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Review – Kidney Cancer

Renal Tumor Biopsies for Evaluation of Small Renal Tumors: Why, in Whom, and How?

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Abstract

Context: Renal tumor biopsies (RTBs) gained popularity in the evaluation of small renal tumors (SRTs) because imaging alone is insufficient to show the underlying aggressiveness of SRTs and more ablative therapies without definitive histology are available.

Objective: To describe why, in whom, and how RTB should be performed for the evaluation of SRTs.

Evidence acquisition: Data were obtained from English-language studies on the use of RTB for the evaluation of solid SRTs in vivo listed in PubMed.

Evidence synthesis: The reasons for RTBs are (1) the increasing incidence of SRTs; (2) the finding that a significant number of SRTs (20%) are benign; (3) the availability of new management options, such as ablative therapy and surveillance strategies; and (4) the fact that imaging alone is unable to predict biologic behavior. In addition, advances in pathologic evaluation have improved the ability of RTB to differentiate the underlying tumor.

Three studies of RTB for SRTs in vivo performed under computed tomography (CT) guidance together with a complete histopathologic evaluation gave accuracies for predicting malignancy, grading, and renal cell cancer subtype of 92–96%, 70–76%, and 78–92%, respectively. RTB was insufficient or inconclusive in 3–21% of cases. RTB was underutilized in ablative therapies of SRT (20–45% had no or inconclusive histology). The use of RTB was limited in multiple renal tumors and hybrid tumors. The complication rate was low (<5%), major complications were very rare (<1%), and tumor spreading has been reported only anecdotally. RTB are recommended to help in differentiating benign from malignant SRTs prior or during ablative therapies and in follow-up, especially after radiofrequency (RF) ablation.

Conclusions: RTB is a safe and accurate procedure by which to evaluate SRTs. RTB can help in defining patient management—especially the use of ablative surgery—and to find benign renal tumors.

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1. Introduction

The landscape of renal tumors has recently changed [1–4]. The majority (≤60% [4]) of renal tumors are small (≤4 cm) and found incidentally on imaging in asymptomatic patients [1–3]. The incidence of renal tumors was increasing, and the highest incidence of incidentally detected small renal tumors (SRT) was seen in elderly patients, who often presented with several comorbidities [1,2].

Nephron-sparing surgery (NSS) remains the standard of care for small renal cell carcinoma (RCC), but energy-ablative techniques and surveillance protocols have evolved as alternative management options [5]. Today, the challenge that SRT presents is to find a balance between the need for the surgical treatment of aggressive tumors and the observation of less aggressive or harmless tumors. Tumor size and imaging were inadequate parameters by which to further evaluate the underlying tumor biology [3,6–8]. Consequently, renal tumor biopsy (RTB) has recently gained in popularity. The objective of this review is to give the reasons for this gain in popularity: to identify indications for RTB, to describe how to perform this procedure, to note its accuracy and limitations, and to outline its disadvantages.

2. Renal tumor biopsy: why?

2.1. *Incidence*

The incidence of renal tumors in Austria increased from 1983 to 1997 (7.0:100 000 to 11.0:100 000, respectively) and thereafter decreased to 9.4:100 000 in 2004 [9]. In the United States (NCI Surveillance Epidemiology and End Results Program [SEER] data) between 1983 and 2002, the incidence of renal tumors <2 cm, 2–4 cm, 4–7 cm, and >7 cm in size rose by 285%, 244%, 50%, and 26%, respectively [2]. The majority of renal tumors were detected in asymptomatic patients, and about 50% were seen in patients aged ≥65 yr [1]. Incidental tumors are smaller, of lower stage, of lower histologic grade, and have better survival rates than symptomatic tumors.

Thus, more and more SRTs are being detected in asymptomatic patients; because these patients are often afflicted with comorbidities and represent poor candidates for surgery, ablative therapies and even surveillance strategies have been developed [10–12].

