Title
Cost Comparisons Between Different Techniques of Percutaneous Renal Biopsy for Small Renal Masses.

Journal
Journal of endourology, 30 Suppl 1(Suppl 1)

ISSN
0892-7790

Authors
Dutta, Rahul
Okhunov, Zhamshid
Vernez, Simone L
et al.

Publication Date
2016-05-01

DOI
10.1089/end.2016.0015

JOURNAL OF ENDOUROLOGY
Volume 30, Supplement 1, May 2016

Pp. S-28–S-33
DOI: 10.1089/end.2016.0015

Cost Comparisons Between Different Techniques of Percutaneous Renal Biopsy for Small Renal Masses

Rahul Dutta, BS,[1] Zhamshid Okhunov, MD,[1] Simone L. Vernez, BA,[1] Kamaljot Kaler, MD,[1] Anjalie T. Gulati,[1] Ramy F. Youssef, MD,[1] Kari Nelson, MD,[2] Yair Lotan, MD,[3] and Jaime Landman, MD[1]

Abstract

Purpose: To compare the costs associated with ultrasound (US)-guided hospital-based (UGHB), CT-guided hospital-based (CTG), and US-guided office-based (UGOB) percutaneous renal biopsy (PRB) for small renal masses (SRMs).
Methods: We retrospectively analyzed patient demographics, tumor characteristics, R.E.N.A.L. nephrometry scores, and cost data of patients undergoing PRB for SRM at our institution from May 2012 to September 2015. Cost data, including facility costs, professional fees, and pathology, were obtained from the departments of urology, radiology, and pathology.
Results: A total of 78 patients were included in our analysis: 19, 31, and 28 UGHB, CTG, and UGOB, respectively. There was no difference in age, gender distribution, or tumor size among the three groups (p-values 0.131, 0.241, and 0.603, respectively). UGOB tumors had lower R.E.N.A.L. nephrometry scores ($p=0.008$). There were no differences in nondiagnostic rates between the UGHB, CTG, and UGOB groups [4 (21%), 5 (16%), and 6 (21%)] ($p=0.852$). There were no differences in final tumor treatment strategies utilized among the UGHB, CTG, and UGOB groups ($p=0.447$). There were 0, 2 (6%), and 0 complications in the UGHB, CTG, and UGOB biopsy groups. Total facility costs were $3449, $3280, and $1056 for UGHB, CTG, and UGOB PRB, respectively ($p<0.0001$). There was no difference between the urologist's and radiologist's professional fees ($p=0.066$). Total costs, including facility costs, pathology fees, and professional fees, were $4598, $4470, and $2129 for UGHB, CTG, and UGOB renal biopsy, respectively ($p<0.0001$).
Conclusion: For select patients with less anatomically complex, exophytic, and posteriorly located tumors, UGOB PRB provides equivalent diagnostic and complication rates while being significantly more cost-effective than either UGHB or CTG renal biopsy.

Introduction

Advances in cross-sectional imaging have dramatically increased the detection rate of renal cortical neoplasms.[1] Recent analysis of the Surveillance, Epidemiology, and End Results database demonstrated that the incidence of kidney cancer increased by 238% between the years of 1975 and 2006.[2] Most notably, the incidence of small renal masses (SRMs) has increased with a concurrent increase in surgical treatment.[3] Diminutive SRM size is associated with a higher rate of benign tumors and a survival benefit.[1,4] Unfortunately, preoperative imaging is often unable to distinguish between benign and malignant lesions, and hence, the widespread practice of surgical therapy first and diagnosis second.[5] In this setting, the use of percutaneous needle biopsy is one way to establish tumor histopathology and thus guide in treatment strategy tailored to the tumor's histopathology.[6–12]

CT-guided percutaneous renal mass biopsy is currently considered the optimal biopsy method as it has high diagnostic rates and low complication rates; however, this results in a significant dose of ionizing radiation to the patient of, according to one study, 1166 mGy*cm (or approximately 17 mSv effective dose).[13] In contrast, ultrasonography (US) may provide a reasonable alternative to CT scan imaging. US is free of ionizing radiation, less expensive to obtain, and generally available to most urologists. The recent introduction of facilitated ultrasound targeting (FUT) allows the less experienced operator to more accurately perform renal mass biopsy with precision and a low risk for complications by displaying the anticipated needle trajectory on-screen as a dotted line.[14,15]

While the clinical benefits of US technology as an imaging modality for renal biopsy have been reported,[14] the cost associated with using this technology either as an adjunct to CT imaging or as a stand-alone office procedure remains unreported. In this study, we compare the costs associated with ultrasound-guided hospital-based (UGHB) renal mass biopsy, CT-guided hospital-based (CTG) renal mass biopsy

Departments of [1]Urology and [2]Radiology, University of California, Irvine, Orange, California.
[3]Department of Urology, University of Texas Southwestern Medical Center, Dallas, Texas.

