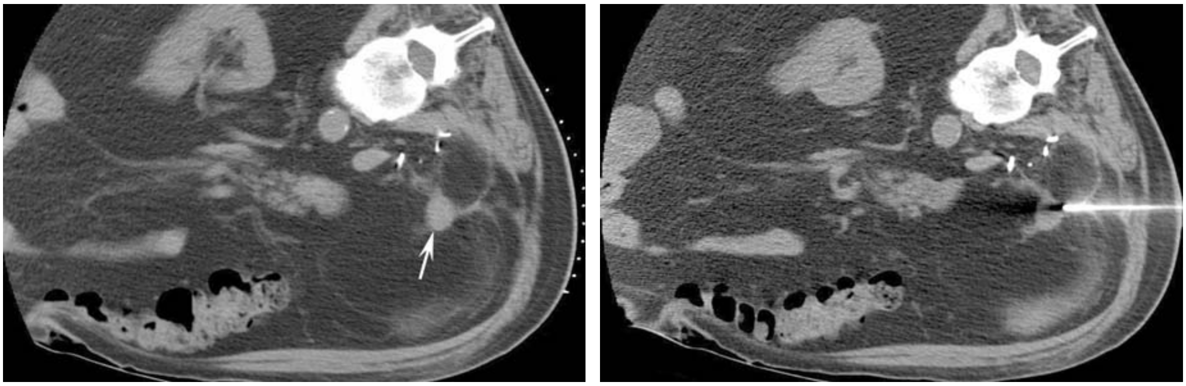

Fig. 21.4a,b. Percutaneous biopsy in a 70-year-old woman with history of renal cell carcinoma. **a** Axial postnephrectomy unenhanced CT scan in lateral position shows a soft tissue nodule (*arrow*) in the nephrectomy bed. **b** Axial unenhanced CT scan in lateral position shows the biopsy needle tip in the soft tissue nodule. The histopathological diagnosis was recurrent renal cell carcinoma.

lation use. This procedure involves placement of a 7-F jugular sheath, an inner stiffening cannula, a 5-F curved catheter, and a 19-G biopsy needle (Fig. 21.5). The biopsy is typically performed on the right kidney because of the relatively shorter length of the right renal vein and better angle for the needle fire. The adequacy rate of renal biopsy is comparable to that of percutaneous biopsy. It can be used in obese patients in whom percutaneous renal biopsy is technically more difficult due to poor visualization and longer skin to renal vein distance (Fine et al. 2004).

21.2.3 Results

Image-guided renal biopsy is a safe, sensitive, and useful procedure in the management of indeterminate renal lesions or renal lesions which are suspected to be of benign etiology. The results of 779 biopsies for focal renal lesions in 8 of the studies performed between 1999 and 2004 show that image-guided biopsies provided sufficient tissue for diagnosis in 704 (90.4%) cases (Barriol et al. 2000; Caoili et al. 2002; Eshed et al. 2004; Hara et al. 2001; Lechevallier et al. 2000; Mignon et al. 2001; Richter et al. 2000; Rybicki et al. 2003; Wood et al. 1999). Richter et al. (2000) in a review of 393 image-guided renal mass biopsies found false diagnoses in only 7 (1.2%). The sensitivity of detection of malignancy is high and ranges from 76 to 93%. Compared with core biopsy, the limitations of fine-needle aspiration include higher false-negative rates and difficulty in diagnosis of oncocytoma and angiomyolipoma (Harisinghani et al. 2003; Rybicki et al. 2003).

Fig. 21.5. Transjugular renal biopsy in a 75-year-old man. Right renal vein is opacified during the transjugular right renal biopsy for medical renal disease. The biopsy needle tip (*arrow*) is located in the right renal vein.

Although there is a high correlation between core biopsy and histological diagnosis, insufficient tissue for diagnosis should be viewed with caution, as some of these lesions may represent neoplasm and surgical resection of localized renal cell carcinoma has a high cure rate. These lesions can be followed up on imaging or can be surgically resected (Eshed et al. 2004; Rybicki et al. 2003).

A majority of the lesions in the study by Rybicki et al. (2003) were biopsied with 14- to 22-G needles. In that study, all false negative results were obtained with 20- or 22-G needles, indicating a higher negative predictive value with larger needles. Some studies have found a higher incidence of insufficient material being acquired for histological evaluation when the tumor is less than 3 cm, but this result is controversial (Eshed et al. 2004; Lechevallier et al. 2000; Mignon et al. 2001; Rybicki et al. 2003). Rybicki et al. (2003) suggested caution when interpreting the results of renal masses less than 3 and more than 6 cm diameter. They showed negative predictive values of 60 and 44% for renal lesions which were less than 3 or more than 6 cm in diameter, respectively. Sampling of the necrotic area in a large mass is an important cause of sampling error. Although these results were not statistically significant, they were lower than the 89% negative predictive value for renal masses between 4 and 6 cm.

