Targeted Renal Biopsy: Predictors on Imaging

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Abstract

Objectives The renal nephrometry score uses imaging characteristics such as lesion diameter, location, and proximity to hilar vessels to categorize renal masses by complexity for preoperative planning. These characteristics may also be used to determine the best approach to targeted renal biopsy. This study was conducted to investigate the impact of renal lesion characteristics as measured by the renal nephrometry score on the choice of modality used for performing a targeted renal lesion biopsy and increasing the chance of yielding a diagnostic biopsy.

Materials and Methods All targeted computed tomography (CT)/ultrasound-guided renal biopsies performed by our radiology department from January 2017 to February 2020 were reviewed. Radiological characteristics and pathological outcomes were recorded with data on lesion size/ side, location in craniocaudal/anterior–posterior planes, endophytic/exophytic/mixed nature, and skin-lesion distance.

Statistical Analysis Chi-squared tests, multivariate analysis, and *t*-tests were used in this study.

Results Of the 145 consecutive patients included in the study, 86.2% (125/145) biopsies were diagnostic. About 54.5% (79/145) biopsies were ultrasound-guided, while 45.5% (66/145) were CT-guided. About 62.1% (90/145) biopsies revealed renal cell carcinoma. The highest rate of diagnostic biopsy was in the exophytic, laterally positioned mass either entirely below lower polar or above upper polar line. Ultrasound was preferred for lesions under 4cm and 4 to 7cm ($p = 0.06$). CT was used for anterior lesions and ultrasound for posterior and lateral lesions ($p < 0.001$). Of the 20 non-diagnostic biopsies, 7/20 had a repeat biopsy, 7/20 underwent surveillance, 5/20 underwent partial or total nephrectomy, and 1/20 underwent a pathological lymph node biopsy.

Conclusions Our study highlights some factors radiologists should consider when predicting whether CT or ultrasound guidance is more appropriate and the probability of achieving a diagnostic biopsy based on lesion characteristics. At our institution, both modalities achieved high accuracy, although we favored ultrasound in lateral, posterior, and small lesions. These factors should be weighed against local experience and preference.

Keywords
- renal
- lesion
- cancer
- targeted
- biopsy

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Introduction

Percutaneous renal biopsy has an important role in establishing a diagnosis for renal masses. In particular, a proportion of small renal lesions (< 3 cm in size) is often benign and therefore can be managed conservatively, avoiding patients being exposed to risks associated with surgical intervention.[1] Percutaneous renal biopsies can, therefore, provide clinicians with pathological correlation and can performed under ultrasound (US) or computed tomography (CT) guidance.

Renal masses are currently characterized based on their US, CT, and often magnetic resonance imaging findings, usually in combination. In circumstances where the lesion demonstrates clear malignant features, surgery can be performed without a preoperative biopsy. In indeterminate lesions however, an image-guided biopsy can confirm the diagnosis and help guide further management.

Established indications for performing a percutaneous renal mass biopsy include patients with known extrarenal primary tumors, imaging findings suggestive of unresectable renal cell cancer, small hyperattenuating and homogeneously enhancing renal lesions under 3cm, indeterminate cystic renal mass, and multiple solid renal masses.[2,3] Performing a biopsy on such indeterminate masses provides a diagnosis and can guide the management and prognosis in such patients. Biopsy can also help establish tumor subtyping, therefore guiding chemotherapeutic options.

In recent years, there has been a significant increase in identification of incidental renal lesions both due to increased access of imaging and improved diagnostic acumen.[4] Hence, it has become even more important to be able to confidently diagnose renal lesions to avoid unnecessary surgical procedures that carry operative risk and to allow for appropriate management of our patients. Targeted renal biopsies have a complication rate of under 10% and a major complication rate of under 1%.[5]

The renal nephrometry score is a widely used tool, by urologists, to objectify the salient anatomic features seen on cross-sectional imaging of a given renal mass that helps in guiding surgical planning.[6,7] Characteristics such as the lesion size, its primary location in relation to the hilar vessels and polar lines, proximity to the collecting system, and whether it is an exophytic or endophytic lesion have been used to enable reproducible standardized classification systems that help stratify complexity of the renal lesion, assisting urologists with surgical approach and expected operative difficutlies.[6,7] Conversely, the choice of imaging modality (US vs. CT) used by radiologists to help guide a percutaneous renal biopsy is usually based on several subjective measures such as individual expertise and clinical judgment. It is known that a "lesion miss rate" does exist and may relate to these subjective measures employed by radiologists.[5,8]

This study was conducted to investigate the impact of pertinent imaging findings, as determined by the renal nephrometry score, on the choice of modality used for performing a targeted renal lesion biopsy, therefore providing radiologists with an objective measure when determining the choice of modality for future biopsies.