(this includes biopsies performed using a combination of CT and US), and ultrasound-guided office-based (UGOB) renal mass biopsy. This analysis includes direct and indirect facility costs, professional fees, and pathology costs. We hypothesize that using US imaging in an office setting instead of a hospital setting may significantly reduce costs associated with renal mass biopsy without compromising biopsy quality and patient care.

Methods

Study design

Single-center retrospective comparison.

Patient identification and data collection

We retrospectively reviewed patients who underwent UGHB, CTG (includes biopsies performed using combination CT and US guidance), and UGOB biopsy for renal mass between May 2012 and September 2015.

We retrospectively recorded and analyzed patient demographics and tumor characteristics. A single observer (Z.O., a urology fellow) reviewed all preoperative CT images and assigned R.E.N.A.L. nephrometry scores as described by Kutikov et al.[16] Surgical pathology results from each biopsy were collected from the electronic medical record. Postbiopsy treatment data following each biopsy were collected. Complications following each procedure were obtained from the procedural note and progress notes within the medical record and stratified using the Clavien–Dindo surgical complication grading system.[17]

Cost data

Cost data for each biopsy procedure were obtained and recorded. Cost structure was analyzed as total facility costs (indirect and direct) and professional fees. Indirect costs include overhead costs for computers, building maintenance, utilities, and administrative staff. Direct costs are those that can be directly connected to the specific service in question, which is, in this case, a renal biopsy; these include biopsy probes, imaging equipment, pathology stains, and so on. Total facility cost is the sum of all direct and indirect costs. Professional fees were for labor involved for each given specialty, based on CPT codes for the specific procedure; these did not vary based on insurance coverage. Only costs specifically associated with the percutaneous renal mass biopsy (including immediate postprocedure observation) were considered in this study.

Biopsy Techniques

Ultrasound-guided hospital-based percutaneous renal mass biopsy

All UGHB percutaneous renal biopsy (PRB) were performed by a team of interventional radiologists. The patient is positioned prone and a preliminary US is performed. The patient is then prepared and draped in a sterile manner. Local lidocaine 1% is injected into the skin and IV sedation is initiated with midazolam and fentanyl. Under real-time US guidance, a 17-gauge introducer needle is advanced to the periphery of the target lesion utilizing the freehand technique and longitudinal approach. The inner stylet of the introducer needle is then removed and 18-gauge coaxial core biopsies under real-time US visualization are obtained. After an adequate specimen has been obtained, the introducer needle is removed and manual compression is applied for 5 minutes. The number of biopsy cores was not standardized and based on operator preference. A postbiopsy US is then performed with Doppler to evaluate for postbiopsy bleeding. The patient is then transferred to the recovery room and monitored for 2–4 hours.

CT-guided percutaneous renal mass biopsy

All CTG renal mass biopsies were performed by a team of interventional radiologists. Some CTG biopsies included US as an adjunct. The patient is positioned prone and a preliminary US is performed. The patient is then prepared and draped in a sterile manner. Local lidocaine 1% is injected into the skin and IV sedation is initiated with midazolam and fentanyl. Under real-time US guidance, a 17-gauge introducer needle is advanced to the periphery of the target lesion utilizing the freehand technique. Scout CT images are then obtained. The needle position is adjusted as required, and the needle is advanced to the lesion's periphery utilizing CT and US. Once the introducer needle is in a satisfactory location, the inner stylet of the introducer needle is removed and 18-gauge coaxial core biopsies are then obtained. After adequate specimen has been obtained, the introducer needle is removed and manual compression is maintained for 5 minutes. The number of biopsy cores was not standardized and based on operator preference. Postbiopsy CT images are obtained to evaluate for postbiopsy hemorrhage. The patient is then transferred to recovery and monitored for 2–4 hours.