2.2. *A significant number of SRTs are actually benign*

Up to 20% of all SRTs are actually benign [3]. These include oncocytomas and angiomyolipomas (AML) with low fat content, which remain difficult to differentiate from RCC, even when the most advanced cross-sectional imaging techniques are used [13]. Frank et al [7] retrospectively examined 2935 solid renal tumors of all sizes treated over a 25-yr period and reported 46.3%, 22.4%, 22.0%, and 19.9% of renal lesions <1, 2, 3, and 4 cm in size, respectively, to be benign. In a recent report by Remzi et al [3], renal tumors ≤2, 2–3, and 3–4 cm in size were reported to be benign in 24.6%, 20.4%, and 16.0% of cases, respectively ($p = 0.66$). Thus, tumor size alone was not able to provide adequate information for a treatment decision [3,6–8].

If benign lesions could be accurately identified preoperatively, this would alter treatment. In a study by Remzi et al [6], only 17% of all benign lesions ($n = 80$) were correctly identified as benign at routine preoperative computed tomography (CT) imaging. Of patients whose benign tumor was incorrectly defined as suspicious for malignant disease on preoperative CT scan, 43% underwent unnecessary radical nephrectomy [6]. In the series of Frank et al [7], 65% (244:376) of benign lesions were treated using radical nephrectomy. Hollenbeck et al showed that even as the rate of NSS increased from 0.21:100 000 in 1988 to 1.6:100 000 in 2002, it was still underutilized [14]. In recent analyses, only 19% of all SRTs were treated by NSS (SEER data). In particular, elderly women and those with cerebrovascular disease were more likely to be at risk to be treated by radical nephrectomy [15].

2.3. *New treatment options: minimally invasive and surveillance strategies*

With respect to SRTs, NSS remains the cornerstone of treatment and provides excellent renal and oncologic outcomes, with a 5-yr cancer-specific survival (CSS) rate of 98–100% [16]. Additionally, ablative therapies showed excellent results, giving a CSS rate >90% [17]. However, the infrequency of local recurrence, even in RCC NSS specimens with questionable negative margins and with potentially incomplete ablations in ≤20% of patients managed by radiofrequency (RF) [18], cryotherapy [5,17] or high-intensity focused ultrasound [19], suggests that many SRTs have a low malignant potential, and surveillance could provide an alternative management strategy [20,21].

Studies on the natural history of SRTs have shown that the growth of SRTs was, in general, slow or undetectable. Approximately one-quarter to one-third of SRTs did not show radiographic growth, and the overall mean growth rate has been reported to be 0.28 cm per year (range: 0.09–0.86) [10,11]. This also supported the potential for observation as a management strategy, particularly in the elderly and infirm patient.

Most series on the natural history of renal tumors have been small, retrospective, and with a short follow-up. Volpe et al [10] followed 29 patients with 32 lesions ≤4 cm in size (25 solid lesions, 4 Bosniak III lesions, and 3 Bosniak IV lesions). The median baseline volume of the 25 solid lesions was 4.9 cm^3. Two-thirds of these lesions showed no growth during follow-up (median follow-up: 28 mo; range: 5.3–143). A meta-analysis by Chawla et al [11] found that, over a mean follow-up of 34 mo, a majority of 234 untreated renal lesions had a slow growth rate (approximately 0.28 cm per year), and metastases were rare (1%).

Therefore, the question arises: Are SRTs harmless? Remzi et al [3] found a dramatic increase in advanced stage (≥pT3a) (10.9% vs 35.7%, respectively) and high Fuhrman grade (4.7% vs 25.5%, respectively) between SRTs <3 cm in diameter and those 3–4 cm in size. Additionally, Minardi et al [22] found that 3.9% of all patients with pT1a clear-cell cancer who underwent partial nephrectomy died of metastatic RCC after a median follow-up of 2 yr. In another recent study by Klatte et al [8], CSS of small nonmetastatic (NX/N0M0) RCC was 96% and 91% after 5 and 10 yr, respectively; however, there was a 7% chance of recurrence at 5 yr postnephrectomy. Independent prognostic factors of CSS were European Cooperative Oncology Group performance status, T stage, the presence of metastatic disease, and Fuhrman nuclear grade. These findings highlighted that a small but not insignificant number of patients experience recurrence after curative surgery [8]. Thus, recurrence, metastases, and death were possible in SRTs; therefore, not all SRTs can be defined as harmless.

