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Beyond complications: Comparison of procedural differences and diagnostic success between nurse practitioners and radiologists performing image-guided renal biopsies

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Abstract

Purpose: Radiology-trained nurse practitioners (NPs) may perform image-guided medical renal biopsies with computed tomography (CT). This study evaluates the procedural differences and diagnostic success between biopsies performed by NPs compared to radiologists.

Data sources: A retrospective study was performed on patients who underwent nontargeted, CT-guided renal biopsy between 2009 and 2014. Provider type (NP or radiologist), number of core specimens obtained, sedation medication dose, CT dose index (CTDI), and diagnostic success were recorded. Categorical and continuous variables were analyzed using χ^2 and Student's two-tailed *t*-test, respectively, comparing NPs with radiologists.

Conclusions: A total of 386 patients were included; radiologists performed 215 biopsies and NPs performed 171 biopsies. There was no significant difference in diagnostic success, amount of tissue harvested (number of cores), radiation dose, or sedation dosage between NPs and radiologists performing CT-guided renal biopsies. Only 4% were nondiagnostic ($n = 7$, radiologists; $n = 9$, NPs; $p = .325$). Overall mean number of cores obtained was 3.7, mean CTDI was 176.5 mGy, mean fentanyl dose was 86.3 μg, and mean midazolam was dose 1.54 mg without a statistically significant difference between provider types.

Implications for practice: NPs perform image-guided medical renal biopsies in a similar fashion to radiologists with respect to diagnostic success, amount of tissue harvested, total radiation dose exposure, and administration of sedation.

Introduction

Medical renal disease (glomerular, vascular, and/or tubulointerstitial disease) is often diagnosed by percutaneous biopsy of the kidney (Horvatić, Hrkać, Zivko, Kozjak, & Galesić, 2007). Biopsy results provide nephrologists with an accurate diagnosis, guide treatment, and change management in patients with renal disease. Since the introduction of the first percutaneous renal biopsy in 1951, many modifications to the procedure have been made to increase diagnostic yield and safety (Korbet, 2002b). Currently, most biopsies are performed using image guidance (computed tomography [CT] or ultrasound) for localization of the target, with automated small gauge biopsy devices without significant complications (Corapi, Chen, Balk, & Gordon, 2012; Korbet, 2002a; Tøndel, Vikse, Bostad, & Svarstad, 2012). Because of the use of image guidance along with other factors, there has been a steady rise in image-guided percutaneous biopsies across all anatomic regions being performed in the radiology department, including image-guided renal biopsies (Korbet, 2002b; Kwan, Bhargavan, Kerlan, & Sunshine, 2010).

Medical renal biopsies are performed under CT guidance primarily because of radiology practice workflow optimization, staff availability, and practitioner experience with CT modality at our institution. Both nurse practitioners (NPs) and radiologists independently perform CT-guided medical renal biopsies, which is in keeping with an increasing trend of NPs as providers of invasive radiology procedures (Bowen, Torres, & Small, 2007; Duszak et al., 2015;

Nandwana et al., 2015). Once credentialed and granted hospital privileges, NPs perform procedures, dictate, sign final reports, and bill under their own national provider identification number. The type of practitioner performing the procedure on any given day is based on the availability of each practitioner and optimal workflow.

Unfortunately, there are limited published data comparing the performance of NPs with radiologists when performing these procedures. One study showed no significant difference in overall complication rates of image-guided hepatic biopsies when performed by NPs as compared to radiologists (Murphy et al., 2014). Likewise, recently published data showed no significant differences in complication rates between NPs and radiologists when performing image-guided medical renal biopsies (Nandwana et al., 2015). The purpose of this investigation was to retrospectively compare additional biopsy metrics such as diagnostic yield and sample adequacy, moderate sedation medication dose, and radiation dose of NPs and radiologists when performing CT-guided medical renal procedures.