Ultrasound-guided office-based percutaneous renal mass biopsy

Patients with exophytic and posteriorly located tumors more amenable to percutaneous biopsy were intentionally selected for UGOB biopsy. All UGOB renal biopsies were performed by a single surgeon using the Preirus or Alpha-7 ultrasound systems (Hitachi Aloka, Mitaka-shi, Tokyo, Japan). This device incorporates an FUT system.[15] This technology allows the biopsy needle to go through a needle guide, which passes through the ultrasound transducer and projects a virtual on-screen dotted line that anticipates the biopsy needle trajectory. The technique and procedure were done as previously described.[14,15] The number of biopsy cores was not standardized and based on operator preference. One hour after completion of the procedure, a urine sample was obtained to assess for hematuria and another renal ultrasound was performed to check for any complications. All patients were observed for a minimum of 1 hour following the procedure, with vital signs monitored continuously. Patients were told to avoid strenuous activity for at least 24 hours following the procedure and to present to the emergency department in the event of any signs of complication, such as blood clots in the urine, nausea, vomiting, difficulty breathing, chest pain, and fever.

Follow-up

All patients were followed by their urologist for at least 3 months following the biopsy procedure.

Statistical analysis

One-way ANOVA and chi-square tests were used to calculate statistical significance in demographics and cost data among patient groups using the JMP Statistical Discovery 12 software (SAS Institute, Cary, NC). A p-value <0.05 was considered statistically significant for all tests.

Results

Patient demographics

We incorporated a total of 78 patients who underwent percutaneous renal mass biopsy. Among these patients, 19, 31, and 28 underwent UGHB, CTG, and UGOB biopsy, respectively. Patient demographics are described in Table 1. The mean age at diagnosis for each group was 67, 65, and 70 years for UGHB, CTG, and UGOB biopsy, respectively ($p=0.131$). The majority of patients were male in each cohort ($p=0.241$).

Tumor and biopsy characteristics

Tumor and biopsy characteristics are described in Table 1. The average tumor size was 3.8, 3.4, and 3.9 cm in UGHB, CTG, and UGOB groups, respectively ($p=0.603$). The mean R.E.N.A.L. nephrometry scores were 7.3, 7.1, and 6.0 for UGHB, CTG, and UGOB biopsies, respectively ($p=0.008$). Distributions of R.E.N.A.L. nephrometry scores varied between the groups ($p=0.025$), with UGHB having the most (26%) high complexity lesions (score 10–12) and UGOB having more (75%) low complexity lesions (score 4–6). The mean number of biopsy cores taken was 4.9, 4.7, and 4.8 for UGHB, CTG, and UGOB biopsies, respectively ($p=0.932$). The most common diagnosis was RCC across each group (63%, 58%, and 46% for UGHB, CTG, and UGOB biopsies, respectively) ($p=0.486$). There were no differences in nondiagnostic rates among UGHB, CTG, and UGOB biopsies [4 (21%), 5 (16%), and 6 (21%)] ($p=0.852$). All the patients with nondiagnostic biopsies in the UGHB (4) and CTG (5) groups went on to pursue active surveillance, after discussing all options with their urologist and interventional radiologist. Five of the six patients (83%) with nondiagnostic biopsies in the UGOB group were, after discussing all options with their urologist, rebiopsied by interventional radiology (4 CTG and 1 UGHB). Of these 5, 3 (60%) yielded a diagnostic result.

Treatment and complications

There were no differences in the distributions of final treatment strategies used to manage the SRMs in the three groups (Table 1) ($p=0.447$). Ten (2 ablation and 8 extirpation), 21 (5 ablation, 14 extirpation, 2 chemotherapy), and 13 (2 ablation, 10 extirpation, 1 chemotherapy) patients went on to definitive treatment in the UGHB, CTG, and UGOB biopsy groups, respectively. There were no complications in the UGHB and UGOB biopsy groups. There were two complications (6%) in the CTG group, one small perinephric hematoma (Clavien I) that required no intervention and

