J Vet Intern Med 2005;19:794–801

Renal Biopsy: A Retrospective Study of Methods and Complications in 283 Dogs and 65 Cats

Shelly L. Vaden, Jay F. Levine, George E. Lees, Reid P. Groman, Gregory F. Grauer, and S. Dru Forrester

Renal biopsy often is required to establish a definitive diagnosis in dogs and cats with renal disease. In this retrospective study, we determined the complications of renal biopsy as well as factors that may be associated with development of complications and procurement of adequate renal biopsy specimens in 283 dogs and 65 cats. Data extracted from medical records at 4 institutions were evaluated using logistic regression. Proteinuria was the most common indication for renal biopsy in dogs. Complications were reported in 13.4 and 18.5% of dogs and cats, respectively. The most common complication was severe hemorrhage; hydronephrosis and death were uncommon. Dogs that developed complications after renal biopsy were more likely to have been 4 to <7 years of age and >9 years, to weigh ≤5 kg, and to have serum creatinine concentrations >5 mg/dL. The majority of biopsies from both dogs (87.6%) and cats (86.2%) were considered to be of satisfactory quality. Biopsies from dogs were more likely to be of high quality if they were obtained when the patient was under general anesthesia and more likely to contain only renal cortex if they were obtained by surgery. We concluded that renal biopsy is a relatively safe procedure, with a low frequency of severe complications. Hospital practices and patient variables have the potential to impact both the quality of the specimen obtained and the rate of complications.

Key words: Kidney biopsy; Renal biopsy quality.

Renal diseases are common in dogs and cats. In 1 study, mortality from renal diseases in dogs was 5%, 2nd only to cancer-related deaths.[1] In another study, the prevalence of renal failure in cats was 2%.[2] History, physical examination, and clinical laboratory data aid in the classification of renal diseases into the general categories of acute renal failure, chronic renal failure, and protein-losing nephropathy, but renal biopsy often is required to establish a definitive diagnosis. Histologic assessment of renal tissue not only has the potential to result in a definitive diagnosis but also provides an estimation of the severity of renal lesions. Formulation of the optimal treatment plan can require a precise histologic diagnosis. Accurate assessment of response to therapy requires knowledge of both the type and severity of the disease being treated.[3–6]

Potential complications of renal biopsy include microscopic and macroscopic hematuria, severe perirenal hemorrhage that may necessitate blood transfusion, hydronephrosis secondary to obstruction of the renal pelvis or ureter by blood clots, renal infarction, alterations of renal vasculature, intrarenal arteriovenous fistula formation, and death.[3,4,7–11] Unilateral, ultrasound-guided renal biopsy had minimal effect on renal function in healthy dogs and cats, but the effect of renal biopsy on renal function in diseased kidneys has not been thoroughly studied.[12,13] The frequency of severe complications is relatively low and renal biopsy minimally affects renal function, but many practitioners are still reluctant to pursue renal biopsy in the clinical evaluation of their patients. The authors believe that this reluctance is intensified by concern that renal biopsy specimens frequently are inadequate for an accurate and meaningful diagnosis to be rendered and that the rendered diagnoses lack consistency. Results of clinical studies indicate that concerns regarding complications after renal biopsy and the quality of renal biopsy specimens are unjustified when proper technique is employed.[3,4,7,8,10,14,15] However, these studies have not identified specific factors associated with complications of renal biopsy and the procurement of adequate biopsy specimens in dogs and cats using statistical methods.

The primary goals of this retrospective study were to (1) determine the complications associated with renal biopsy in a large population of dogs and cats from several institutions, (2) identify factors that may be associated with complications from renal biopsy, and (3) determine which factors potentially affect the quality of renal biopsy specimens. This information should permit veterinarians to improve renal biopsy procedures, reduce the frequency of complications, and improve the quality of specimens obtained by renal biopsy.

Materials and Methods

Case Selection and Data Collection

Medical record databases of the Colleges of Veterinary Medicine Teaching Hospitals of North Carolina State University, Texas A&M University, Colorado State University, and Virginia-Maryland Regional College of Veterinary Medicine were searched to identify dogs and cats that had renal biopsy procedures performed between 1989 and 2000. Some of the institutions also conducted searches of logs maintained in their histopathology laboratories (universities 2 and 3) or radiology-service areas (university 3).

The following information was extracted from medical records: species, breed, gender, age and weight at the time of biopsy, and date of biopsy procedure. Indication for renal biopsy was recorded as proteinuria, acute renal failure, chronic renal failure, renal azotemia that could not be categorized as acute or chronic renal failure, or miscellaneous. Multiple indications were present in 15 animals (13 dogs and 2 cats).

From the Departments of Clinical Sciences (Vaden) and Farm Animal Health and Resource Management (Levine), North Carolina State University, College of Veterinary Medicine, Raleigh, NC; Department of Small Animal Medicine and Surgery, College of Veterinary Medicine, Texas A&M University, College Station, TX (Lees, Groman); Department of Clinical Sciences, College of Veterinary Medicine, Colorado State University, Ft. Collins, CO (Grauer); and Department of Clinical Sciences, Virginia-Maryland Regional College of Veterinary Medicine, Blacksburg, VA (Forrester).

Reprint requests: Shelly Vaden, College of Veterinary Medicine, North Carolina State University, 4700 Hillsborough Street, Raleigh, NC 27606; e-mail: shelly_vaden@ncsu.edu.

