Kidney360

Point-of-Care Ultrasound for Native Kidney Biopsies

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KIDNEY360 1: 527–529, 2020. doi: https://doi.org/10.34067/KID.0001962020

Introduction

Percutaneous kidney biopsy is a key procedure in the diagnosis and management of kidney disease but is being performed by nephrologists with decreasing frequency (1). Although it is a required component of subspecialty training in nephrology, exposure of trainees is often minimal. This results in fewer faculty with this skill, thereby accelerating this decline. The underlying reasons are manifold but stem in part from unfamiliarity with ultrasonography and availability of equipment. Consequently, biopsies are increasingly being performed in radiology departments, often under computed tomography guidance that results in unnecessary radiation exposure and cost because ultrasound guidance is sufficient in most patients (2,3). When performed by nephrologists, the biopsy is usually guided by a sonographer or radiologist, which complicates scheduling and is an inefficient use of manpower.

With point-of-care sonography now widely available and increasingly being taught during medical school and residency, guidance of biopsies should no longer be an obstacle for nephrologists. Comprehensive training in sonography has been a component of the nephrology program at this institution for the past 25 years and has included guidance of percutaneous kidney biopsies. Over two decades ago, we reported a small series showing favorable success and complication rates for biopsies guided and performed entirely by nephrology faculty and trainees (4). We now report our experience with a much larger series of biopsies performed over a 22-year period.

Materials and Methods

Patients

This was a retrospective study in which a database of all kidney ultrasounds performed by the nephrology service at Emory University Hospital was searched for native kidney biopsies from July 1996 to September 2018. In addition to sonographic data, this database also contains information on the success rates. Additional information, including complications, was obtained on all biopsies since 2008 through review of the medical records. The study was approved by the Institutional Review Board of Emory University.

Biopsy Procedure

All biopsies were performed in the inpatient setting and in the patient's room using ultrasound scanners belonging to the Renal Service. Aspirin was not administered for 1 week prior to and after the biopsy. Platelet counts and basic coagulation tests were routinely performed prior to biopsy, with platelet function tests performed as indicated by the clinical situation. If the biopsy was deemed emergent, abnormalities were treated with fresh frozen plasma or desmopressin. Patients were monitored overnight. The following procedure was used for most biopsies. Patients were placed in the prone position with a pillow or other object placed under the superior iliac crest in order to flatten the back as much as possible. Generally, the left kidney was imaged, and if there were concerns about accessibility, the right kidney was then imaged. The selected kidney was observed during respiration in order to determine the timing of the biopsy. With the ultrasound probe maintained perpendicular to the bed, the lower pole was centered in both the longitudinal and transverse planes. After marking of the skin and local anesthesia, a small longitudinal incision was made with a #11 scalpel. An 18.8-cm, 20-gauge needle was then inserted perpendicular to the bed to provide deeper anesthesia and to confirm the true depth of the kidney (usually 1.0–1.5 cm greater than the sonographic depth) by observing respiratory movement. The needle was removed and used to mark the depth on the biopsy device (Monopty 18-gauge device with a 1.7-cm sampling length; Bard Peripheral Vascular, Tempe, AZ). This device was inserted perpendicularly to that depth without ultrasound guidance and activated, with respiration timed appropriately. Occasional biopsies were performed with real-time guidance, either planned or because of difficulty with the above procedure.

Results

A total of 1255 planned biopsies were identified from the database, of which 12 were not performed because of the appearance of the kidneys on the sonogram. Findings that precluded biopsy were small size or thin cortex indicative of chronic, irreversible disease or cysts in both lower poles. Mean depth was 5.2 cm (range, 1.3–11) with a mean of 3.9 attempts (range, 1–15), of which 2.8 (range, 0–5) were successful. Kidney tissue was obtained in 98.8%. Ultrasound guidance

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was done in real time in 8.3%. Review of medical records was performed for the 431 planned clinical biopsies from 2008 on. In five patients, the biopsy was not attempted because of the appearance of the kidneys, poor patient cooperation, predisposition to bleeding, or inability to cross-match for blood. Four patients were referred for computed tomography guidance because the kidneys were insufficiently visualized or were too deep. Ranges for ages, body weight, and body mass index were 13–84 years old, 41–147 kg, and 16–52 kg/m^2, respectively.

Biopsy parameters are presented in Table 1. The right kidney was selected only if the left kidney was poorly visualized, too deep, or structurally abnormal. One biopsy was performed in the lateral decubitus position, and approximately 7% were performed with real-time guidance. Approximately 90% were performed entirely or partly by trainees, with a total of 70 different trainees performing 1–12 procedures each and a median of 5 per trainee. Supervision was by 22 different faculty members with 1–105 procedures each and a median of 5. Approximately 55% of the biopsies were supervised or performed by just three faculty members. Slightly over 10% were performed solely by faculty. The time required to perform the ultrasound guidance and biopsy (available for 25 procedures during the last 2 years) averaged 36 minutes, with a range of 23–51.

