Evaluation of the effects of nephrotomy on renal function in clinically normal cats

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Objective—To evaluate the effects of nephrotomy on renal function in clinically normal cats.

Animals—20 specific-pathogen-free, 9- to 11-month-old female mixed-breed cats.

Procedure—Serum chemistry analyses, CBC determinations, urinalyses, microbiologic urine cultures, renal ultrasonography, abdominal radiography, and single-kidney and total glomerular filtration rate (GFR) determinations by use of renal scintigraphy and measurements of plasma disappearance of technetium 99m-diethylenetriaminepentaacetic acid were performed before surgery and at 3, 12, 26, 52, and 78 weeks after surgery in 10 cats that underwent unilateral nephrotomy and in 10 control cats that underwent a sham surgical procedure.

Results—Two cats (1 from each group) did not complete the study, and their data were eliminated from analyses. Unilateral nephrotomy resulted in a 10% to 20% reduction in mean single-kidney GFR, compared with that of nephrotomy contralateral control kidneys. However, mean total GFR in nephrotomy-group cats was not significantly different from that of sham-group cats. Over the 78 weeks of study, mean total GFR declined 34% and 40% in nephrotomy- and sham-group cats, respectively. Adverse events associated with nephrotomy included persistent microscopic hematuria, renal pelvis hyperechogenicity with distant shadowing on ultrasonographic evaluation, dilatation of renal pelvises, and hydronephrosis.

Conclusions and Clinical Relevance—Nephrotomy in normal functioning feline kidneys results in a modest relative reduction in renal function, compared with contralateral control kidneys, but has minimal effect on total GFR when compared with sham-operated control cats. However, any detrimental effects of nephrotomy may be magnified in cats with diseased kidneys, which may have little or no capacity for repair or compensation. (Am J Vet Res 2005;66:1400–1407)

Urolithiasis is one of the most common urinary tract disorders encountered in feline practice. Although most feline uroliths are identified in the urinary bladder and urethra, uroliths located in the kidneys (nephroliths) pose unique diagnostic and therapeutic challenges. Nephroliths may be clinically silent and unassociated with substantial morbidity or mortality. Conversely, cats affected with actively enlarging nephroliths may have signs of pain, fever, or renal failure attributable to fibrosis, infection, or urine outflow obstruction. The optimal method for managing feline nephroliths has not been determined. In humans, extracorporeal shock wave lithotripsy is widely used for the management of nephroliths. However, in a preliminary study of extracorporeal shock wave lithotripsy in 4 cats with nephroliths, 2 stones did not fragment and only partial fragmentation was achieved in the stones of the remaining cats. The ineffectiveness of extracorporeal shock wave lithotripsy in these cats may be related to the finding that the shock wave dose must be substantially reduced in cats, compared with humans and dogs, to minimize shock wave–induced renal injury.

Most feline nephroliths are composed of calcium salts, with calcium oxalate being the most common mineral type. Because nephroliths composed of calcium salts are generally not amenable to medical dissolution, surgical removal by nephrotomy or pyelolithotomy remains the most commonly used methods of managing nephroliths in cats. However, clinical observations suggest that nephrotomy may adversely affect renal morphology in cats with preexisting renal disease. Progressive reduction in kidney size was observed in a cat during a 3-year period following unilateral nephrotomy for removal of multiple calcium phosphate nephroliths. Although the contralateral nonoperated kidney contained a similar number of nephroliths, the nonoperated kidney did not change in size or morphology during the 3-year follow-up period. Unfortunately, renal function was not evaluated in this patient. There have been several short-term studies of the effect of nephrotomy on renal function in dogs. In one 2-day study and another 6-week study of nephrotomy in dogs, investigators observed a 15% to 50% decline in glomerular filtration rate (GFR), compared with presurgical values. In 2 subsequent studies, nephrotomy did not appear to adversely affect GFR in dogs during a 30- to 42-day postoperative observation period. Nephrotomy in humans with nephrolithiasis may be associated with significant declines in renal function. The decline in renal function following nephrotomy was believed to be the result of direct nephron damage; ischemic damage as a result of vascular occlusion; and alterations in nephron...
function as a result of inflammation, edema, neovascularization, fibrogenesis, and wound contraction. Partial recovery of renal function after nephrectomy was believed to be the result of subsiding healing processes, repair of some nephrons, and an increase in function (compensatory hypertrophy) of the surviving nephrons. In contrast to other species, the short- and long-term effects of nephrectomy on renal function in either clinically normal cats or cats with preexisting renal disease have not been investigated.