Received June 26, 2003; Revised September 4, 2003, and March 2, 2005; Accepted May 23, 2005.

0891-6640/05/1906-0002/$3.00/0

In these animals, the final data set included the strongest indication for renal biopsy: proteinuria for the 11 animals that had proteinuria and chronic renal failure, acute renal failure for the 2 animals that had acute renal failure and proteinuria, and chronic renal failure for the 2 animals that had chronic renal failure and a miscellaneous indication.

The medical records were searched to determine whether certain screening tests (eg, coagulation profile, abdominal ultrasound, systemic blood pressure) that are commonly recommended in the evaluation of patients with renal disease before renal biopsies were performed. If performed, results were categorized as normal or abnormal. Coagulation profiles were assessed based on the established reference range for each institution and considered to be abnormal when the platelet numbers were increased or decreased, fibrin degradation products were increased, or prothrombin time or partial thromboplastin times were prolonged. Methods used to measure blood pressure varied. Systolic pressure of >180 mm Hg was considered abnormal. Specific abnormalities were not recorded. The serum creatinine and urea nitrogen (SUN) concentrations of record closest to the time of renal biopsy were recorded. Serum creatinine concentration was categorized as not increased (≤1.8 mg/dL), moderately increased (>1.8–5.0 mg/dL), or severely increased (>5.0 mg/dL). Likewise, serum urea nitrogen concentration was categorized as not increased (≤30 mg/dL), moderately increased (31–100 mg/dL), or severely increased (>100 mg/dL).

The person performing the biopsy was categorized by level of training (intern, resident, senior clinician, other, or unspecified) and type of specialization (internal medicine, surgery, radiology, or other).

The medical records were searched to determine whether or not the animal was anesthetized or sedated for the renal biopsy procedure; the anesthetic or sedative agents used were recorded. Expected level of sedation or anesthesia was categorized as sedation, general anesthesia induced by injectable agents, general anesthesia induced by inhalation, or unspecified.

The method used to obtain the renal biopsy was categorized as percutaneous blind, percutaneous with ultrasound guidance, surgical, or laparoscopic. When a biopsy was obtained by surgery, it was further characterized as wedge or needle biopsy whenever possible. For needle biopsies, the size of the needle was recorded when it was noted in the medical record.

The tissue content of the renal biopsy specimen was extracted from the pathology report and recorded as renal cortex only, cortex and medulla, medulla only, renal tissue not present, or content unknown. When possible, investigators reviewed the microscopic slides to determine tissue content when this information was not included in the pathology report. Morphologic diagnoses rendered by initial pathologic reviews of the renal biopsy were extracted from the medical records. The biopsy specimen was recorded as satisfactory, and therefore of good quality, if adequate renal cortex was obtained for a morphologic diagnosis to be rendered. The number of glomeruli in the specimen was not consistently reported and, therefore, was not considered in determining whether a biopsy was satisfactory. If a diagnosis was obtained via later necropsy examinations, this diagnosis was recorded and compared with the biopsy diagnosis. Morphologic diagnoses were placed into 1 of the following categories on the basis of the pathology report: glomerular disease, inflammatory tubulointerstitial disease, noninflammatory tubulointerstitial disease, no microscopic lesions, and diagnosis not rendered. No attempt was made to review renal biopsies for accuracy of morphologic diagnoses.

Medical records were searched for evidence of complications associated with renal biopsy procedures. Whether or not a urinalysis was evaluated within 48 hours of renal biopsy was recorded. The presence of either gross or microscopic hematuria or severe hemorrhage was noted. Severe hemorrhage was defined as a decrease in PCV of >20% of the prebiopsy value within 24 hours of the renal biopsy procedure. Medical records also were searched for evidence of hydronephrosis or infection of the biopsy site developing after the biopsy procedure and evidence that patient death occurred as a result of the biopsy procedure.

If a patient had more than 1 renal biopsy, only data from the 1st renal biopsy procedure were included; data from subsequent biopsy procedures were excluded. Data from dogs or cats that had nephrectomies or nephrotomies were excluded.

Statistical Analysis

The potential association of each demographic-, clinical diagnostic-, and institution-associated variable with the occurrence of complications associated with renal biopsy was examined in a series of independent and multivariable logistic regression models.[16] Additional models were developed to assess the association of each variable with biopsy quality and biopsy content. Changes in adjusted odds ratios and corresponding confidence intervals derived from the beta coefficient were used to assess the contribution of each variable to a model.[17] Changes in the standard error of the beta coefficient and the size of the confidence intervals generated for the estimated odds ratios were used to assess the stability of each model. Severe hemorrhage was identified as the primary complication postbiopsy and, because of covariation, made the model unstable. Accordingly, an additional series of models was developed to identify variables that were associated with severe hemorrhage postbiopsy. Similarly, due to substantial colinearity (linear changes in 1 variable were associated with similar linear changes in another), the variables creatinine, blood urea nitrogen, weight and breed, and diagnosis and indication were examined in separate models. After identifying variables associated with postbiopsy complications and severe hemorrhage, separate and combined models were developed for signalment (eg, age and breed), practice-related variables (eg, university and method of biopsy), and clinical findings (eg, SUN and diagnosis). As anticipated, the standard error increased and confidence intervals increased as variables were added to the model. However, these changes did not alter the final assessment of each variable. No clinically relevant loss of precision or validity was apparent when these groups of variables were examined separately or combined. A final model was developed including all relevant variables, but to enhance the clinical clarity of presentation of this modeling effort, patient-associated variables (signalment and clinical variables) and practice-related variables (eg, institution) are presented separately. Additional stratified analysis using logistic regression was conducted to identify factors associated with specific selected outcomes (eg, renal biopsy quality).