Table 1. Patient Demographics and Tumor Characteristics

	UGHB	*CTG*	*UGOB*	p-*value*
N	19	31	28	
Mean age at diagnosis	67 (51–83)	65 (35–87)	70 (43–89)	0.131
Gender (M/F)	15/4	23/8	15/13	0.241
Average lesion size (cm)	3.8 (1.4–8.9)	3.4 (1.8–5.6)	3.9 (1.8–7.0)	0.603
Mean R.E.N.A.L. nephrometry score	7.3 (4–11)	7.1 (4–11)	6.0 (4–8)	**0.008**
Breakdown by R.E.N.A.L. nephrometry score:				**0.025**
Low complexity (4–6)	8 (42%)	15 (50%)	21 (75%)	
Intermediate complexity (7–9)	6 (32%)	12 (40%)	7 (25%)	
High complexity (10–12)	5 (26%)	3 (10%)	0	
Number of biopsy cores	4.9 (2–13)	4.7 (3–8)	4.8 (3–9)	0.932
Histopathology based on biopsy				0.486
Renal-cell carcinoma	12 (63%)	18 (58%)	13 (46%)	
Benign[a]	3 (16%)	7 (23%)	9 (32%)	
Other	0	1 (3%)	0	
Nondiagnostic	4 (21%)	5 (16%)	6 (21%)	0.852
Treatment				0.447
Active surveillance	8 (42%)	9 (29%)	13 (46%)	
Cryoablation	2 (11%)	5 (16%)	2 (7%)	
Partial nephrectomy	3 (16%)	11 (35%)	8 (29%)	
Radical nephrectomy	5 (26%)	3 (10%)	2 (7%)	
Chemotherapy	0	2 (6%)	1 (4%)	
Lost to follow-up	1 (5%)	1 (3%)	2 (7%)	
Complications	0	2 (6%)	0	
Clavien I	0	1 (3%)	0	
Clavien II	0	1 (3%)	0	

[a]Includes angiomyolipoma, oncocytoma, medical renal disease, and benign cysts.
UGHB = ultrasound-guided hospital-based; CTG = computed tomography-guided hospital-based; UGOB = ultrasound-guided office-based.
Bold values are statistically significant p-values at the $p<0.05$ level.

Table 2. Tumor Specimen Histopathology

Final tumor histopathology	*UGHB*	*CTG*	*UGOB*	p-*Value*
Renal-cell carcinoma	8 (100%)	15 (88%)	10 (100%)	0.691
Clear cell	7 (88%)	10 (67%)	8 (80%)	
Chromophobe	1 (13%)	2 (13%)	1 (10%)	
Papillary	0	3 (20%)	1 (10%)	
Angiomyolipoma	0	1 (6%)	0	
Transitional-cell carcinoma	0	1 (6%)	0	
Concordance with biopsy pathology[a]	7 (100%)	15 (100%)	9 (100%)	

[a]For patients with diagnostic biopsy and surgical specimen histopathology available.

one bleed from the needle insertion site (Clavien II) that resolved uneventfully after Gelfoam injection. Final surgical pathology was RCC for 8 (100%), 15 (88%), and 10 (100%) for UGHB, CTG, and UGOB biopsies, respectively. There were no differences in the distribution of tumor specimen histopathology by final surgical pathology among the three groups ($p = 0.691$) (Table 2). For patients with diagnostic biopsy and surgical pathology available, the biopsy specimen accurately predicted the final surgical specimen's histopathology (Table 2). According to the operative reports, there was no report of increased operative difficulty due to the previous biopsy or a seeded biopsy track.

Cost comparison

Cost data can be found in Table 3. Total facility costs were \$3449, \$3280, and \$1056 for UGHB, CTG, and UGOB percutaneous renal mass biopsy, respectively ($p < 0.0001$ for UGOB vs either UGHB or CTG). Direct facility costs were \$2461, \$2140, and \$754 for UGHB, CTG, and UGOB PRB, respectively ($p < 0.0001$). Indirect facility costs were \$988, \$1140, and \$302 for UGHB, CTG, and UGOB PRB, respectively ($p < 0.0001$). Professional fees were \$870, \$818, and \$745 for UGHB, CTG, and UGOB PRB, respectively ($p = 0.066$). Pathology fees were \$279, \$372, and \$328 for UGHB, CTG, and UGOB PRB, respectively ($p = 0.059$). Total costs, including facility costs, pathology, and professional fees, were \$4598, \$4470, and \$2129 for UGHB, CTG, and UGOB PRB, respectively ($p < 0.0001$).