Many consider that SRTs are better managed with ablative therapy than with surveillance. As no final histology is available following ablative techniques, RTB should be performed to further define follow-up.

2.4. *Imaging alone is unable to predict biological behavior of renal tumors*

Modern imaging was frequently unable to identify the aggressiveness of renal tumors, especially of SRTs [6]. The proportion of benign lesions was significantly higher in women than in men [23]. Skolarus et al [24] showed, in a cohort of 1043 renal masses operated on for presumed malignancy, that the number of AML decreased ($p < 0.001$), whereas the number of oncocytomas increased with age ($p < 0.001$).

Although oncocytomas showed a characteristic central stellate and fibrotic scarring in 33%, they were indistinguishable from RCC [13]. In addition, oncocytoma may be associated with RCCs in up to 20% [25,26]. Approximately 4.5% of AMLs did not show identifiable macroscopic fat and are indistinguishable from RCC on imaging studies alone [13]. Only a few studies have reported that special imaging studies can differentiate "low-fat" AML from RCC [27,28]. In one study, Kim et al [27] reported that homogeneously enhanced and hyperattenuated renal masses on biphasic CT scans were AML containing minimal fat and that the signal intensity index and tumor-to-spleen ratio in AML and non-AML were significantly different, with an area under the receiver operating characteristic curve of 97.5%.

Measuring the lesion growth rate on serial cross-sectional imaging (CT or magnetic resonance imaging [MRI]) has been shown to be insufficient for predicting the true natural history of renal masses. In a study by Chawla et al [11], mean tumor sizes at first presentation were 2.00 ± 0.99 cm (median: 1.50, range: 1–3.9) and 2.21 ± 1.5 cm (median: 2.0, range: 0.20–12.0) in oncocytomas and RCCs, respectively ($p = 0.59$). The mean growth rate of oncocytomas and RCC variants did not differ statistically (0.05 ± 0.67 cm per year, median: 0.16, range: 1.62–0.62; and 0.4 ± 0.41 cm per year, median: 0.35, range: 0.42–1.6, respectively, $p = 0.15$). In the study by Neuzillet et al, 15 oncocytomas diagnosed by RTB were followed for a mean of 30 ± 19.8 mo. Nine (60%) had no surgical treatment after a mean follow-up of 49.7 ± 17.8 mo, but four out of the six surgically treated lesions had a growth rate >0.5 cm/year. Surgically treated patients were significantly younger (45.5 ± 11.1 yr vs 65.6 ± 10.3 yr, $p = 0.001$) and had larger initial tumor size (50 ± 30.1 mm vs 27.3 ± 10.5 mm, $p = 0.02$) [29]. Similar results were seen by Siu et al; no parameter was able to differentiate between oncocytomas and RCCs [30]. Additionally, the proportions of RCC in lesions with zero or negative growth rates (33%) and those with positive growth (67%; median: 0.31 cm/year) were similar ($p = 0.56$) in both groups (83% and 89%, respectively) [31]. Kouba et al showed that the initial tumor size was unable to predict subsequent growth rate [32]. In addition, growth of renal lesions in younger patients (aged <60 yr) appeared to progress faster than that in older patients [11,21,29,32].