Results

Of 348 patients that underwent renal biopsy procedure between 1989 and 2000, 283 (130 male, 153 female) were dogs and 65 (42 male, 22 female, 1 intersex) were cats (Table 1). Dogs ranged in age from 0.33 to 15 years and in weight from 1 to 57 kg. Cats ranged in age from 0.33 to 16 years and in weight from 1 to 7 kg. There was no apparent association between year of biopsy and development of complications, including severe hemorrhage or the quality or content of the renal biopsy.

Proteinuria was the most common indication for renal biopsy in dogs, whereas renal biopsies were most frequently obtained from cats that had other indications or were in chronic renal failure (Table 1). Clinical research (n = 16), isosthenuria (n = 8), or renomegaly or renal mass (n = 8) were the most common other indications for renal biopsy in dogs. Renomegaly or renal mass (n = 6) or other ultrasonographic abnormalities (n = 5) were the most common other indications for renal biopsy in cats.

Only 39 (13.8%) dogs and 3 (4.6%) cats in this study had all of the prebiopsy screening tests that are commonly recommended; there was no evidence in the medical re-

Table 1. Summary statistics of demographic and hospital variables from dogs and cats undergoing renal biopsy.

Variable	Dogs		Cats
Age (years)	6 (3.9)[a]		6 (3.5, 10)
<1	30 (10.6%)[b]	<3.5	40 (61.5%)
1–4	57 (20.1%)	≥3.5	25 (38.5%)
4–<7	68 (24.0%)		
7–9	66 (23.3%)		
>9	61 (21.6%)		
Weight (kg)	18 (10, 29.3)		4 (5, 3)
≤5	30 (10.6%)	<4	25 (38.5%)
>5–15	68 (24.0%)	≥4	40 (61.5%)
>15–25	57 (20.1%)		
>25	127 (44.9%)		
Gender			
Male	130 (45.9%)		42 (64.6%)
Female	153 (54.1%)		22 (33.8%)
Intersex			1 (1.5%)
Indication for biopsy			
Proteinuria	131 (46.3%)		6 (9.2%)
Acute renal failure	48 (17.0%)		8 (12.3%)
Chronic renal failure	38 (13.4%)		18 (27.7%)
Azotemia (unclassified)	7 (2.5%)		8 (12.3%)
Other	59 (20.8%)		25 (38.5%)
Prebiopsy evaluation			
Coagulation profile	161 (56.9%)		27 (41.5%)
Abdominal ultrasound	253 (89.4%)		59 (90.8%)
Systemic blood pressure	69 (24.4%)		6 (9.2%)
Person obtaining biopsy			
Level of training			
Intern	1 (0.4%)		
Resident	110 (38.9%)		25 (38.5%)
Senior clinician	164 (58.0%)		38 (58.5%)
Unspecified	8 (2.8%)		2 (3.1%)
Speciality			
Internal medicine	32 (11.3%)		11 (16.9%)
Surgery	123 (43.5%)		29 (44.6%)
Radiology	125 (44.2%)		24 (36.9%)
Other/unknown	3 (1.1%)		1 (1.5%)
University			
1	59 (20.8%)		15 (23.1%)
2	85 (30.0%)		19 (29.2%)
3	90 (31.8%)		12 (18.5%)
4	49 (17.3%)		19 (29.2%)

[a] Data presented as median (Q1, Q3).
[b] Data presented as number of animals (percent).

Table 2. Type of anesthesia and method used to obtain renal biopsies and resultant content and quality of renal biopsies from dogs and cats.

Variable	Dogs	Cats
Anesthetic type		
Sedation only	29 (10.2%)	9 (13.8%)
General anesthesia, injectable	16 (5.7%)	4 (6.2%)
General anesthesia, inhalant	201 (71.0%)	38 (58.5%)
Unspecified	37 (13.7%)	14 (21.5%)
Biopsy method		
Percutaneous, blind	1 (0.4%)	8 (12.3%)
Percutaneous, ultrasound guidance	136 (48.1%)	26 (40.0%)
Surgical	126 (44.5%)	30 (46.1%)
Wedge	64 (22.6%)	13 (20.0%)
Needle	57 (20.1%)	16 (24.6%)
Unspecified	5 (1.8%)	1 (1.5%)
Laparoscopic	19 (6.7%)	1 (1.5%)
Unspecified	1 (0.4%)	
Size of biopsy needle (gauge)		
14	11 (5.2%)	1 (2.0%)
16	34 (16.0%)	5 (9.8%)
18	94 (44.1%)	18 (35.3%)
Unspecified	74 (34.7%)	27 (52.9%)
Tissue content in biopsy		
Renal cortex only	169 (59.7%)	31 (47.7%)
Renal cortex and medulla	58 (20.5%)	19 (29.2%)
Renal medulla only	10 (3.5%)	4 (6.2%)
Content unknown	38 (13.4%)	11 (16.9%)
Renal tissue not present	8 (2.8%)	
Biopsy quality		
Satisfactory	248 (87.6%)	56 (86.2%)
Unsatisfactory	35 (12.4%)	8 (12.3%)
Unknown		1 (1.5%)