Discussion

There has been a significant rise in incidentally discovered SRMs associated with cross-sectional imaging use.[3] Approximately half of these SRMs are benign or indolent[1,4] and preoperative imaging alone is largely unable to distinguish benign from malignant lesions.[5,18,19] In contemporary practice, most urologists proceed to surgical management without preoperative diagnostic biopsy.[20] PRB is a highly sensitive and specific method to obtain a pathologic diagnosis for SRMs.[6–9,11,12,21,22] At our institution, a PRB is performed for any patient for which knowledge of the tumor histopathology has the potential to alter our management plan. These biopsies are traditionally performed using real-time CT guidance. However, in an effort to reduce ionizing radiation exposure to patients and decrease costs, new techniques using hybrid CT and US guidance, as well as office-based US alone have been developed.[6,11,15,21] Pi et al. reported an average radiation dose of 1166 mGy*cm (or approximately 17 mSv effective dose) using standard CT-guided renal mass biopsy, which is a potentially significant contribution given the current guidelines of limiting radiation exposure to less than 50 mSv per year.[13] The introduction of FUT, which affords the user a dotted-line projection of the virtual needle trajectory on screen, has been shown to aid both experienced individuals and novices in precise needle placement for renal mass biopsy.[14,15] However, to date, there has been no comparison of the costs among the different biopsy techniques.

Nondiagnostic rates were similar among the biopsy groups ($p = 0.852$). The lesions in the UGOB group were on the whole larger, less complex, more exophytic, and posteriorly located when compared with the CTG and UGHB lesions. These characteristics made the biopsy less technically challenging. This finding was expected given our process of selecting only exophytic, posterior, and posterolateral located tumors for UGOB biopsy. The more endophytic and anteriorly located tumors were referred to the interventional radiology team for a hospital-based biopsy done under US and/or CT guidance.

The decision to refer challenging cases for hospital-based biopsy and reserving the simpler cases for office biopsy is well supported by the literature. A retrospective analysis by Prince et al. found certain anatomic features, including cystic components, smaller size, higher skin-to-tumor distance, lower

Table 3. Cost Comparisons

Cost type (\$)	*UGHB* (n = *19*)	*CTG* (n = *31*)	*UGOB* (n = *28*)	p-*Value*
Total facility costs	3449 (1990–5586)	3280 (1713–4860)	1056 (497–2149)	**<0.0001**
Direct component	2461 (1455–3872)	2140 (1126–3246)	754 (353–1526)	**<0.0001**
Indirect component	988 (536–1714)	1140 (587–1650)	302 (144–623)	**<0.0001**
Professional fee[a]	870 (765–1236)	818 (244–868)	745 (384–849)	0.066
Pathology	279 (239–357)	372 (273–681)	328 (274–473)	0.059
Total	4598 (2988–5932)	4470 (3101–6242)	2129 (1729–3376)	**<0.0001**

[a]Urology for UGOB, Interventional Radiology for UGHB and CTG.
Bold values are statistically significant p-values at the $p < 0.05$ level.

enhancement (<20 Hounsfield units), and left kidney location, to be independently associated with lower diagnostic rates.[23] Similarly, Richard et al. noted that exophytic location and increased tumor size were independently associated with higher diagnostic rates on multivariate analysis.[24] Therefore, we are not suggesting that UGOB biopsy performed by urologists replace hospital-based biopsy, but rather that UGOB biopsy presents a viable option for the urologist to apply to carefully selected patients. Because it is associated with few complications and yields high diagnostic rates, UGOB biopsy is an appropriate tool for diagnosis and management of properly selected and anatomically favorable SRMs.

While diagnostic renal biopsy has been shown to be a cost-effective strategy when compared with immediate nephron-sparing surgery,[25,26] we provide initial data demonstrating that total costs, including facility costs, professional fees, and pathology fees, associated with UGOB biopsy,[14] are significantly lower than either UGHB or CTG biopsies ($p < 0.0001$). While there was no significant difference between professional fees and pathology costs among various approaches, the large difference in facility costs for UGOB is likely attributable to the cost of in-hospital observation following the biopsy procedure as well as usage of the CT scanner (in the CTG group). Of note, although our patients were observed in the outpatient office following their biopsy for a minimum of 1 hour, there was no separate cost determined for this period. The 1-hour observation was included in the office facility cost. Two previous studies have shown that in-office observation is a safe alternative to in-patient observation. A prospective study of 100 outpatient ultrasound-guided renal biopsies by May and Allon recorded no major complications, no delayed complications, and only small ($<2 \times 2$ cm) perinephric hematomas that required neither intervention nor blood transfusion; four patients required in-patient observation due to a decreased hematocrit, but none of them required transfusion nor vascular intervention.[27] Another larger retrospective study of 475 outpatient ultrasound-guided renal biopsies reported a major complication rate of 1.3% and a minor complication rate of 6.9%.[28] Several other studies have also shown PRB to be safe, with complications rates in the 5%–10% range; of note, most of the complications were Clavien I, specifically, perinephric hematomas that required neither intervention nor blood transfusion.[11,21,29] Our data are in accordance with the literature, with only two complications (2.6%) of low Clavien grade. In addition, abdominal and flank ultrasound examination following the biopsy procedure provides for a quick and reliable way to detect any immediate or delayed complications.[21]