21.2.4 Complications

The complication rate from renal biopsies for focal lesions is low and most can be treated conservatively. Complications include hemorrhage (perinephric, subcapsular, and retroperitoneal) hematuria, arteriovenous fistula, pseudoaneurysm, urinoma, arterial hypertension, pneumothorax, renal abscess, and needle-track seeding (Figs. 21.6, 21.7). Hematoma in or around the kidney is a well-known post-procedural complication; however, the majority of patients do not need treatment but should be conservatively followed. Compression of the renal parenchyma by the hematoma can cause ischemia and secondary hypertension (Mackie et al. 2004; Wanic-Kossowska 1998).

Hematuria is the most common complication of percutaneous renal biopsy but usually resolves on its own. Transfusion is needed in only a minority of cases. Tumor seeding of the needle track, hemothorax, intestinal perforation, and disseminated intravascular coagulation are rare and occur only as case reports in the literature. Seeding has been reported rarely with biopsy of renal cell carcinoma, transitional cell carcinoma, Wilms' tumor, and oncocytoma (Auvert et al. 1982; Bush et al. 1977; Gibbons et al. 2004; Kiser et al. 2004; Lee et al. 1995; Shenoy et al. 1991; Slywotzky and Maya 1994). Arteriovenous fistula is most often subclinical, most commonly does not require treatment, and resolves on its own. About 30% of cases do not regress and are associated with unfavorable outcome. Uncommonly they can cause hematuria, hypertension, or renal function impairment, and need treatment by selective coil embolization or surgical ligation (Horcicka et al. 2002; Lund-Sorensen et al. 1995; Memis et al. 1992).

Complications associated with transjugular renal biopsy include hemorrhage from capsular or pelvicalyceal system penetration. Capsular perforation is a common occurrence from the needle throw and was recorded in 73.9% of 23 patients by Thompson et al (2004). Hemorrhage can result in perinephric/retroperitoneal hematoma or hydronephrosis from clots in the pelvicalyceal system. Hypovolemic shock is an uncommon complication, but the majority of patients do not need transfusion, although they should be followed.

21.3 Radiofrequency Ablation

21.3.1 Background

With increased detection of renal masses on CT the role of the nephron-sparing procedure has become important, especially for tumors which are small or which may not be malignant. The techniques available now include laparoscopic partial nephrectomy, radiofrequency ablation (RFA), and cryoablation. Radiofrequency ablation is an alternative to nephron-sparing surgery. There is less patient morbidity

Fig. 21.6. Complication after renal biopsy in a 57-year-old man. Axial unenhanced post-procedure CT scan shows a posterior perinephric (*arrowhead*) and posterior pararenal space hematoma (*arrow*).