Although renal function may be assessed by a variety of methods, quantitative estimation of total GFR by urinary or plasma clearance methods is considered the best global indicator of renal function. Total GFR may be estimated by measuring plasma clearance of the radiopharmaceutical technetium 99m-diethylenetriaminepentaacetic acid (99mTc-DTPA). Plasma 99mTc-DTPA clearance has been shown to correlate well with the other methods of estimating total GFR in cats. A disadvantage of this and other plasma and urine clearance methods for estimating GFR is that these tests do not account for the differential contribution of each individual kidney to total GFR (ie, single-kidney GFR) can be determined noninvasively by quantitative 99mTc-DTPA renal scintigraphy. Alternatively, single-kidney GFR may be estimated by simultaneously performing quantitative renal scintigraphy and measuring total GFR by plasma clearance with a single IV bolus injection of 99mTc-DTPA. On the basis of clinical observations and results of studies in other species, we hypothesized that nephrectomy in clinically normal cats would adversely affect renal function. The specific aims of this study were to prospectively evaluate the effects of nephrectomy on renal function in clinically normal cats by use of 99mTc-DTPA renal scintigraphy and measure total GFR and 99mTc-DTPA renal scintigraphy to estimate relative single-kidney GFR, describe radiographic and ultrasonographic morphologic changes associated with nephrectomy in clinically normal cats, and identify clinical complications associated with nephrectomy in clinically normal cats.

Materials and Methods

Animals—Twenty specific-pathogen–free, healthy female mixed-breed cats between 9 and 11 months of age were acquired from a commercial vendor. The cats were routinely vaccinated and group housed in the University Laboratory Animal Resources facility for the first 16 weeks of the study. After the initial 16 weeks, 18 cats were placed in private homes for the duration of the study. Cats that were not adopted remained group housed in the university facility. All cats were fed the same dry commercial maintenance diet for the duration of the study. The Michigan State University All University Committee on Animal Use and Care approved this study.

Experimental protocol—Cats were randomly assigned to the following 2 groups: the nephrectomy group in which one of the cat’s kidneys underwent a nephrectomy surgical procedure and the sham group in which one of the cat’s kidneys underwent a procedure mimicking nephrectomy but without kidney incision and suturing. Once assigned to the nephrectomy or sham group, the right or left kidney within each cat was randomly assigned to receive the specified group treatment (treatment) or to remain a control (contralateral control). Clinical assessments and testing procedures were conducted for each cat and each kidney within a cat at each of the following 6 times: time 0 (before surgery) and at 3, 12, 26, 52, and 78 weeks after surgery.

Surgical procedures—One day after the preoperative scintigraphy, cats were premedicated with acepromazine (0.05 mg/kg, IM) and butorphanol (0.2 mg/kg, IM) and anesthetized with acepromazine (0.05 mg/kg, IM) and ketamine (9 mg/kg, IM). An orotracheal tube was placed, and anesthesia was maintained by means of 1% to 2% halothane in oxygen. All cats received 10 mL/kg/h of lactated Ringer’s solution during anesthesia. All surgical procedures were performed by the same surgeon (CB).