Outcomes are shown in Table 2. Adequate tissue was obtained in almost 97%, usually with three to four attempts and an average of one failed attempt. All attempts were successful in 53%. There was no significant change in blood hemoglobin level, usually measured 4–6 hours after the biopsy. Major complications occurred after only seven of the biopsies, which included three cases of gross hematuria, three cases of hypotension, and three cases requiring transfusions. Of these, only two required intervention to control bleeding, consisting of intra-arterial embolization. Among the 20 biopsies that were unsuccessful, yielded inadequate tissue, or had major complications, neither body mass index (26.1 kg/m^2) or biopsy depth (5.5 cm) was greater than in the other biopsies.

Discussion

As shown by the extensive experience at this institution, ultrasound guidance by nephrologists results in excellent success and complication rates for percutaneous biopsy of native kidneys. The favorable outcomes cannot be explained by involvement of just a few highly trained nephrologists because most of the biopsies were performed by trainees and were supervised by 22 different faculty. The outcomes compare favorably with previously published data on ultrasound-guided kidney biopsy (5–7). Although ultrasound guidance was not directly compared between nephrologists and radiologists, the results are consistent with a retrospective study showing similar outcomes in 441 ultrasound-guided biopsies performed by nephrologists and 217 performed by radiologists (8). Ultrasound guidance by nephrologists simplifies logistics and increases efficiency by eliminating the need for radiologists or sonographers without any detrimental effect on outcomes. With the increasing availability of and training in point-of-care ultrasound, this should be easily incorporated into nephrology practice. The training required is minimal, and the kidneys are easily visualized in most patients. Ultrasound guidance should therefore not be a barrier to nephrologists performing kidney biopsies.

The small size of the biopsy needle (18 gauge) may have contributed to the low complication rate. A meta-analysis showed higher complication rates with larger needles (5), whereas a subsequent large series (6) found no correlation between needle size and complications. Even though larger needles can provide more tissue, the yield of glomeruli reported here was similar to that reported for 14-gauge needles (7), most likely explained by a higher yield of cortex. Thus, use of an 18-gauge needle, as performed here, seems to reduce complications without affecting adequacy of the sample.

The results also demonstrate that excellent outcomes can be obtained with simple localization of the kidney prior to rather than during the biopsy. This has certain advantages in that the biopsy path is predetermined and therefore, can be precisely anesthetized; in the case of a single operator, both hands are free to hold and activate the biopsy device. There were insufficient numbers of biopsies performed with real-time guidance in order to directly compare the techniques, but the success rate and rate of major complications with this prelocalization technique compare favorably with prior reports of real-time guidance (5,7,8). This is consistent with a previous retrospective study in which there were no difference in outcomes between biopsies performed by nephrologists with premarking (n=271) or real-time guidance (n=170) (8). A much smaller study showed better outcomes with real-time guidance (9), but this likely reflects instead differences in skill because the two techniques were supervised by different faculty and the outcomes with prelocalization were much poorer than reported here or in the previously cited study (8).

In summary, this study shows excellent outcomes from percutaneous renal biopsies both guided and performed by nephrologists. Furthermore, this can be accomplished with simple, sonographic prelocalization of kidneys rather than real-time guidance during the procedure. With the increased availability of point-of-care ultrasound, it is hoped that this will encourage more nephrologists to perform this essential procedure.

Table 1. Biopsy parameters

Kidney, % left	91.0
Depth, cm	5.4±0.8 (2–11)
Patient position, %	
Prone	99.8
Lateral decubitus	0.2
Ultrasound guidance, %	
Prebiopsy	93.1
Real time	6.9
Timing, %	
End inspiration	51.0
End expiration	43.8
None or not indicated	5.2
Operator, %	
Trainee	89.8
Faculty only	10.2

Author Contributions

W.C. O'Neill conceptualized the study; W.C. O'Neill and J. Palacherla were responsible for data curation and formal analysis;

Table 2. Biopsy outcomes

Kidney tissue obtained, %	98.6
Adequate tissue for diagnosis, %	96.9
No. of glomeruli	28.3±0.9 (0–100)
No. of attempts	3.56±0.07 (1–10)
No. of successful attempts	2.54±0.04 (1–5)
Blood hemoglobin, g/dl	
Prebiopsy	11.2±0.1
Postbiopsy	10.9±0.1
Change	−0.3±0.03 (−4.3–2.6)
Major complication, %	1.7

Postbiopsy hemoglobin level was measured the morning after the biopsy.

W.C. O'Neill was responsible for methodology; W.C. O'Neill wrote the original draft; and W.C. O'Neill and J. Palacherla reviewed and edited the manuscript.

Disclosures

W.C. O'Neill derives income from training courses in sonography, reports personal fees from Childrens Healthcare of Atlanta outside the submitted work, and receives garnt support from the National Institutes of Health and the American Heart Association unrelated to this work. All remaining authors have nothing to disclose.

Funding

Funding was provided by clinical revenue and the Data Analytics and Biostatistics Core in the Department of Medicine.

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