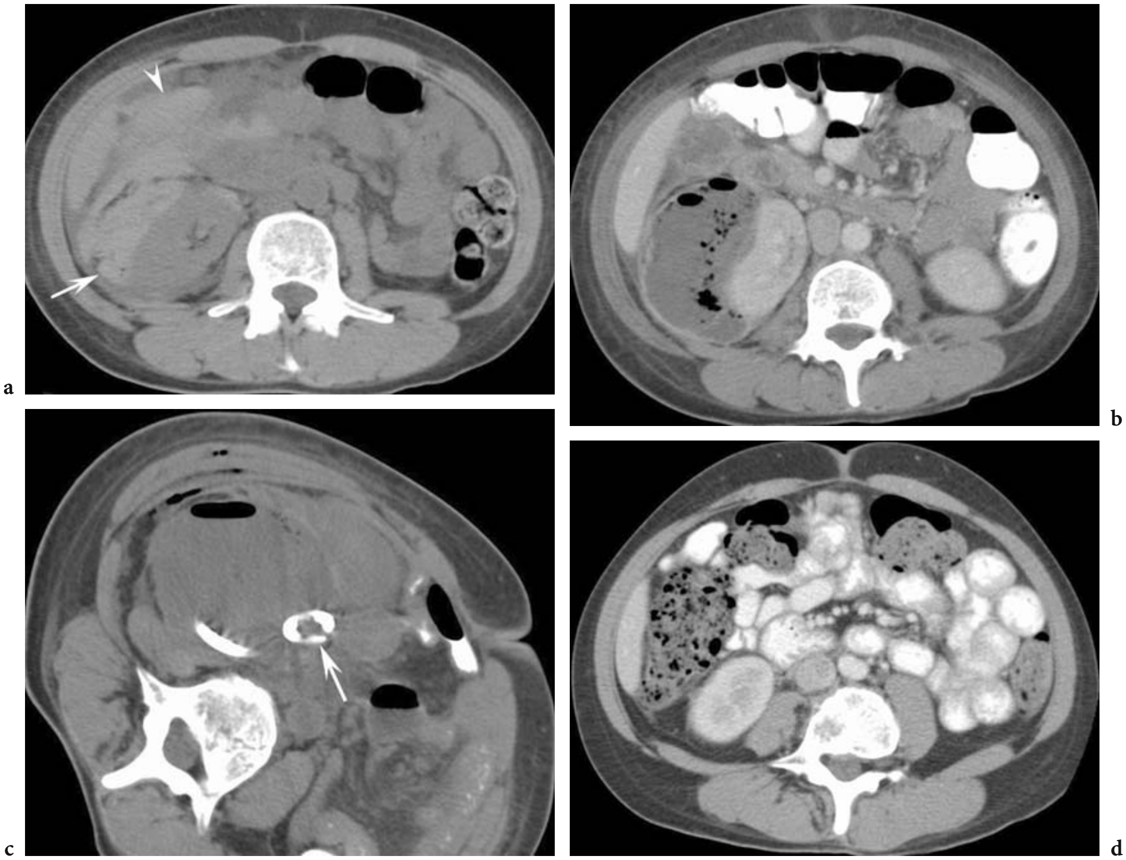

Fig. 21.7a-d. Complication after renal biopsy in a 37-year-old woman. **a** Axial unenhanced post-procedure CT scan shows a subcapsular (*arrow*), anterior pararenal space, and Morrison's pouch (*arrowhead*) hematoma. **b** Follow-up axial contrast-enhanced CT scan shows increase in size of the collection, enhancement of wall, and development of air pockets. The findings were consistent with subcapsular abscess. **c** Post-drainage axial CT scan shows the percutaneous drainage catheter (*arrow*) in the abscess. **d** Follow-up axial CT scan shows complete resolution of the abscess.

and it can be performed under sedation in patients who are poor surgical risks.

Radiofrequency ablation has been used traditionally in the treatment of liver neoplasm but is increasingly more being used for the treatment of renal lesions in patients who are poor surgical risks or who refuse surgery (de Baere et al. 2002; Gazelle et al. 2000; Goldberg and Dupuy 2001a; Goldberg and Dupuy 2001b). It is also used in patients with a solitary kidney and as an alternative to nephron-sparing surgery (Farrell et al. 2003).

Since the description by Zlotta et al. (1996) of RFA of the human kidney ex vivo and in vivo, several studies have established this modality as an alternative to other nephron-sparing procedures in the treatment of renal tumors (de Baere et al. 2002; Gazelle et al. 2000; Goldberg and Dupuy 2001a; Goldberg and Dupuy 2001b; Zlotta et al. 2004).

21.3.2 Principle

The ideal lesion for RFA is a solitary renal lesion less than 3 cm in diameter and predominantly exophytic in location. It is more difficult to treat tumors which are centrally located, due to heat dissipation by the renal vasculature. In a study by Gervais et al. (2003) only 45% (5 of 11) of central or mixed tumors were treated with technical success, which meant absence of enhancement on 1-month imaging follow-up. Peripherally located renal tumors are not found in the vicinity of large vessels and are surrounded by perinephric fat which provides insulation; therefore, the results of radiofrequency ablation are better for exophytic tumors (Gervais et al. 2000). Larger tumors are more difficult to treat and often need more than one overlapping treatment to cover the entire tumor volume and provide a tumor-free peripheral margin.

This is analogous to liver RFA, where smaller tumors are more likely to be completely treated than larger tumors (LIVRAGHI et al. 2000).

21.3.3 Technique

Radiofrequency ablation procedures can be performed with CT or US guidance, under sedation or general anesthesia (Figs. 21.8, 21.9). Although a number of radiofrequency generators are available, the two most commonly used are the internally cooled single or cluster electrodes with pulsed current: RITA (Radiofrequency interstitial tissue ablation) device (Rita Medical Systems, Mountain View, Calif.); and multi-timed expandable electrodes with temperature control: Radionics Device (Radionics, Burlington, Mass.). The starburst needle (Rita Medical Systems) is used to treat lesions smaller than