cords that any of these tests were performed in 10 (3.5%) dogs and 3 (4.6%) cats (Table 1). When a coagulation profile was performed, results were considered abnormal in 64 (39.8%) dogs and 14 (51.9%) cats. The kidneys had abnormal ultrasonographic appearance in 178 (70.4%) of the dogs and 52 (88.1%) of the cats evaluated. Hypertension was documented in 22 (31.9%) of the dogs and 2 (33.3%) of the cats for which blood pressure was measured. Serum creatinine concentration was not increased in 149 (53.2%) dogs and 19 (31.1%) cats, moderately increased in 75 (26.8%) dogs and 26 (42.6%) cats, and severely increased in 56 (20%) dogs and 16 (26.2%) cats. Likewise, serum urea nitrogen concentration was not increased in 133 (47.5%) dogs and 25 (41.0%) cats, moderately increased in 99 (35.4%) dogs and 21 (34.4%) cats, and severely increased in 47 (16.8%) dogs and 15 (24.6%) cats.

The majority of biopsies were obtained by senior clinicians and by surgeons or radiologists (Table 1). Anesthesia or sedation was provided and recorded in the medical records of 271 (95.8%) dogs and 61 (93.8%) cats (Table 2). General inhalant anesthesia was the most common form of anesthesia provided. Needle biopsies (213 dogs, 51 cats) were more commonly obtained than were wedge biopsies (64 dogs, 13 cats). An 18-gauge needle appeared to be the size most commonly used, but this information often was missing from the record. Most biopsy specimens contained renal cortex only, with only 10 (3.5%) and 4 (6.2%) biopsies obtained from dogs and cats, respectively, containing only renal medulla. The exact tissue content in the biopsy specimens could not be determined in 38 (13.4%) dogs and 11 (16.9%) cats because it was not recorded on the histopathology reports and slides were not available for review.

The hospital at which biopsies were obtained and the level of training of the person obtaining the biopsy were associated with the tissue content of biopsy specimens obtained from dogs (Table 3). Biopsies obtained at university

Table 3. Final logistic regression model for the potential association of variables with only renal cortex being present in renal biopsies obtained from dogs.

Variable	Odds Ratio	95% Confidence Interval
University		
1	5.54	1.87–16.46
2	1.93	0.94–3.93
3	1.00	Reference category
4	0.43	0.10–1.83
Level of training		
Senior clinicians	1.00	Reference category
Residents	2.40	1.16–4.95
Specialty		
Surgery	1.00	Reference category
Radiology	1.04	0.53–2.06
Internal medicine	0.34	0.11–1.06

1 and those obtained by residents were more likely to contain only renal cortex.

A majority of biopsies were considered satisfactory (87.6% of specimens from dogs, 86.2% of specimens from cats). Biopsies that were considered to be of good quality were more likely to be obtained from dogs that were under injectable or inhalant general anesthesia (odds ratio, 2.56; 95% confidence interval, 0.99–6.62). When surgical biopsies were obtained, general inhalant anesthesia was used in 83.3 and 89.7% of dogs and cats, respectively (Table 4). However, general anesthesia also was used when biopsies were obtained by other methods in 55.4 and 37.1% of dogs and cats, respectively. There was no difference in the quality of biopsies obtained percutaneously (odds ratio, 0.78; 95% confidence interval, 0.37–1.62) or laparoscopically (odds ratio, 1.06; 95% confidence interval, 0.22–5.09) in dogs. Biopsies of good quality were more likely to be diagnostic in dogs (odds ratio, 18.6; confidence interval, 8.81–39.46).

Sample size limitations prevented similar assessment of biopsies obtained from cats.

The size of needle used to obtain needle biopsies could not be included in multivariate analysis because of the large number of cases for which needle size was unspecified. However, results of a stratified independent analysis of the potential association of needle size with biopsy content, biopsies were more likely to contain only cortex and less likely to contain medulla when a 16-gauge (odds ratio, 19.38; 95% confidence interval, 3.52–106.65) or 18-gauge (10.12, 2.12–48.64) needle was used than when a 14-gauge needle was used to obtain the biopsy specimen. When all needle biopsies were combined, 2 (16.7%), 31 (79.5%), and 73 (65.2%) of biopsies obtained using 14-, 16- and 18-gauge needles, respectively, contained only renal cortex. Similarly, 9 (75%), 36 (92.3%), and 97 (86.6%) of all biopsies obtained using 14-, 16-, and 18-gauge needles, respectively, were considered to be of satisfactory quality. When biopsies were obtained by surgery, good-quality biopsies were approximately 5 times more likely to be obtained with wedge biopsies than with needle biopsies (odds ratio, 5.02; 95% confidence interval, 1.01–24.89).

Table 5. Complications associated with renal biopsy in dogs and cats.

	Dogs	Cats
Number of animals with complications	38 (13.4%)	12 (18.5%)
Type of complication		
Gross hematuria	12 (4.2%)	2 (3.1%)
Severe hemorrhage	28 (9.9%)	11 (16.9%)
Hydronephrosis	1 (0.4%)	2 (3.1%)
Infection	0[a]	0
Death	7 (2.5%)	2 (3.1%)

[a] Postbiopsy fever developed in 1 dog.