Punnen et al [33] observed inter- and intraobserver variability in the measurement of tumor diameter (±0.3 cm). As tumor volume is exponentially related to tumor diameter, the accuracy of measuring tumor volume was associated with a greater error (inter- and intraobserver variability for tumor volume: 2.515 mm^3 and 2.075 mm^3, respectively). SRTs are not necessarily spheroidal, which increases the error in measuring tumor volume. Therefore, neither tumor size nor tumor volume were reliable parameters for further decision making.

2.5. *Improvements in pathologic evaluations of biopsies*

Frozen sections have been shown to be insufficient for RTB; 11–17% were found to be nondiagnostic, and the accuracy was only 75% in one study [34]. The cytomorphologic features of malignant renal tumors, including RCC and its various subtypes, have been better defined [35]. RCC subtypes have distinct cytogenetic abnormalities, such as the loss of 3p in clear cell, trisomy 7 or 17 in papillary, and widespread chromosomal losses in chromophobe variants [36]. Barocas et al [37] were able to improve the accuracy of RCC subtyping from 90% to 95% by adding molecular diagnostic extraction and quantification of RNA for four gene products using real-time polymerase chain reaction (PCR). However, the results presented by Barocas et al are not directly transferable to patients undergoing percutaneous RTB of SRTs with a 18- or 20-gauge needle, because all biopsies were performed ex vivo in nephrectomy specimen, and a 14-gauge needle was used. In a recent study, histopathology RTB correctly identified the tumor subtype in 27 (75%) biopsies; four (11%) were incorrectly classified, and five (14%) were inadequate for diagnosis. With the addition of fluorescence in situ hybridization, 31 (86%) were correctly subtyped, two (6%) were incorrect, and three (8%) were inadequate [38]. In the hands of experienced pathologists, the accuracy of histologic subtype definition by RTB can be as high as 91% [39].

AMLs have been considered difficult to identify on biopsy, as they display nuclear atypia and pleomorphisms comparable to those found in RCC [36]. HMB-45 has been found to be consistently expressed by AML but not by RCC or liposarcomas. Additionally, AML has been shown to be cytoceratin negative [40].

Oncocytomas continue to pose the major diagnostic challenge, as oncocytotic cells were also found in numerous RCCs, such as the chromophobic and granular cell variants of clear-cell RCC, and in the eosinophilic variant of the papillary type (type 2). Immunocytochemistry can help distinguish between RCC and oncocytomas. Liu et al [41] reported that all oncocytomas were vimentin negative, whereas granular cell and eosinophilic papillary RCC were positive for this stain. Chromophobe RCC was also vimentin negative but could be differentiated from oncocytomas using Hale's colloidal iron staining; c-kit [36], kidney-specific cadherin [42], and cytokeratin 7 [39,42] have also proved useful.

These advances in pathologic evaluation have improved the ability of RTB to differentiate the underlying tumor. RTB may also provide additional information on molecular markers by which to differentiate the aggressive potential of the underlying renal tumor [43].

3. Renal tumor biopsy: how?

3.1. *Fine needle aspiration cytology and core biopsies*

Fine needle biopsies (FNB) were in general defined as biopsies using needles $\leq$20 G in thickness [21,36,44]. Tissue obtained by aspiration biopsy was examined cytologically. In contrast, core biopsies were used to obtain tissue for further histologic analyses. Both techniques can be combined in the same procedure.

All biopsies should be performed through a coaxial guide or cannula. Under image guidance, the guide is inserted into the lesion, and the stylet then is removed. Both aspiration cytology and core biopsy are then taken, while aspiration is performed first.

The accuracy of core biopsies has been shown to be superior to that of fine needle aspiration (FNA) in solid renal tumors, especially in the evaluation of tumor grade and histologic subtype [21,39]. Also, the rate of insufficient material was higher in aspiration (11%) than in core biopsy (3%) [39].

3.2. *Computed tomography- or ultrasound-guided renal tumor biopsies?*

RTBs were mostly performed under CT guidance and under local anesthesia in an outpatient setting [44]. MRI-guided RTB was not common because of the need for a nonferromagnetic needle, reduced operational availability, and higher costs [45].