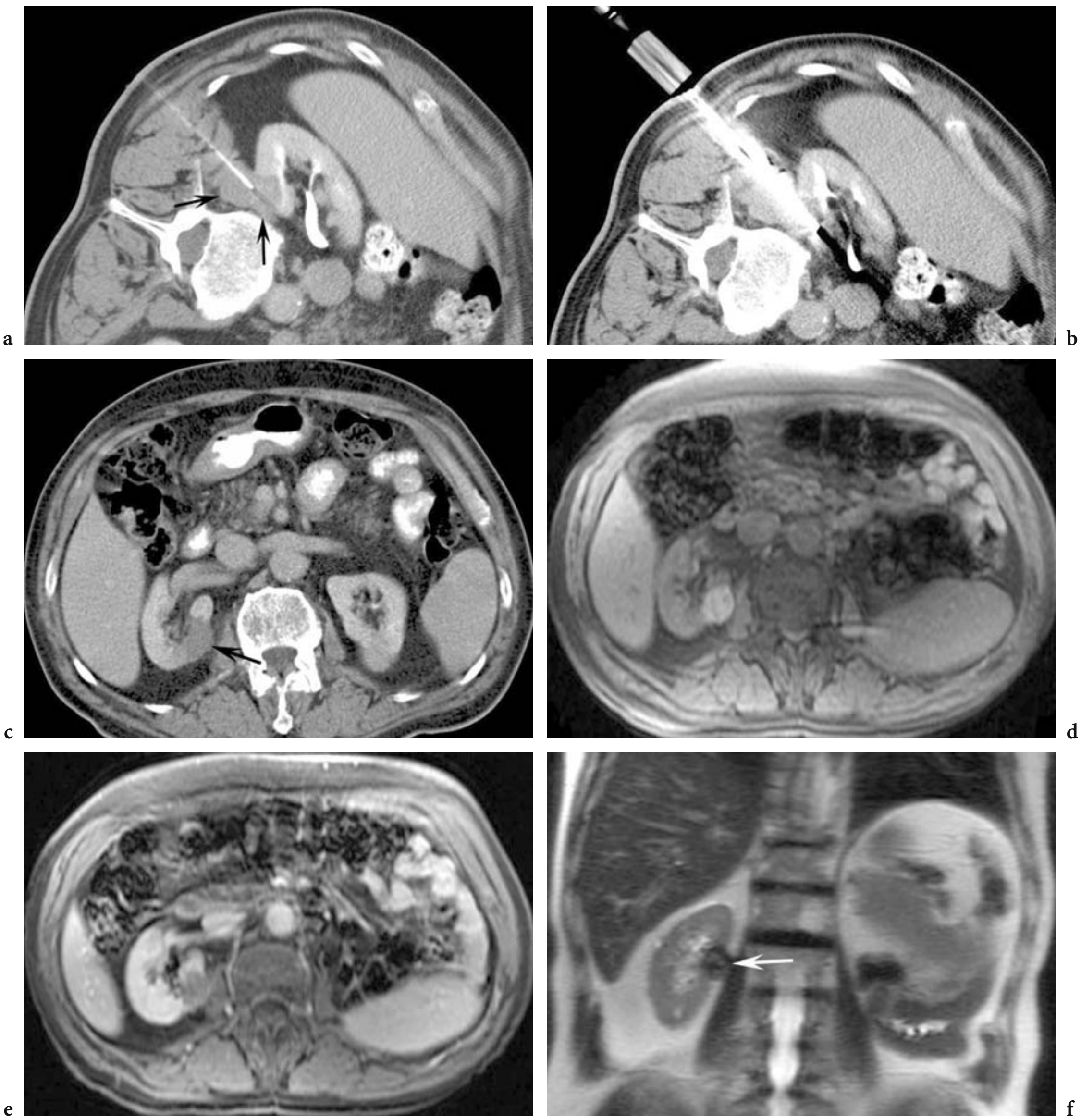

Fig. 21.8a-f. Percutaneous needle biopsy and radiofrequency ablation in a 78-year-old man with right renal mass. **a** Axial CT scan at the time of diagnosis shows the needle tip within the right renal mass (*arrows*). The histopathological diagnosis was renal cell carcinoma. **b** Axial CT scan shows that cluster probe electrodes are positioned within the right renal mass. **c** Follow-up axial CT shows a nonenhancing defect (*arrow*) in the right renal cortex, at the site of the previously seen mass. Axial **d** unenhanced T1-weighted MR image shows a focal hyperintense lesion which does not enhance on **e** contrast-enhanced T1-weighted MR image and is hypointense (*arrow*) on **f** T2-weighted MR image.