Ultrasound-guided PRB has been historically performed by interventional radiologists and nephrologists. Urologists, however, are familiar with FUT because of its similarity to contemporary transrectal US-guided prostate biopsy technology, with a dotted line displaying the potential needle trajectory on the ultrasound monitor. Incorporation of this technique for renal mass biopsy allows for a greater number of interventional radiologists, nephrologists, and now urologists to be involved in the preoperative diagnosis of renal masses rather than providing extirpative treatment first and diagnosis later. Indeed, in our current cohort, 38% of patients avoided surgery and proceeded to active surveillance.

There are several limitations to this study. First, it is a retrospective analysis. Second, while all UGOB were performed by a single surgeon, the CTG and UGHB biopsies were done by several different interventional radiologists; results were not subdivided based on the physician. Third, patients were carefully selected for UGOB; this also skews diagnostic rates and tumor characteristics among the three cohorts. Fourth, our analysis did not include the cost of re-biopsy. This is because nondiagnostic biopsies were managed differently depending on what type of biopsy they originally underwent; the majority of UGOB biopsy patients went on to subsequent rebiopsy, while CTG and UGHB biopsy patients went on to active surveillance. Finally, we did not do a subanalysis of comparing costs based on the mass's R.E.N.A.L. nephrometry score.

Conclusions

PRB is a cost-effective and safe method for the histopathologic diagnosis of SRMs. For selected patients with exophytic, posteriorly located, and less anatomically complex tumors, UGOB renal biopsy provides an equivalent diagnostic accuracy and an equally low complication rate to in-patient biopsy, while providing significant cost reduction. UGOB biopsy is a cost-effective method for the diagnosis of SRMs, thereby precluding a surgical diagnosis/extirpative procedure in upward of one-third of patients.

Author Disclosure Statement

Dr. Jaime Landman is a consultant for Hitachi Aloka (Mitaka-shi, Tokyo, Japan).

References

1. Nguyen MM, Gill IS, Ellison LM. The evolving presentation of renal carcinoma in the United States: Trends from the Surveillance, Epidemiology, and End Results program. J Urol 2006;176:2397–2400.
2. Nepple KG, Yang L, Grubb RL, 3rd et al. Population based analysis of the increasing incidence of kidney cancer in the United States: Evaluation of age specific trends from 1975 to 2006. J Urol 2012;187:32–38.
3. Hollingsworth JM, Miller DC, Daignault, S. et al. Rising incidence of small renal masses: A need to reassess treatment effect. J Natl Cancer Inst 2006;98:1331–1334.
4. Frank I, Blute ML, Cheville JC, et al. Solid renal tumors: An analysis of pathological features related to tumor size. J Urol 2003;170:2217–2220.
5. Remzi M, Katzenbeisser D, Waldert M, et al. Renal tumour size measured radiologically before surgery is an unreliable variable for predicting histopathological features: Benign tumours are not necessarily small. BJU Int 2007;99:1002–1006.
6. Mukhtar KN, Mahmood SN, Umair SF. CT guided percutaneous renal biopsy versus ultrasound guided for obtaining adequate tissue. J Pak Med Assoc 2012;62:880–882.
7. Gellert LL, Mehra R, Chen YB, et al. The diagnostic accuracy of percutaneous renal needle core biopsy and its potential impact on the clinical management of renal cortical neoplasms. Arch Pathol Lab Med 2014;138:1673–1679.
8. Connolly SS, Koo B, Warren AY, et al. Modern myths of percutaneous renal tumour mass biopsy. BJU Int 2015;115: 8–9.
9. He Q, Wang H, Kenyon J, et al. Accuracy of percutaneous core biopsy in the diagnosis of small renal masses (</=4.0 cm): A meta-analysis. Int Braz J Urol 2015;41: 15–25.