Ultrasound guidance seems to have several advantages: It is generally available, most urologists can perform it by themselves, the device is portable and provides multiplanar and real-time imaging, and the procedure costs less than CT. Unfortunately, not all SRTs can be visualized on ultrasound, and adjacent structures and organs cannot be differentiated as well as on CT. In addition, gas, ribs, and other structures can obscure visibility. Use of ultrasound-guided RTB also required a significant learning curve [21].

The advantages of CT guidance are that most renal tumors can be identified, adjacent structures and organs can be differentiated, locations within the tumor (eg, necrosis) can be better discriminated, and the skill the technique requires can be acquired more rapidly [21]. Thus, the rate of false-negative biopsies can be reduced to as low as 3% [39].

Three studies reported the results of RTB under ultrasound guidance only. A study by Caoili et al [46] reported a sensitivity and specificity of 100% in 26 ultrasound-guided RTBs, but the indications for RTB were highly selected (requested by a urologist: $n = 10$; requested by an oncologist: $n = 10$; requested by both: $n = 3$; requested by an internist: $n = 3$), and most of the patients also had other malignancies ($n = 9$) or metastases ($n = 4$). RCC was found in only 11 cases, whereas histology revealed metastases in 3 cases, lymphoma in2 cases, and transitional cell carcinoma (TCC) in 2 cases. Between 1993 and 1998, Johnson et al [47] reviewed the results of 44 consecutive patients (other malignancies: $n = 29$; lymphoma: $n = 5$; RCC and poor surgical candidates: $n = 7$; oncocytoma: $n = 1$; others: $n = 2$) and reported a failure rate of 18% and an accuracy of 100%. A study by Reichelt et al [48] found a 25% failure rate in 30 selected cases with a homogenous noncystic mass and a mean tumor size of 2.9 ± 1.13 cm. Most other studies were performed using a combination of ultrasound and CT or CT guidance only [21,39, 44,49,50].

In our institution, patients are placed in a prone position. Under local anesthesia and utilizing helical CT-fluoroscopic guidance, a 17-G coaxial needle is directed to the tumor, avoiding necrotic zones when present. The stylet is then removed, and FNA can be carried out. After air-drying the sample, it is immediately analyzed by a cytopathologist. Using the same sheath, a 20-G core biopsy needle is then inserted to obtain two or three biopsy cores for histologic evaluation. Two hours after RTB, ultrasound examination is performed to rule out post-biopsy hematoma.

3.3. *Accuracy of the procedure and insufficient RTB*

Overall, most of the studies have evaluated the value of RTB in retrospective studies, with highly selected patient cohorts and no standardized biopsy protocols. Only a few studies have evaluated RTB in SRTs prospectively (Table 1) [39,50,51]. The reported sensitivity of biopsy for the diagnosis of malignancy ranged from 80% to 92%, regardless of the needle size used or whether the specimens were examined cytologically, histologically, or both [21,36,49]. False-negative results were most often the result of a failure to place the needle tip accurately, and the false-positive rate was nearly zero [49]. In 2000, Lechevallier et al presented their results for RTB in 63 patients [48]. The biopsy site chosen was in the peripheric area of the tumor, avoiding necrosis. The tip of the needle was placed 0.1 cm outside the tumor to include the renal capsule, and two to four cores were taken. Biopsy was insufficient in 21%. The tumor size of the failed biopsies (3 cm) was significantly smaller than that of sufficient biopsies (4.8 cm; $p = 0.03$). Final histology was available in 26 patients and showed no false-positive biopsies. The accuracy for differentiating between malignant and benign tissue, for histologic subtype, and for Fuhrman grade was 89%, 78%, and 74%, respectively. No tumor was erroneously classified as low (G1–2) or high (G3–4) Fuhrman grade. Neuzillet et al [50] reported the results of percutaneous CT-guided needle biopsy in 88 patients with a tumor size <4 cm. Biopsy was insufficient in 3.4% and inconclusive in 5.6%. Biopsy accuracy for detecting benign and malignant tissue, subtype, and Fuhrman grade was 92%, 92%, and 70%, respectively. Neuzillet et al [50] stated that RTB changed their tumor management in 47.8% of patients. Lebret et al [52] proposed