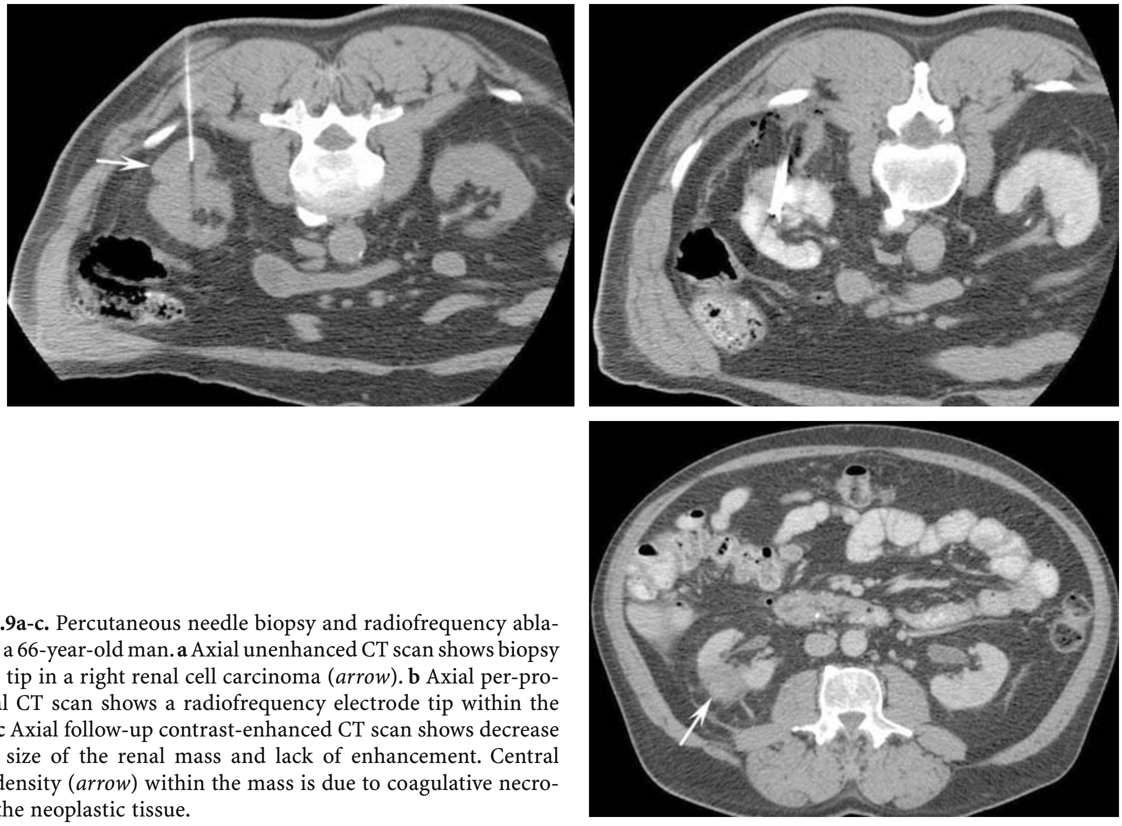

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Fig. 21.9a-c. Percutaneous needle biopsy and radiofrequency ablation in a 66-year-old man. **a** Axial unenhanced CT scan shows biopsy needle tip in a right renal cell carcinoma (*arrow*). **b** Axial per-procedural CT scan shows a radiofrequency electrode tip within the mass. **c** Axial follow-up contrast-enhanced CT scan shows decrease in the size of the renal mass and lack of enhancement. Central hyperdensity (*arrow*) within the mass is due to coagulative necrosis of the neoplastic tissue.

2 cm, and the starburst XL needle (Rita Medical Systems) is used in larger lesions.

The Radionics device includes a cool-tip single electrode and cool-tip cluster electrode kit; the needle length varies from 10 to 25 cm in the former and 10 to 20 cm in the latter. Each kit includes an electrode, inflow tubing set, outflow tubing set, ground pads, and introducer (with cluster electrode only). The grounding pads are applied to the thighs, at an equal distance from the treatment site. The inflow and outflow tubing are responsible for the flow of iced water or saline to and from the electrode tip. The active tip of the electrodes is typically 2–3 cm in length and lies entirely inside the tumor to prevent damage to the surrounding tissues. Care is taken to avoid damage to important structures such as ureter or major vessels. After positioning the electrode tip in the tumor under image guidance, the tumor is ablated with one or more heating cycles lasting 12 min each. The current is pulsed in response to a rapid increase in impedance, which is caused by charring of tissue and subsequent inhibition of heat diffusion. As the geometry of the burn diameter may not cover the entire tumor, so often more than one overlapping treatments are required to cover the entire tumor. For example, 142 overlapping ablations were needed for the treatment of 42 tumors in the study by Gervais et al. (2003). The aim of the treatment is to produce a tumor free margin of up to a centimeter around the tumor.

A pre-ablation biopsy at the same sitting or at an earlier session is commonly performed and may alter the treatment or follow-up of these patients. A benign diagnosis on biopsy precludes an unnecessary RFA procedure.

When US guidance is used, intense echoes spreading from the electrode tip can be seen. This appearance is secondary to the microbubbles produced by tissue ablation. This appearance is transient and the echogenicity of the focal renal lesion becomes heterogeneous after a few minutes.