10. Hu R, Montemayor-Garcia C, Das K. Role of percutaneous needle core biopsy in diagnosis and clinical management of renal masses. Hum Pathol 2015;46:570–576.
11. Prasad N, Kumar S, Manjunath R, et al. Real-time ultrasound-guided percutaneous renal biopsy with needle guide by nephrologists decreases post-biopsy complications. Clin Kidney J 2015;8:151–156.
12. Bernhard JC, Bigot P, Pignot G, et al. The accuracy of renal tumor biopsy: Analysis from a national prospective study. World J Urol 2015;33:1205–1211.
13. Pi XL, Tang Z, Fu LQ, et al. A new method of kidney biopsy using low dose CT-guidance with coaxial trocar and bard biopsy gun. Biol Proced Online 2013;15:1.
14. Menhadji A, Nguyen V, Cho J, et al. In vitro comparison of a novel facilitated ultrasound targeting technology vs standard technique for percutaneous renal biopsy. Urology 2013;82:734–737.
15. Menhadji AD, Nguyen V, Okhunov Z, et al. Technique for office-based, ultrasound-guided percutaneous biopsy of renal cortical neoplasms using a novel transducer for facilitated ultrasound targeting. BJU Int 2013. [Epub ahead of print]; DOI: 10.1111/bju.12489.
16. Kutikov A, Uzzo RG. The R.E.N.A.L. nephrometry score: A comprehensive standardized system for quantitating renal tumor size, location and depth. J Urol 2009;182: 844–853.
17. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;240:205–213.
18. Vasudevan A, Davies RJ, Shannon BA, et al. Incidental renal tumours: The frequency of benign lesions and the role of preoperative core biopsy. BJU Int 2006;97:946–949.
19. Choudhary S, Rajesh A, Mayer NJ, et al. Renal oncocytoma: CT features cannot reliably distinguish oncocytoma from other renal neoplasms. Clin Radiol 2009;64:517–522.
20. Tan HJ, Jacobs BL, Hafez KS, et al. Understanding the role of percutaneous biopsy in the management of patients with a small renal mass. Urology 2012;79:372–377.
21. Franke M, Kramarczyk A, Taylan C, et al. Ultrasound-guided percutaneous renal biopsy in 295 children and adolescents: Role of ultrasound and analysis of complications. PLoS One 2014;9:e114737.
22. Jeon HG, Seo SI, Jeong BC, et al. Percutaneous kidney biopsy for a small renal mass: A critical appraisal of results. J Urol 2015;195:568–573.
23. Prince J, Bultman E, Hinshaw L, et al. Patient and tumor characteristics can predict nondiagnostic renal mass biopsy findings. J Urol 2015;193:1899.
24. Richard PO, Jewett MA, Bhatt JR, et al. Renal tumor biopsy for small renal masses: A single-center 13-year experience. Eur Urol 2015;68:1007–1013.
25. Pandharipande PV, Gervais DA, Hartman RI, et al. Renal mass biopsy to guide treatment decisions for small incidental renal tumors: A cost-effectiveness analysis. Radiology 2010;256:836–846.
26. Heilbrun ME, Yu J, Smith KJ, et al. The cost-effectiveness of immediate treatment, percutaneous biopsy and active surveillance for the diagnosis of the small solid renal mass: Evidence from a Markov model. J Urol 2012;187:39–43.
27. Maya ID, Allon M. Percutaneous renal biopsy: Outpatient observation without hospitalization is safe. Semin Dial 2009;22:458–461.
28. Jiang SH, Karpe KM, Talaulikar GS. Safety and predictors of complications of renal biopsy in the outpatient setting. Clin Nephrol 2011;76:464–469.
29. Ali H, Murtaza A, Anderton J, et al. Post renal biopsy complication rate and diagnostic yield comparing hands free (ultrasound-assisted) and ultrasound-guided biopsy techniques of renal allografts and native kidneys. Springerplus 2015;4:491.

Address correspondence to:
Jaime Landman, MD
Department of Urology
University of California, Irvine
333 City Boulevard West, Suite 2100
Orange, CA 92868

E-mail: landmanj@uci.edu

Abbreviations Used

CT = computed tomography
CTG = computed tomography-guided hospital-based
FUT = facilitated ultrasound targeting
SRMs = small renal masses
UGHB = ultrasound-guided hospital-based
UGOB = ultrasound-guided office-based
US = ultrasound