Table 1 – Prospective clinical studies on renal tumor biopsy (RTB) for the evaluation of small renal tumors in vivo conducted since 2000

	Schmidbauer et al [34]	Lechevallier et al [46]	Neuzillet et al [45]
Number of patients	78	63	88
Age (years)	63 ± 13.5	60 ± 14	61 ± 13
Tumor size (cm)	4 ± 1.8	4	2.8
Tumors ≤4 cm in size	58%	–	100%
RTB type	CT 18 g	CT 18 g	CT 18 g
RCC	79%	60.4%	75%
Insufficient/inconclusive	3%	21%	9.1%
Accuracy: benign/malignant tissue	96%	89%	92%
Accuracy: grading	76%	74%	70%
Accuracy: RCC subtyping	91%	78%	92%

RCC = renal cell carcinoma.

watchful waiting in 34.2% of their patients after RTB revealed benign histology and, after a mean of 36 mo (range: 21–46) of follow-up, no tumor progression was seen.

In 78 consecutive patients, sensitivity of FNA for the differentiation of malignant and benign tissue was 90.6%, specificity was 100%, and positive predictive value (PPV) and negative predictive value (NPV) were 100% and 70%, respectively [39]; however, grading accuracy was only 28%. FNA cytology was insufficient in 11%, showing no cells in one and only blood cells in four. Core biopsies showed a higher sensitivity (95.2%) and NPV (81.3%) but the same specificity and PPV (both 100%) for the diagnosis of malignant and benign tissue. Histologic subtype and Fuhrman grade accuracies were 91% and 76%, respectively.

4. Limitations of renal tumor biopsy

4.1. *Synchronous renal tumors*

Knowing the histology of one tumor does not reveal information about any synchronous tumors [39]. Thus, if RTB is considered in the case of multiple synchronous renal tumors, all of them have to be biopsied.

4.2. *Hybrid tumors*

Hybrid tumors cannot be defined adequately using RTB [39]. Hitting the oncocytoma area of a hybrid tumor will merely provide a diagnosis of oncocytoma in terms of RTB; only final histology will reveal the hybrid nature of these tumors. The only way RTB can deliver the correct diagnosis of a hybrid tumor is if the biopsy hits the hybrid area by chance.

4.3. *Complex cystic tumors*

Lechevallier et al [51] reported that the rate of adequate biopsy cores in cystic renal lesion was as high as that in solid renal tumors. Richter et al [53] found that 89.4% of 227 Bosniak II/III lesions were correctly classified using a combination of FNA cytology and RTB. Harisinghani et al [54] were able to avoid unnecessary surgery in 39% of Bosniak III cysts following a benign finding on FNA cytology combined with RTB and a negative follow-up.

RTB was not recommended in patients with acquired polycystic disease on dialysis or in adults with polycystic disease because of the risk of misdiagnosing the papillary hyperplasia that frequently occurs with RCC in these cysts [21].

5. Disadvantages of renal tumor biopsy

5.1. *Tumor seeding*

Rates of needle tract seeding after nonrenal abdominal biopsies were low (0.003–0.009%) [55]. All six reports dealing with needle tract seeding after RTB of renal tumors were published prior to 1993 [56–61]. Only four of them involved RCC [52–55], one involved a liposarcoma [61], and one an oncocytoma [60]. In 2474 RTBs reported up to the year 2000 [49] and in all recent reports, no case of tumor seeding has been reported. This might be related to the improved technique of using introducers to protect the biopsy needle from contact with the surrounding tissue. Somani et al [62] reported no specific survival difference after nephrectomy among patients with and without preoperative biopsy. However, it is important that no urothelial carcinoma is biopsied because of the high potential for spreading. Thus, RTB should not be performed when TCC of the upper urinary tract is suspected.