Success of RFA is indicated by lack of enhancement on follow-up CT or MR imaging. Treated tumors are seen as a hypodense or hypointense defect in the renal parenchyma. The exophytic tumors retain the configuration of the original tumor with minimal decrease in size after RFA. The findings on follow-up CT or MR imaging also include fatty replacement at the interface with normal kidney and soft tissue stranding in fat around the tumor (Gervais et al. 2003b, Matsumoto et al. 2004).

21.3.4 Complications

Overall RFA is a low morbidity procedure in the treatment of renal neoplasm. Complications of RFA include hemorrhage, lumbar plexus damage, urinoma, ureteral stricture, and abscess (Figs. 21.10–21.14). Post-procedural pain along the distribution of the lumbar plexus may occur in patients treated by the posterior approach where the psoas muscle is heated. There is one report of needle-track seeding after RFA of a renal mass (Mayo-Smith et al. 2004).

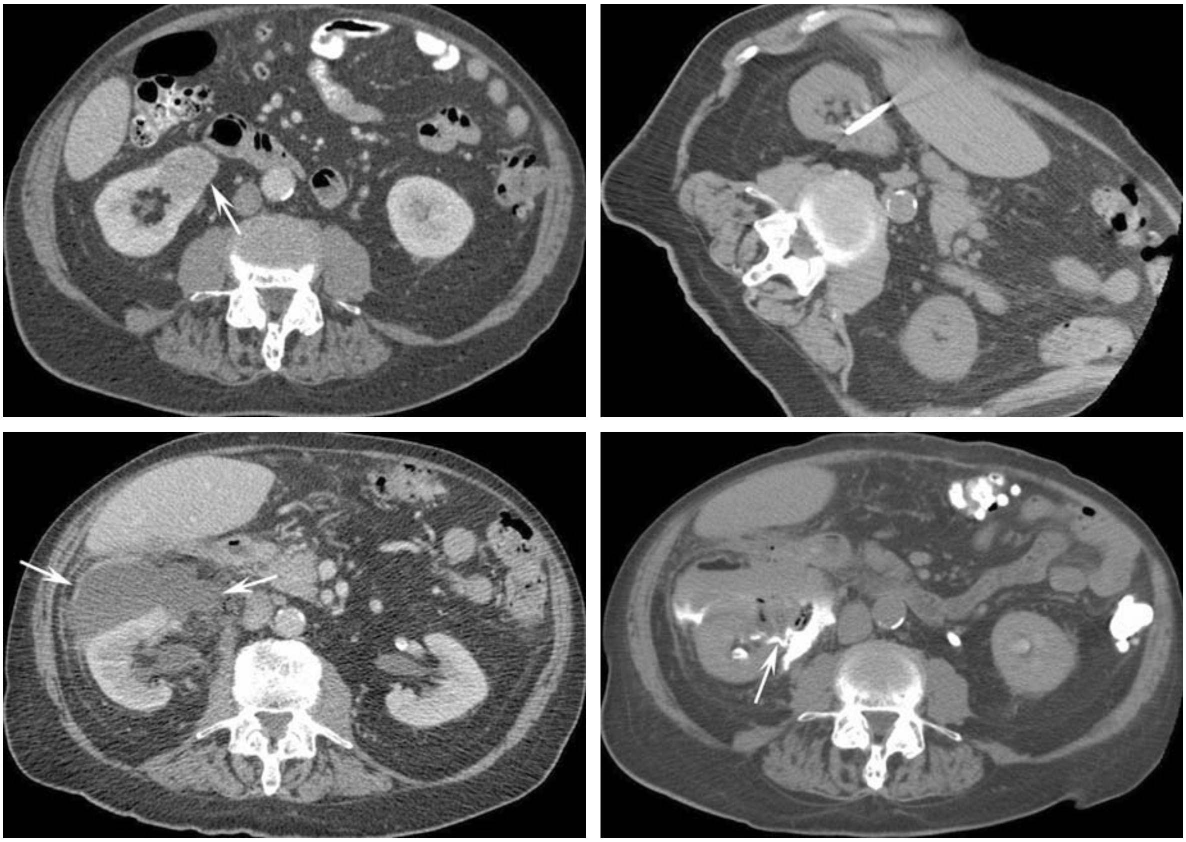

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Fig. 21.10a-e. Complication after radiofrequency ablation in a 87-year-old man. **a** Axial contrast enhanced CT scan shows a right renal mass (*arrow*). **b** Axial CT scan shows Radionics electrode tip at the junction of the mass and the normal renal parenchyma. **c** Axial contrast-enhanced CT scan shows perinephric fluid collection (*arrows*). **d** Delayed axial contrast-enhanced CT scan shows communication (*arrow*) of the right pelvicalyceal system, with the anterior collection. **e** Tube injection through the percutaneous drainage catheter placed in a bilobed anterior collection (*arrow*) shows prompt opacification of the right pelvicalyceal system.