Materials and Methods

Study Population

This retrospective single-center cohort study was conducted in an inner-metropolitan tertiary center. Our database included 145 consecutive patients that underwent an US or CT-guided targeted biopsy for a suspicious cystic or solid renal lesion between January 2017 and February 2020.

All inpatient and outpatient targeted renal lesion biopsies performed using CT or US were included. All nontargeted renal biopsies were excluded.

Image Analysis

Data entry was performed by senior radiology trainees. The total number of nondiagnostic biopsies was recorded and investigated individually. For the remainder, their histopathological result was recorded with key lesion characteristics, as adapted from the nephrometry score. Radiological characteristics recorded were the lesion size as measured in axial diameter, location both in the craniocaudal and anteroposterior planes, whether the lesion was endophytic, exophytic, or mixed and the shortest skin to lesion distance to be used when taking a biopsy. All data were collected retrospectively from request forms, imaging, and the patient's clinical record. To ensure that assessment of each of these characteristics was uniform between the investigators, a single consultant radiologist with abdominal radiology expertise established how the characteristics were to be measured and reviewed certain cases out of the compiled data from each of the different years to ensure that the data recording standardization was within satisfactory limits.

Procedural Details

All biopsy requests were reviewed by radiology consultants and trainees and directed toward CT or US, based upon their clinical judgement. A single interventional radiologist with abdominal expertise was available for advice. Multiple radiologists were then responsible for performing or supervising renal biopsies. The consultant radiologists involved had at least 5 years of clinical experience. The modality used for the procedure could have been altered on the day of the procedure based upon personal preference.

The precise biopsy technique varied depending on the supervising interventional radiologist. A sonographer was available if lesion identification was required. Intravenous conscious sedation was universally given with midazolam and fentanyl which was titrated according to patient requirement. An 18-gauge core biopsy gun (Bard Magnum) with a co-axial needle was used to obtain at least two passes of the required lesion. Further passes were determined by the interventional radiologist based on quality of tissue samples obtained. Gelfoam that was prepared with constant agitation was used post-biopsy.

Histopathological Analysis

Tissue samples were analyzed by multiple different pathologists. A pathologist was not routinely available during the biopsy to assess on sample adequacy.

Statistics

Chi-squared tests and multivariate analysis were applied for diagnostic biopsy and imaging modality versus size of lesion as a categorical variable, location of lesion in the craniocaudal, and anteroposterior planes and lesion characteristics. *t*-test was applied for imaging modality versus size of lesion and distance from skin as continuous variables.

Results

Study Population

A total of 145 patients, with an average age of 64 years (standard deviation [SD] ± 12.2), were included in this retrospective study. About 66.2% (96/145) of the patients were male. About 54.5% (79/145) of patients had an US-guided biopsy and the remaining 45.5% (66/145) had CT guidance. Patient demographics are summarized in ►**Table 1**. US was the preferred modality in lesions between 4 and 7 cm (67%) as well as lesions larger than 4cm (83.3%). CT was the preferred modality in anterior lesions (68.6%), while in posterior and lateral lesions, US was preferred (73 and 62%, respectively).

Diagnostic Accuracy

Of the 145 targeted biopsies, 86.2% (125/145) were diagnostic and 13.8% (20/145) were nondiagnostic. A summary of biopsy outcomes is presented in ►**Table 2**.

About 89.2% (83/93) lesions measuring less than or equal to 4 cm yielded a diagnostic biopsy and 78.6% (22/28) lesions between 4 and 7cm yielded a diagnostic biopsy. Further, of the six diagnostic biopsies that were performed in patients with lesion size more than 7cm, 100% (6/6) were diagnostic. Only one out of these six were biopsies under CT guidance, while the rest were using US ($p = 0.054$).

The location of the lesion in the craniocaudal plane did not have a significant impact in the choice of modality used but did impact the diagnostic rate. For lesions entirely above the upper polar line or entirely below the lower polar line, CT and US were used in similar frequencies; 23/48 and 25/48, respectively

Table 1 Patient demographics

Characteristic	Number (*n*, %)
Number of patients	145 (100)
Age (years), mean ± SD	64.2 ± 12.2
Gender, Male (%): Female (%)	96 (66.2): 49 (33.8)
Biopsy modality, total	
Ultrasound guidance	79 (54.5)
CT guidance	66 (45.5)

Abbreviations: CT, computed tomography; SD, standard deviation.