Materials and methods

Patient selection

Institutional review board approval was obtained and a waiver of informed consent was granted for this Health Insurance Portability and Accountability Act compliant retrospective study. The study was performed at a major academic medical center with two large hospitals. No industry support was provided for the study. Our department's radiology report database was searched to identify patients who underwent a CT-guided medical renal biopsy between January 1, 2009 and December 31, 2013. Patients were excluded if they underwent a renal biopsy for a diagnosis other than medical renal disease (i.e., targeted renal mass).

All patients underwent standardized preprocedural laboratory testing including platelet count and international normalized ratio (INR) within 30 days of outpatient biopsy or 7 days of inpatient biopsy. Patients had to demonstrate a platelet count greater than 50,000/μL and INR less than 1.5 in order to proceed with biopsy. Anticoagulation therapy, including aspirin, clopidogrel, and warfarin, was discontinued 5 days preceding the biopsy as per our institutional protocol. Use of low molecular weight heparin was discontinued for 24 h prior to the procedure as per our institutional protocol.

Procedure method

All biopsies are performed utilizing CT guidance on a General Electric (GE) Volume CT (VCT) 64/GE LightSpeed 16 CT (GE Healthcare, Buckinghamshire, United Kingdom) or a Siemens Somatom Emotion 16 CT scanner (Siemens Healthcare, Erlangen, Germany). A limited initial noncontrast scan is performed through the kidneys to locate an appropriate safe site in the inferior pole of either kidney for biopsy. The appropriate site is selected, avoiding vital structures such as adjacent bowel, and the skin site is then marked. The area is prepped with chlorhexidine solution and draped in a sterile fashion. The skin and subcutaneous tissues are anesthetized with 1% lidocaine hydrochloride, and a small dermatotomy is made with a scalpel. All biopsies are performed with a 17-gauge introducer with its tip placed in the inferior pole of the kidney using intermittent CT guidance. Final introducer placement is confirmed by CT imaging before performing the biopsy. During suspended respiration or timed end-expiration, two or three separate cores (depending on the hospital site) are obtained with an automated 18-gauge biopsy gun (Bard, Murray Hill, NJ or Cook, Bloomington, IN). Samples are immediately evaluated for adequacy by the pathology department using light microscopy. If samples are deemed inadequate at the time of procedure, additional cores are obtained at the discretion of the proceduralist (either the NP or radiologist).

During the procedure, patients are continuously monitored by a dedicated radiology registered nurse with vital signs recorded every 5 min. After the procedure, outpatients are monitored in a dedicated radiology postprocedural area for at least 4 h and discharged after 4 h when presedation level of consciousness has returned and the patient is hemodynamically stable. Inpatients are transferred back to nursing unit when they regain the preprocedural level of consciousness and appropriate vital sign parameters.

Data collection and statistical analysis

The electronic medical record was searched for each patient who underwent an image-guided nontargeted renal biopsy, and the following factors were recorded: gender, age, clinical indication for renal biopsy, number of samples obtained, diagnostic adequacy, sedation medication dosage, total radiation dose estimated by the volume CT dose index (CTDI) the patient received during the procedure, and documentation of whether an NP or an attending radiologist performed the procedure.

Statistical analysis included calculation of median (*Mdn*), mean, and standard deviation (*SD*) for the following measures: number of samples obtained, total radiation dose (CTDI), sedation dosage, gender, and age in each patient group (radiologist vs. NP performing the procedure). In addition, final diagnostic adequacy was recorded as a percentage for each patient population. Biopsies were

Table 1 Performance of radiologists versus NPs for image-guided nonfocal renal biopsies

	Radiologist	NP	*p*-Value
N	215	171	
Age[a]	45.5 ± 15.6	45.7 ± 15.6	.9005
No. of cores[a]	3.7 ± 1.4	3.6 ± 1.0	.306
Diagnostic[b]	208 (96.7%)	162 (94.7%)	.325
Intraprocedural medication			
Midazolam (mg)[a]	1.53 ± 0.73	1.55 ± 0.82	.8
Fentanyl (μg)[a]	86.6 ± 43.5	86.0 ± 47.8	.897
CTDI (mGy)[a]	181.8 ± 98	169.4 ± 91.5	.204