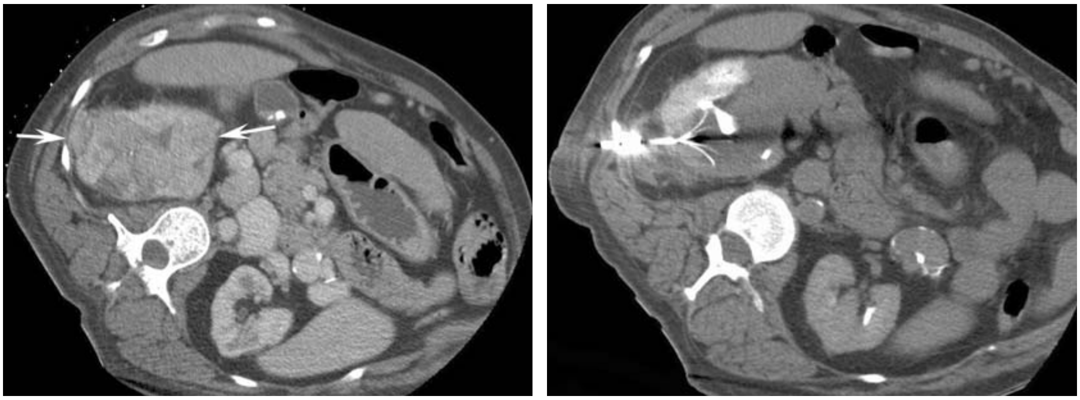

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Fig. 21.11a-c. Complication after radiofrequency ablation in a 47-year-old woman with large renal cell carcinoma. **a** Axial contrast-enhanced CT scan shows a large right renal cell carcinoma (*arrows*). **b** Axial per-procedural CT scan shows a Rita probe within the mass. **c** Axial post-procedure CT scan shows posterior perinephric and posterior pararenal hematoma (*arrows*).