Postmortem examinations eventually were performed on 45 dogs and 14 cats. Renal histopathologic diagnoses obtained from tissues obtained during postmortem examination were in agreement with the original diagnoses in 27 (60.0%) dogs and 5 (35.7%) cats. There was nonspecific agreement (ie, 1 histopathologic diagnosis was nonspecific but compatible with the other diagnosis) in 6 (13.3%) dogs and an additional (7.1%) cat.

Complications were infrequent, occurring in only 13.4% of dogs and 18.5% of cats (Table 5). Severe hemorrhage was the most common complication observed after renal biopsy. Of the 64 dogs with abnormal coagulation profiles, 9 (14.1%) had severe hemorrhage versus 10 (10.3%) of the 97 dogs that had coagulation profile results that were within the reference ranges. Likewise, 4 (28.6%) of the 14 cats that had abnormal coagulation profiles had severe hemorrhage. However, severe hemorrhage also developed in 2 (15.3%) of the 13 cats that had coagulation profile results that were within reference ranges. Results of urinalyses of urine samples collected within 48 hours of renal biopsy were recorded in the medical records from only 15 dogs (5.3%) and 3 (4.6%) cats, precluding the evaluation of postbiopsy microscopic hematuria in this study population.

Table 4. The number of dogs (cats) that received the different classes of anesthesia/sedation as listed by methods used to obtain renal biopsies.

	P-B	P-US	Sx	Lap	USp
Anesthetic type					
Sedation only	0 (1)	25 (8)	0 (0)	4 (0)	0 (0)
General anesthesia, injectable	0 (1)	8 (2)	6 (1)	1 (0)	1 (0)
General anesthesia, inhalant	1 (3)	72 (9)	113 (25)	15 (1)	0 (0)
Unspecified	0 (3)	31 (7)	6 (4)	0 (0)	0 (0)

P-B, percutaneous blind; P-US, percutaneous with ultrasound guidance; Sx, surgical; Lap, laparoscopic; USp, unspecified.

Table 6. Final logistic regression model for the potential association of animal-related variables with all complications and severe hemorrhage only following renal biopsy in dogs.

	All Complications		Severe Hemorrhage Only	
Variable	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval
Age (years)				
<1	3.97	0.59–26.60	1.11	0.07–16.61
1–3	1.00	Reference category	1.00	Reference category
4–6	6.43	1.53–27.07	6.51	1.11–38.17
7–9	3.08	0.79–12.05	2.78	0.48–15.98
>9	3.97	0.98–15.56	4.62	0.83–25.68
Weight (kg)				
≤5	7.47	2.03–27.48	4.76	1.18–19.21
>5	1.00	Reference category	1.00	Reference category
Serum creatinine (mg/dL)				
Normal (≤1.8)	1.00	Reference category	1.00	Reference category
Moderate azotemia (1.8–5)	1.34	0.52–3.49	2.18	0.69–6.92
Severe azotemia (>5)	5.55	1.93–16.01	6.15	1.82–20.80

However, 10 of these 15 dogs (66.7%) and 1 of the 3 cats (33.3%) had microscopic hematuria. Other complications were noted in 2 of the 10 dogs and the 1 cat with microscopic hematuria.

Hydronephrosis and death were rare complications in dogs and cats of this study. None of the animals developed clinically apparent infections associated with the renal biopsy procedure. Severe hemorrhage contributed to death in 3 dogs and 2 cats. Poor recovery from anesthesia was listed as a factor contributing to death in 3 dogs. The cause of death was not listed or unknown in 2 dogs. In addition to severe hemorrhage, 1 of the 2 cats that died also developed neurologic abnormalities up recovery from anesthesia that led to euthanasia.

Dogs that developed complications after renal biopsy were more likely to have been 4 to <7 years of age and >9 years, to weigh ≤5 kg, and to have serum creatinine concentrations >5 mg/dL (Table 6). Dogs with complications were also more likely to have undergone renal biopsy at university 2 than the other institutions and to have had the biopsy obtained by a radiologist or an internist (Table 7). Severe hemorrhage was the most common complication in dogs of this study. Dogs with severe hemorrhage were more likely to have been 4 to <7 years of age, weigh ≤ 5 kg, and have a serum creatinine concentration >5 mg/dL (Table 6). Dogs with severe hemorrhage after renal biopsy were more likely to have undergone renal biopsy at university 2 (Table 7).

Cats with moderately high SUN concentration (31–100 mg/dL) were more likely to have complications (odds ratio, 12.0; 95% confidence interval, 1.33–107.93) and severe hemorrhage (9.6, 1.05–87.79). Cats with severe hemorrhage after renal biopsy also were more likely to have undergone renal biopsy at university 2 (Table 8).

Dogs weighing ≤5 kg were not more likely to have renal biopsies obtained via surgery when compared with other methods (odds ratio, 1.25; 95% confidence interval, 0.50–3.11). The number of dogs that weighed ≤5 kg and developed complications when biopsies were obtained by the different methods was as follows: (1) ultrasound guidance (7 dogs): severe hemorrhage, 2 (29%); death, 1 (14%); (2) surgical wedge biopsy (4 dogs): severe hemorrhage, 2 (50%), death 1 (25%); (3) surgical needle biopsy (4 dogs):

Table 7. Final logistic regression model for the potential association of hospital variables with all complications and severe hemorrhage only following renal biopsy in dogs.