Table 2 Biopsy outcomes

	Number (*n*, %)
Diagnostic biopsy	125 (86.2)
Operator	
Consultant radiologist	27 (18.6)
Trainee radiologist	118 (81.4)
Histology	
Normal parenchymal tissue	20 (13.8)
RCC[a]	90 (62.1)
Oncocytic neoplasm	21 (14.5)
Angiomyolipoma	5 (3.4)
Urothelial carcinoma	1 (0.7)
Metastatic tumor	5 (3.4)
Renal cyst	2 (1.4)
Lymphoma	1 (0.7)

[a]Renal cell carcinoma (RCC) includes RCC with papillary features, clear cell carcinoma, chromophobe RCC.

($p = 0.444$). We achieved the highest rate of diagnostic biopsy when the lesion was either entirely above the upper polar line or below the lower polar line ($p = 0$ 0.011).

The highest diagnostic biopsy rates were obtained when the lesion was lateral, which was the case in 38.4% (48/125) of diagnostic biopsies ($p = 0.020$). US was preferred if the lesion was lateral and this was the case in 62.2% (33/53) of biopsies ($p < 0.001$).

In terms of lesion characteristics, 93.8% (30/32) endophytic lesions, 90% (45/50) exophytic lesions, and 86.7% (39/45) mixed in our study yielded a diagnostic biopsy ($p = 0.009$).

Distance from skin, when measured as a continuous variable, did not have a significant impact on the probability of a diagnostic biopsy ($p = 0.133$). The mean distance of skin to lesion for biopsies performed using CT was deeper at 8.37 ± 2.22 SD in cm and 6.51 ± 2.24 SD for biopsies performed using US.

From the 20 nondiagnostic biopsies, 65% (13/20) were from patients with lesion size less than or equal to 3 cm, while 25% (5/20) were between 3 and 8 cm ($p = 0.248$) and 10% (2/20) were greater than 8 cm.

A logistic regression found no statistical difference in diagnostic biopsy rate between modalities after adjusting for potential confounders (►**Table 3**).

Nondiagnostic Biopsies

The 20 nondiagnostic biopsies and their outcomes are recorded in ►**Table 4**. Seven of twenty patients had a repeat biopsy, and all of these revealed a diagnostic result.

A further 7/20 patients (all with a lesion size < 2cm) were planned for surveillance. Of these seven, two underwent follow-up imaging at our institution; one lesion remained unchanged on an US study 5 months later, while the second one remained unchanged on CT up to 2 years after the

Table 3 Odds ratio estimates for diagnostic biopsy rate from logistic regression

Variable	Odds ratio (95% CI), *p*-Value
Modality (US/CT)	0.43 (0.10–1.94), $p = 0.274$
Patient level Location of lesion (polar line)	1.19 (0.56–2.54), $p = 0.649$
Location of lesion (AP plane)	1.28 (0.60–2.76), $p = 0.527$
Distance of skin to lesion	1.15 (0.85–1.55), $p = 0.355$
Size of lesion by category	0.77 (0.29–2.05), $p = 0.595$

Abbreviations: AP, anteroposterior; CI, confidence interval; CT, computed tomography.

nondiagnostic biopsy. Details for the remaining five patients were not available.

Five of twenty patients underwent a partial or radical nephrectomy. The pathology for all these five returned as clear cell renal cell carcinoma.

One patient underwent biopsy of a pathological retroperitoneal lymph node that showed metastatic urothelial cancer.

Discussion

Our study highlights that there are several factors that can impact both on the most appropriate choice of modality and the probability of achieving a diagnostic biopsy.

Of the diagnostic biopsies performed in our institution, 38% returned a benign diagnosis and allowed the patient to be reassured and avoid an unnecessary therapeutic intervention. Our review demonstrates that a renal lesion, which is either entirely above the upper polar or below the lower polar line, laterally positioned and exophytic, has the highest chance of yielding a diagnostic result.