5.2. *Complications*

In the study by Schmidbauer et al [39], no serious adverse events were reported, and only four patients showed a clinically insignificant subcapsular hematoma at routine ultrasound 6 hr postbiopsy. One patient had a marginal pneumothorax, which resolved spontaneously. The most frequent complication of RTB was hemorrhage, which in the majority of cases occurred without clinical evidence and remained self-limiting [21,36,49]. Serious adverse events, such as persistent gross hematuria, retroperitoneal bleeding requiring transfusions or nephrectomy, or arteriovenous fistulas were very rare (<1%) [36]. Lechevallier reported that of 565 RTBs, only two cases of symptomatic perirenal hematoma necessitating hospitalization for surveillance but no intervention was needed [44]. The mortality rate after percutaneous FNB of abdominal lesions was 0.031% (five deaths after 16 381 biopsies), all in nonurologic tumors [55].

6. When is renal tumor biopsy useful?

RTB is always useful when its result will change treatment or will help interpret the follow-up of a patient more adequately. In benign renal tumors, surgical treatment is generally an overtreatment [6]. RTBs are therefore key in tailoring treatment decisions.

In minimally invasive treatments, RTBs were helpful [63] for defining treatment success and interpreting the need for further interventions. Finally, with a more detailed preoperative diagnosis, including more information (benign/malignant, subtype, nuclear grade) about the underlying renal tumor, the patient can be better informed about the diagnosis and the further treatment of his or her SRT.

Cryoablation and RF ablation are currently the most used ablative therapies. Treatment success after these ablations has relied only on radiographic imaging. At the time of diagnosis, it is generally believed that nonenhancing lesions on CT/MRI are not malignant. These findings were also adapted unproven for measuring the efficacy of ablation treatments [5]. Only two series with three [64] and six [65] patients, respectively, correlated radiographic features after ablation of SRT with pathologic outcomes. In the study by Park et al, two delayed nephrectomies were performed because of residual enhancement at the periphery of the ablation zone, and one ablation was performed for related ureteropelvic junction obstruction after RF ablation. At the initial ablation, all three patients had biopsy-proven RCC, and the mean time to delayed nephrectomy was 18 mo. Histologically, all demonstrated the absence of residual RCC [64]. In contrast, the study by Weight et al [66] showed that 6 out of 24 lesions (25%) treated with percutaneous RF ablation and without contrast enhancement on follow-up CT showed viable tumor cells on a routine 6-mo follow-up biopsy. The same authors have not seen any viable tumor at their 6-mo follow-up biopsy after cryoablation and no contrast enhancement on follow-up CT ($n = 60$). Thus, the authors concluded that postcryoablation contrast enhancement was a reliable tool and follow-up biopsies were of low value whereas after RF ablation, radiologic findings were not reliable and follow-up biopsies had an impact on further decision making.

Opting for a surveillance strategy on the sole basis of tumor diameter poses a potential risk, because not all SRTs are harmless [3]. Thus, RTB might help in identifying patients suitable for surveillance strategy and potentially not suitable for surveillance because of high nuclear grade.

7. Recommended uses for renal tumor biopsy in small renal tumors

Recommended uses for RTB in SRT are (1) to help in differentiating benign from malignant SRTs; (2) prior to or during ablative therapies; and (3) during follow-up after ablative therapies, especially after RF ablation, for defining treatment success or failure.

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Study concept and design: Remzi, Marberger.
Acquisition of data: Remzi.
Analysis and interpretation of data: Remzi, Marberger.
Drafting of the manuscript: Remzi.
Critical revision of the manuscript for important intellectual content: Remzi, Marberger.
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