	All Complications		Severe Hemorrhage Only	
Variable	Odds Ratio	95% Confidence Interval	Odds Ratio	95% Confidence Interval
University				
1	0.33	0.05–2.09	0.40	0.03–5.10
2	12.26	3.70–40.62	10.31	2.09–50.86
3	1.00	Reference category	1.00	Reference category
4	1.27	0.27–5.98	1.92	0.26–14.05
Specialty				
Surgery	1.00	Reference category	1.00	Reference category
Radiology	3.11	1.14–8.49	2.67	0.82–8.71
Internal medicine and other	3.76	0.98–14.31	3.22	0.69–15.20

Table 8. Final logistic regression model for the potential association of hospital-related variables with severe hemorrhage following renal biopsy in cats.

Variable	Odds Ratio	95% Confidence Interval
University		
1	1.00	Reference category
2	22.15	2.88–170.27
3	2.62	0.31–22.23

severe hemorrhage, 1 (25%); 3 laparoscopy (3 dogs): no complications.

Complications and severe hemorrhage were more likely to be observed in dogs and cats undergoing renal biopsy at university 2. Although clinicians at university 2 were more likely to obtain surgical biopsies (odds ratio, 3.02; 95% confidence interval, 1.78–5.13) through the surgical service (1.910, 1.10–3.32), dogs at university 2 were more likely to have complications (10.62, 5.16–21.83) and severe hemorrhage (8.95, 3.64–22.04) as a result of the biopsy procedures when compared with the other 3 universities. Clinicians at university 2 were more likely to use sedation rather than general anesthesia (2.35, 1.07–5.14) and less likely to use an inhalant agent to maintain general anesthesia (0.44, 0.20–0.96) when compared with injectable agents. In addition, dogs undergoing biopsy at university 2 were more likely to have moderately high serum creatinine concentration (2.42, 1.34–4.39) and moderately high SUN concentration (2.53, 1.43–447). When the morphologic diagnoses were grouped as glomerular disease, inflammatory tubulointerstitial diseases, noninflammatory tubulointerstitial disease, or no microscopic lesion, dogs undergoing renal biopsy at university 2 were more likely to have glomerular disease (2.28, 1.05–4.97) and inflammatory tubulointerstitial disease (2.64, 1.07–6.50). When dogs and cats were combined, 24.0% from university 2 had chronic renal failure versus 13.5, 11.8, and 13.2% from universities 1, 3, and 4, respectively.

Of the 30 cats that had renal biopsies obtained by surgical methods, 5 (16.7%) had complications. Wedge biopsies were obtained in 4 of these cats; a needle biopsy was obtained in 1 cat. Of the 126 dogs that had surgical renal biopsies, 21 (16.7%) had complications. Wedge and needle biopsies were obtained in 11 (8.7%) and 9 (7.1%) of these dogs, respectively; the method was unspecified in 1 dog. Complications occurred in 12 (8.8%) of the 136 dogs and 4 (15.4%) of the 26 cats that had biopsies obtained under ultrasound guidance. No obvious complications occurred in any of the animals that had biopsies obtained by the blind percutaneous method. Only 1 (5.3%) dog had a complication after laparoscopy with renal biopsy.

Of the 35 cats that had needle biopsies performed (ie, via surgery, laparoscopy, or percutaneous methods), 4 had complications. For 1 of these cats, an 18-gauge needle was used; the needle size was not recorded in the medical records of the remaining 3 cats. Of the 213 dogs that had needle biopsies, 23 had complications. Unfortunately, the needle size was not recorded in the medical records of 16 of these dogs. Of the 7 dogs in which the needle size was recorded and complications occurred, 0, 5, and 2 of the dogs that had biopsies obtained using 14-, 16-, and 18-gauge needles, respectively, had complications.

Discussion

Renal biopsy frequently is required to refine the diagnosis of renal disease in dogs and cats. However, the authors believe that renal biopsies often are not collected from dogs and cats with renal disease, in part because of clinicians' concern of associated complications as well as concerns about the accuracy of diagnosis. In this study, we cataloged the frequency of complications associated with renal biopsy and identified factors that potentially were associated with complications and might affect the quality of the renal biopsy specimen.

The majority of biopsies obtained from dogs and cats of this study were considered to be of satisfactory quality, containing adequate renal cortex and facilitating diagnosis, even if the diagnosis was listed as normal renal tissue. The potential association between providing general anesthesia and obtaining a quality biopsy specimen is not surprising. Immobilization of the patient is an important component of the proper technique of biopsy collection. The association between the use of general anesthesia and obtaining a quality biopsy is probably not due solely to using surgery to obtain the biopsy because a large percentage of dogs and cats that had biopsies collected by other methods also were given inhalant anesthesia. In dogs and cats that had biopsies collected by surgical methods, wedge biopsies were more likely to be of good quality than were needle biopsies. One has more control over the depth of biopsy and the volume of tissue collected when a wedge biopsy is obtained as compared with a needle biopsy.

Variation in biopsy content among universities most likely reflects specific practices at the different universities. A quality biopsy is more likely to be obtained if good technique is employed. However, it was surprising that biopsies were more likely to contain only renal cortex if collected by a resident when compared with senior clinicians. Although it is likely that senior clinicians supervised biopsy procedures performed by residents, this practice was not possible to assess in a retrospective study.