US was used for performing 54% of our first-attempt biopsies. Interestingly, even on the seven redo biopsies, US was used for three out of seven times; albeit with a different operator, indicating that our local preference is using US. While this may partly be due to improved access to US, in our opinion the dynamic assessment and ease of repositioning that US offers are unparalleled and quicker to perform. It may also be that operator experience is important rather than limitations of the modality used, as most nondiagnostic

Table 4 Nondiagnostic biopsies

	Lesion size (cm)	Initial biopsy modality (CT/US)	Management	Operator for repeat biopsy (D, S)	Outcome
1	1.2	US	Repeat US-guided biopsy	D	Angiomyolipoma
2	2.1	CT	Repeat CT-guided biopsy	D	Chromophobe RCC
3	3.0	US	Repeat CT-guided biopsy	D	Clear cell RCC
4	3.3	CT	Repeat US-guided biopsy with CT to confirm needle position	D	Clear cell RCC
5	2.5	US	Repeat US-guided biopsy	D	Clear cell RCC
6	3.4	US	Repeat CT-guided biopsy	D	Chromophobe RCC
7	3.9	CT	Repeat CT-guided biopsy but with consultant supervision	S	Clear cell RCC
8	8.0	US	Biopsy of enlarged retroperitoneal lymph node	–	Metastatic urothelial carcinoma
9	9.5	US	Radical nephrectomy	–	Clear cell RCC
10	4.3	US	Partial nephrectomy	–	Clear cell RCC
11	2.6	US	Partial nephrectomy	–	Clear cell RCC
12	2.3	CT	Partial nephrectomy	–	Clear cell RCC
13	4.0	CT	Radical nephrectomy	–	Clear cell RCC
14	2	CT	Surveillance	–	Stable on imaging two years later
15	1.2	US	Surveillance	–	Stable on imaging for two years later
16	2.2	US	Surveillance	–	Unavailable
17	1.6		Surveillance	–	Unavailable
18	2	US	Surveillance	–	Unavailable
19	1.4	CT	Surveillance	–	Unavailable
20	1.7	US	Surveillance	–	Unavailable

Abbreviations: CT, computed tomography; D, different; RCC, renal cell carcinoma; S, same; US, ultrasound.

biopsies that were repeated used the same modality and returned a diagnostic result. In the case of CT, there was one biopsy repeated by the same operator, but under closer consultant supervision the second time indicating that review of the planning and needle position on CT by an experienced proceduralist is of immense value.

Our rate of nondiagnostic biopsy of 13.8% correlates closely with the rate of 14.1% described in a meta-analysis comprising 2,929 patients and 3,113 biopsies and this is despite many of the biopsies being performed by radiology trainees under consultant supervision.[9] This meta-analysis also described an 80% diagnostic rate in biopsies that were repeated, and we had a success rate of 100% on repeat biopsy even when performed under the same modality as the original procedure.

Another systematic review comprising 57 studies and 5,228 patients found a median diagnostic rate of 92% that is greater than our rate, although many of the studies did not report the size of lesions and there was significant variation in the diagnostic rates between the individual studies.[9]

Significant benefits exist to discussing nondiagnostic biopsies at a multidisciplinary meeting (MDM) as is evident from the outcomes of our 20 nondiagnostic biopsies. It provides the opportunity to make a well-informed decision regarding if a repeat biopsy is required or if the patient should proceed directly to surgery. Furthermore, the likely etiology of the lesion, the potential reason for the nondiagnostic biopsy and the patient's wishes and comorbidities, can be weighed to make management decisions. It is reassuring that in all cases where it was decided to proceed to surgery, a malignant diagnosis was returned. For the 7 of 20 nondiagnostic biopsies that underwent surveillance, these were all under 2 cm, and in our limited follow-up remained stable on follow-up imaging, highlighting another advantage of the MDM discussion. It is worth noting that the probability of metastatic disease from a renal cell carcinoma under 30mm is around 1% and this is even less for tumors under 20mm and so surveillance can be a safe option for many patients.[10,11]

Additionally, an MDM can be an excellent opportunity for the radiologist to discuss the technical challenges that the biopsy may have had, whether they may be modifiable or not if a repeat biopsy was to be planned. The pathologist may also be able to provide a weighted opinion regarding the biopsy specimen based on any suspicious features seen. It is also reassuring that a decision to repeat the biopsy also yielded a high diagnostic rate even when performed using the same modality.

Limitations of our study included its retrospective nature and the fact that multiple proceduralists and pathologists were involved. However, this does allow the results to replicate daily practice. The experience of the individual proceduralists was not accounted for and neither were their preferences regarding modality, or the complexity of biopsies that they were prepared to undertake.

Conclusion

Our review highlights that percutaneous targeted renal biopsies are of immense benefit in the diagnosis, management, and prognostication of a patient with an indeterminate renal mass. Using imaging characteristics that are reported in the renal nephrometry score can assist radiologists doing such procedures with an objective measure for determining the choice of imaging modality. At our institution, both CT and US achieved high accuracy; however, US was favored in lateral, posterior, and smaller lesions. These factors should be weighed against the radiologists' experience and preference.

Conflict of Interest
None declared.

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