[a]Data presented as mean ± SD.
[b]Data presented as *N* (%).

considered diagnostic if the tissue sample was adequate for the pathologist to provide a diagnosis. Categorical and continuous variables were analyzed using χ^2 and Student's two-tailed *t*-test, respectively, comparing NPs with radiologists with the significance level set at $p < .05$.

Results

Radiologists ($n = 16$) performed 215 biopsies and NPs ($n = 2$) performed 171 biopsies on 386 patients (mean age 45, 59% female, 41% male) between January 2009 and December 2013. Only 4% of all biopsies were nondiagnostic. Of those that were nondiagnostic, seven were performed by radiologists and nine were performed by NPs, not statistically significant between groups ($p = .325$). Mean number of cores obtained in all patients was 3.7 (*SD* 1.3; range 2–10, *Mdn* 3) with radiologists obtaining an average of 3.7 cores (*SD* 1.4, *Mdn* 3) and NPs obtaining an average of 3.6 cores (*SD* 1.0, *Mdn* 3), $p = .306$. The mean CTDI in all patients was 176.5 (*SD* 95.3; range 34.2-600.5; *Mdn* 154.4). Mean CTDI of radiologists was 181.8 mGy (*SD* 98, *Mdn* 163.3), whereas mean CTDI of NPs was 169.4 mGy (*SD* 91.5, *Mdn* 143.8), $p = .204$.

Mean fentanyl dose for all patients was 86.3 μg (*SD* 45.4; range 12.5–300; *Mdn* 75), with radiologist-prescribed mean fentanyl dose of 86.6 μg (*SD* 43.5, *Mdn* 75) and NP-prescribed mean fentanyl dose of 86 μg (*SD* 47.8, *Mdn* 75), $p = .897$. Mean midazolam dose for all patients was 1.54 mg (*SD* 0.77; range 0.25–5; *Mdn* 1.5), with radiologist-prescribed mean dose of 1.53 mg (*SD* 0.73, *Mdn* 1.5) and NP-prescribed mean dose of 1.55 mg (*SD* 0.82, *Mdn* 1.25), $p = .8$.

No statistically significant difference was found between radiologists and NPs in terms of diagnostic yield, number of cores obtained, CTDI dose, or medication sedation dose with fentanyl or midazolam (Table 1).

Discussion

It is difficult to understand the benefits and risks of having NPs performing image-guided procedures without an adequate investigation comparing a variety of procedural and outcome metrics between the two types of providers. Previously published data in this patient population demonstrated that only 5% of all image-guided renal biopsies resulted in clinically relevant complications that led to an overnight observation or therapy, with no statistical difference between NPs and radiologists (Nandwana et al., 2015). This study expands upon that data by also evaluating diagnostic yield and adequacy, radiation exposure, and sedation dose differences between types of providers. Furthermore, it contributes to a growing literature base evaluating NPs and radiologists with regard to performance and outcomes on other image-guided biopsies (Murphy et al., 2014).

In particular, there was no statistically significant difference in the diagnostic yield of biopsies performed by the two groups, with an overall nondiagnostic rate of 4%. The overall high diagnostic rate for both groups is likely due to real-time evaluation of tissue samples under light microscopy, by the pathology department, prior to the conclusion of the procedure. If the initial tissue samples are deemed inadequate, the proceduralist (NP or radiologist) may obtain more samples to increase the chances of obtaining a pathologic diagnosis, assuming the patient is stable and it is safe to proceed. Interestingly, our findings did not show a difference in the number of cores obtained between the two groups, indicating that the similar diagnostic yield was not because of harvesting more cores by one group.