Complications in this study population were relatively infrequent, occurring in 13.4 and 18.5% of dogs and cats, respectively. Severe hemorrhage was the most common complication, developing in 9.9% of all dogs and 16.9% of all cats, which is higher than previously reported.[7,9] However, the prevalence of severe hemorrhage after renal biopsy varied among universities, with 2 centers reporting prevalences that were similar to and 2 reporting prevalences that were higher than previously reported. The occurrence of hydronephrosis (0.4% in dogs and 3.1% in cats) was lower in dogs yet higher in cats than in a previous report.[7] Death occurred in only 3.1% and 2.5% of cats and dogs, respectively. Death and hydronephrosis are uncommon complications of renal biopsy.

Dogs that were of middle (4 to <7 years) and advanced age (>9 years), were of small body size (ie, ≤5 kg) and those with severe azotemia (serum creatinine concentration >5 mg/dL) were more likely to develop complications as-

sociated with renal biopsy. Dogs of advanced age may have been more likely to have had other concurrent diseases that increased the likelihood of complications or to have limited compensatory abilities and reduced tolerance of anesthesia and biopsy. Furthermore, pet owners may have been more likely to elect euthanasia if an older dog developed a serious postbiopsy complication. We were unable to identify factors related to the development of complications in small dogs. The number of dogs developing complications that were ≤5 kg was similar when biopsies were obtained by ultrasound guidance versus surgery. No complications occurred with laparoscopic biopsies in small dogs, but the number of dogs in this group was very small. The higher frequency of complications in small dogs may have been related to collecting biopsies from smaller kidneys while using similar-sized needles or obtaining similar-sized wedges that one would use on a larger kidney, consequently increasing the likelihood of transecting a larger vessel in the comparatively smaller kidney. The finding that complications were more likely in dogs with advanced azotemia is expected. Other studies have demonstrated a similar association in people undergoing renal biopsy.[11,18,19] Abnormal bleeding in patients with uremia is characterized by increased bleeding time and platelet-function abnormalities. These functional defects likely contributed to the increased frequency of complications in dogs with advanced azotemia in this study.

Hospital factors that were potentially associated with complications in dogs included undergoing biopsy at university 2 and having a radiologist or internist collect the biopsy instead of a surgeon. Although this finding may suggest that dogs that had renal biopsies collected by either percutaneous methods or laparoscopy were more likely to have complications, biopsy method did not appear in the final logistic regression model. Two important factors were identified that may have contributed to the higher number of complications at university 2. The 1st factor is that patients may have been less likely to be adequately immobilized during the renal biopsy procedure at university 2, where sedation and injectable general anesthesia were more likely to be used. The 2nd factor is that dogs undergoing renal biopsy at university 2 may have been more seriously ill than those undergoing biopsy at the other institutions as suggested by the fact that they were more likely to have a moderately high degree of azotemia and glomerular disease or inflammatory tubulointerstitial disease. Likewise, relatively more patients with chronic renal failure underwent renal biopsy at university 2 when compared with the other universities. Studies have demonstrated an increased risk of complication associated with renal biopsy in people with chronic renal failure.[18] The prevalence of complications of renal biopsy in children decreased as clinicians gained experience with the technique.[20] Improper technique may have contributed to the higher number of complications at university 2, but this suspicion could not directly be evaluated in this study. Surprisingly, a large percentage of dogs had limited evaluations in the post-biopsy period. Thus, it also is possible that animals seen at university 2 had more complete postbiopsy evaluations, leading to a larger number of complications being detected.

The potential association of developing complications after renal biopsy and having a radiologist or internist collect the biopsy may be due to the fact that radiologists and internists are most likely to obtain biopsies by percutaneous methods. Obtaining biopsies by percutaneous methods precludes complete visualization of the kidneys, limits control of needle penetration into deeper parts of the kidney, and prevents control of hemorrhage once initiated. Because renal vessels progressively increase in size from the surface of the kidney toward the pelvis, limiting penetration of the needle to the superficial cortex is important in control of hemorrhage. Unfortunately, the small number of percutaneous biopsies performed at the participating institutions precluded statistical analysis. Alternatively, radiologists and internists may have been more likely to use sedation or injectable anesthesia for patient mobilization during renal biopsy.

Severe hemorrhage was the most common complication, developing in 9.9% of dogs and 16.9% of cats. Patient and hospital variables that potentially were associated with severe hemorrhage in dogs were similar to those associated with the development of complications. Although an abnormal coagulation profile intuitively would increase the likelihood that severe hemorrhage would occur during renal biopsy, the small number of animals in which tests of coagulation were evaluated precluded statistical analysis. A previous study demonstrated a correlation between biopsy-associated hemorrhage and thrombocytopenia (dogs and cats), prolonged 1-stage prothrombin time (dogs), or prolonged activated partial thromboplastin time (cats).[21] However, in this report, the occurrence of severe hemorrhage was only slightly higher in those dogs and cats that had abnormal coagulation profiles. This finding suggests that other factors, such as the presence of severe azotemia and the use of improper technique, may be equally important in determining the rate of postbiopsy hemorrhage. These factors may become even more relevant in dogs that are small or of advanced age.

Obtaining an accurate histopathologic diagnosis should increase our understanding of the pathology associated with various renal diseases as well as enhance our knowledge of the natural history of each disease. However, whether or not obtaining an accurate histologic diagnosis by renal biopsy outweighs the risk to the patient of the biopsy procedure is debated. Knowledge of renal histology altered patient management in 42% of people undergoing renal biopsy.[5] The authors concluded that renal histology was essential in the management of patients with renal disease. Renal biopsy was more likely to alter patient management in people with nephrotic-range proteinuria and acute renal failure and less likely to alter management in people with chronic renal failure, non–nephrotic-range proteinuria, or hematuria. We need to determine the influence of accurate histologic diagnosis on patient management in veterinary medicine. As our understanding of the pathology and natural history of renal diseases increases, renal biopsy may have greater impact on patient management.