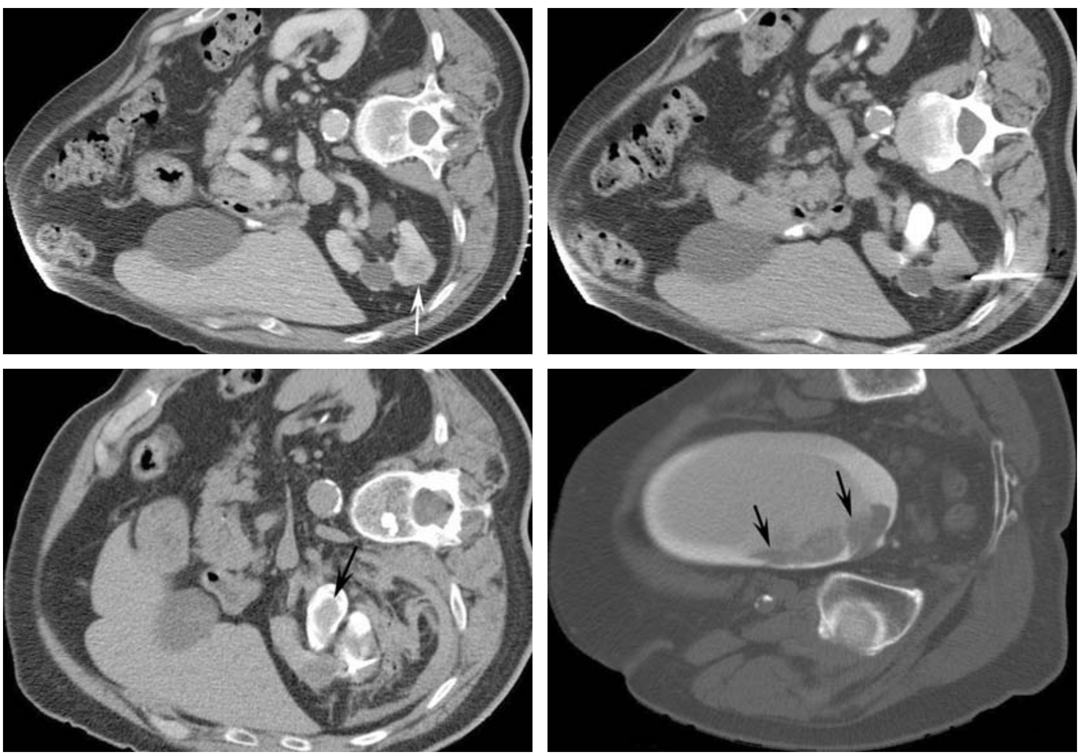

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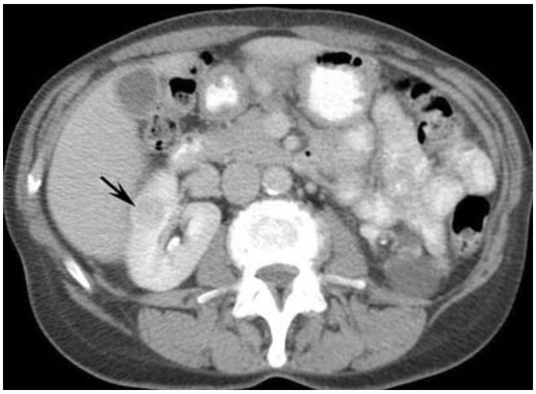
Fig. 21.12a-d. Complication after radiofrequency ablation in a 79-year-old man. **a** Axial contrast-enhanced CT scan shows a solid right renal mass (*arrow*). **b** Axial CT scan shows the biopsy needle tip within the renal mass. Axial post-radiofrequency ablation CT scans show clots (*arrows*) within **c** the right pelvicalyceal system and **d** urinary bladder.



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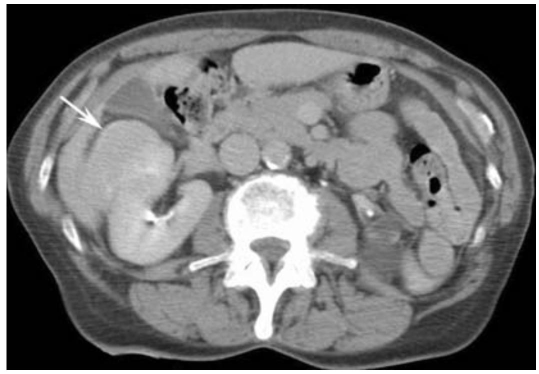

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Fig. 21.13a-c. Complication after radiofrequency ablation in a 61-year-old woman with atrophic left kidney. **a** Axial contrast-enhanced CT scan shows an enhancing right renal mass (*arrow*). **b** Axial per-procedural contrast-enhanced CT scan shows the ablation electrode tip in the mass. A transhepatic route was adopted for this radiofrequency ablation. **c** Axial post-procedural CT scan shows an anterior perinephric hematoma (*arrow*).

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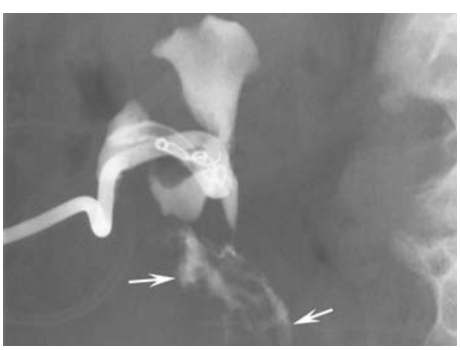

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Fig. 21.14a-e. Complication after radiofrequency ablation in a 77-year-old man. **a** Axial contrast-enhanced CT scan shows a heterogeneously enhancing left renal mass (*arrow*). **b** Axial per-procedural CT scan shows that a single Radionics electrode tip is identified within the left renal mass. **c** Left renal angiogram after radiofrequency ablation shows an arteriovenous fistula with early opacification of renal vein (*arrow*). **d** Post-embolization renal angiogram shows resolution of the fistulous communication. **e** Tube injection through the percutaneous nephrostomy catheter shows leakage of contrast outside the pelvicalyceal system, into the urinoma (*arrows*).

21.4 Conclusion

Image-guided percutaneous renal biopsy is safe and accurate in sampling the lesion and coming to a final histopathological diagnosis. Image-guided renal mass biopsy is useful for avoiding unnecessary surgery for benign masses and in the diagnosis of renal metastases, lymphoma, differentiation of centrally located renal cell carcinoma from renal cell carcinoma, and complex cystic renal lesions. The renal biopsy can be performed with either CT or US guidance, although the majority of the current literature is based on CT-guided procedures.

Although radiofrequency ablation has been used most often for liver tumors, its use for renal masses is relatively recent and has shown promising clinical results. Long-term follow-up radiofrequency ablation results for renal masses are still being performed to define the position of this treatment in the management of renal neoplasm. The ideal lesion for radiofrequency ablation in the kidney is single, peripherally located and less than 3 cm diameter renal mass. Radiofrequency ablation of a renal mass is often useful as an alternative to nephron-sparing surgery in poor surgical risk patients and in patients with a solitary kidney.

As the frequency of detection of renal masses increases and the utility of percutaneous biopsy and radiofrequency ablation are better defined in the literature, we are likely to see these procedures become more frequent in patient management.

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