Similarly, there was no statistically significant difference in radiation dose administered by radiologists or NPs during the CT-guided procedures as measured by CTDI. CTDI is an accurate measurement of the overall radiation output of a CT system (McCollough et al., 2011). Therefore, CTDI allows for the comparison of the relative amount of radiation usage between proceduralists. This is particularly important as the general principle of radiation dose being as low as reasonably achievable is critical to maximize the benefits of medical imaging in patients (Huda, 2015). Additional safeguards to minimize radiation at our institution include utilizing iterative reconstruction algorithms and limiting image scan length to approximately 15 mm above and below the intended slice selection for needle placement during all procedural imaging regardless of the type of proceduralist performing the biopsy.

Both NP providers and radiologists are trained in administering moderate sedation so that all biopsies can be performed with sedation. Our study showed no

significant difference between the amounts of fentanyl and midazolam used between the two groups. This is in contrast to a prior study that showed radiologists used higher doses of medication when compared to NPs performing image-guided hepatic biopsies (Murphy et al., 2014). However, in both studies, all doses were within acceptable safe limits and no complications were identified with regard to moderate sedation administration in either group.

Acceptance of "nonphysician providers" performing image-guided procedures is slowly growing as evidenced by a dramatic increase in Medicare claims for invasive radiology services provided by advanced practice providers (APPs) such as NPs (Hawkins, Bowen, Gilliland, Walls, & Duszak, 2015). Despite this, there is sparse literature comparing the performance and outcomes of NPs to radiologists when performing these procedures, which may contribute to continued hesitation in widespread utilization of APPs as proceduralists. Furthermore, the scope of practice for APPs is inconsistent nationwide and highly dependent on state laws and hospital credentialing boards (Smolenski, 2005; Taylor, Sansivero, & Ray, 2012).

Georgia State licensed NPs are required to have graduated from an accredited master's program and pass a national board certification exam. In addition, NPs must demonstrate satisfactory performance of at least 20 image-guided percutaneous organ biopsies under direct supervision of a radiologist prior to obtaining hospital procedural privileges at our institution (Murphy et al., 2014; Nandwana et al., 2015). However, it is important to note that there is no national policy or universal guidelines outlining what hospitals may require for NPs to obtain procedural privileges.

Projected shortages in the number of physicians, including radiologists, coupled with increasing healthcare demands have been reported (Association of American Medical Colleges, 2015; Bhargavan, Sunshine, & Schepps, 2002). Utilization of APPs can help buffer this shortage and improve throughput by increasing the number of trained staff available to perform image-guided procedures. This study demonstrates that NPs can function in this role while preserving quality and patient Safety.

Limitations of the study include it being a retrospective review and potential lack of generalizability in performing medical renal biopsies with other modes of image guidance such as ultrasound. In addition, the study only evaluated two NPs at our institution, and further studies are required to evaluate larger groups of NP providers at multiple institutions. Both NPs had been practicing for at least 10 years with a minimum of 1 year of radiology experience at the start of the retrospective review and all radiologists were board certified.

Conclusions

Our study contributes to a small but increasingly important body of literature suggesting that NPs can independently perform some types of image-guided procedures with no significant differences in diagnostic rate, number of samples obtained, radiation exposure, or sedation regimen when compared with radiologists.

Acknowledgments

Dr. Sadhna Nandwana developed the research project, participated in data collection, performed statistical analysis, and wrote the initial draft of manuscript. Deborah G. Walls developed the research project, participated in data collection, and revised the manuscript for final submission. Dr. Oluwayemisi Ibraheem participated in data collection and revised the manuscript for final submission. Dr. Frederick Murphy participated in data collection and revised the manuscript for final submission. Dr. Srini Tridandapani participated in data collection, performed statistical analysis, and revised the manuscript for final submission. Dr. Kelly Cox developed the research project, participated in data collection, and revised the manuscript for final submission.

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