Continued development of our understanding of renal diseases in animals requires accurate histologic diagnoses to be rendered. Although several attempts have been made to classify the various forms of renal diseases in dogs, especially glomerular diseases in which renal biopsy findings

may have the greatest impact, lack of a standard nomenclature and the use of different morphologic criteria for rendering diagnoses have made it difficult to compare findings in different studies.[6,22] More importantly, lack of standard morphologic criteria and nomenclature has made it difficult to apply the information obtained in a renal biopsy report to patient management. A lack of consistency in diagnosis may have led to the seemingly poor association between the histopathologic diagnoses rendered at the time of biopsy and postmortem examinations in this study. Alternatively, disease progression or development of a 2nd renal disease may have contributed to the apparent lack of association between biopsy and postmortem assessments.

In summary, renal biopsy is a relatively safe procedure and the frequency of severe complications is low. Hospital practices have the potential to impact both the quality of the specimen that is obtained and the rate of complications. Biopsies are more likely to contain only renal cortex if they are obtained by surgery and be of better quality if the patient is under general anesthesia. Biopsies of good quality are more likely to be diagnostic. Complications are more likely to develop in dogs that are of middle to advanced aged, of small body size, or are severely azotemic.

References

1. Bronson RT. Variation in age at death of dogs of different sexes and breeds. Am J Vet Res 1982;43:2057–2059.

2. Lund EM, Armstrong PJ, Kirk CA, et al. Health status and population characteristics of dogs and cats examined at private veterinary practices in the United States. J Am Vet Med Assoc 1999;214:1336–1341.

3. Grauer GF, Twedt DC, Mero KN. Evaluation of laparoscopy for obtaining renal biopsy specimens from dogs and cats. J Am Vet Med Assoc 1983;183:677–679.

4. Minkus G, Reusch C, Hörauf A, et al. Evaluation of renal biopsies in cats and dogs—Histopathology in comparison with clinical data. J Sm Anim Pract 1994;35:465–472.

5. Richards NT, Darby S, Howie AJ, et al. Knowledge of renal histology alters patient management in over 40% of cases. Nephrol Dial Transplant 1994;9:1255–1259.

6. Vilafranca M, Wohlsein P, Trautwein G, et al. Histological and immunohistological classification of canine glomerular disease. J Vet Med A 1994;41:599–610.

7. Jeraj K, Osborne CA, Stevens JB. Evaluation of renal biopsy in 197 dogs and cats. J Am Vet Med Assoc 1982;181:367–369.

8. Léveillé R, Partington BP, Biller DS, Miyabayshi T. Complications after ultrasound-guided biopsy of abdominal structures in dogs and cats: 246 cases (1984–1991). J Am Vet Med Assoc 1993;203:413–415

9. Osborne CA. Clinical evaluation of needle biopsy of the kidney and its complications in the dog and cat. J Am Vet Med Assoc 1971;158:1213–1228.

10. Hager DA, Nyland T, Fisher P. Ultrasound-guided biopsy of the canine liver, kidney and prostate. Vet Radiol 1985;26:82–88.

11. Sweet EI, Davidson AJ, Hayslett JP. Complications of needle biopsy of the kidney in the dog. Radiology 1969;92:849–854.

12. Groman RP, Bahr A, Berridge BR, Lees GE. Effect of serial ultrasound-guided renal biopsies on kidneys of healthy adolescent dogs. Vet Rad Ultrasound 2004;45:62–69.

13. Drost WT, Henry GA, Meinkoth JH, et al. The effects of a unilateral ultrasound-guided renal biopsy on renal function in healthy sedated cats. Vet Radiol Ultrasound 2000;41:57–62.

14. Osborne CA, Low DG. Size, adequacy and artifacts of canine renal biopsy samples. Am J Vet Res 1971;32:1865–1871.

15. Wise LA, Allen TA, Cartwright M. Comparison of renal biopsy techniques in dogs. J Am Vet Med Assoc 1989;195:935–939.

16. Hosmer DW, Lemeshow S. Applied Logistic Regression. New York, NY: John Wiley and Sons Inc; 1989:82–105.

17. Kleinbaum DG. Logistic regression: A self-learning text. New York, NY: Springer-Verlag; 1994:164–181

18. Parrish AE. Complications of percutaneous renal biopsy: a review of 37 years' experience. Clin Nephrol 1992;38:135–141.

19. Diaz-Buxo JA, Donadio JV. Complications of percutaneous renal biopsy: An analysis of 1,000 consecutive biopsies. Clin Nephrol 1975;4:223–227.

20. Dodge WF, Daeschner CW, Brennan JC, et al. Percutaneous renal biopsy in children. General considerations. Pediatrics 1962;30:287–296.

21. Bigge LA, Brown DJ, Pennick DG. Correlation between coagulation profile findings and bleeding complications after ultrasound-guided biopsies: 434 cases (1993–1996). J Am Anim Hosp Assoc 2001;37:228–33.

22. Murray M, Wright NG. A morphologic study of canine glomerulonephritis. Lab Invest 1974;30:213–221.