Using an aseptic surgical technique, a standard ventral midline celiotomy was performed. In cats in the nephrectomy group, 1 kidney was assigned by random selection to undergo a nephrectomy. The kidney was mobilized from its peritoneal attachment and the renal vessels digitally occluded by the assistant surgeon during the procedure. To access the renal pelvis, an incision was made in the renal capsule along the greater curvature of the kidney, extending not more than two thirds of the length between the cranial and caudal pole. The renal parenchyma was then bluntly dissected by use of a scalpel handle. The 2 halves of the kidney were spread apart by use of a hemostat to expose the renal pelvis. The renal pelvis was visually examined, explored with a hemostat, and flushed with sterile saline (0.9% NaCl) solution. The kidney was closed by manually apposing the 2 halves of the kidney for approximately 1 minute and by placing simple interrupted sutures of 5-0 polydioxanone in the renal capsule, avoiding the renal parenchyma. Total renal ischemia time averaged approximately 10 minutes for all the procedures, during which time the incision, renal pelvis inspection, and closure were completed. Hemorrhage was controlled by gentle digital pressure. The kidney was then placed back into its original position in the abdomen. No procedures were performed on the contralateral control kidney. A routine ovariohysterectomy was performed prior to closure.

In the sham group, 1 kidney was randomly selected to undergo a procedure mimicking nephrectomy without incision and suturing. The selected kidney was mobilized from its peritoneal attachment by the assistant surgeon who digitally occluded the renal artery and vein for approximately 10 minutes. The kidney was then placed back into its original position in the abdomen. No procedures were performed on the contralateral control kidney. A routine ovariohysterectomy was performed prior to closure.

After surgery, all cats received lactated Ringer’s solution IV (4 mL/kg/h) and buprenorphine (0.01 mg/kg, IM) every 8 hours for the first 24 hours following surgery. The cats were closely monitored during the first 10 days after surgery by means of daily physical examinations and assessment of records of food and water consumption.

Clinical evaluations—A physical examination, CBC determination, serum chemistry analysis, urinalysis, quantitative aerobic microbiologic culture of urine, renal ultrasonography, abdominal radiography, and single-kidney and total GFR determinations by use of renal scintigraphy and measurement of plasma disappearance of 99mTc-DTPA were performed before surgery and at 3, 12, 26, 52, and 78 weeks after surgery in each cat. Survey radiography and ultrasonography were used to evaluate renal morphologic changes associated with nephrectomy and sham nephrectomy procedures. Standard survey lateral and ventrodorsal abdominal radiographic views were obtained for each cat. The length of each kidney in each cat was measured along the longitudinal axis in the ventrodorsal radiographic view and expressed as a...
ratio of kidney length to length of the second lumbar vertebra as seen on the same radiograph. Renal ultrasonographic examination was performed by use of a 7.5-MHz linear transducer probe to evaluate renal morphology and measure kidney length. Longitudinal (sagittal) plane images of each kidney were made with the cat in lateral recumbency, and the length of the kidneys was measured in centimeters. The same radiologist (DSR) performed all ultrasonographic examinations and was masked as to the treatment of each cat.

Renal function was evaluated by estimating total and single-kidney GFRs for each cat at each of the 6 times. General anesthesia was used to facilitate placement of IV catheters and collection of urine and blood samples and to ensure that cats remained motionless during renal scintigraphy. For preoperative GFR studies, anesthesia was induced with isoﬂurane in oxygen as a single agent administered by mask. An orotracheal tube was placed, and anesthesia was maintained with isoﬂurane in oxygen. However, because many cats had varying degrees of muscular spasm and excitation during recovery from isoﬂurane alone, all cats were subsequently sedated with acepromazine (0.05 mg/kg, IM) and butorphanol (0.2 mg/kg, IM) prior to the induction of anesthesia with isoﬂurane for all follow-up evaluations. An IV catheter was placed in a cephalic vein for IV administration of fluids and 99mTc-DTPA. A central venous catheter was placed in either a jugular vein or a medial saphenous vein for blood collection. To ensure adequate hydration and support blood pressure during anesthesia, each cat received a volume of lactated Ringer’s solution IV that was equal to 3% of its body weight prior to clearance studies.

The relative contribution (%) of each individual kidney to total GFR was estimated by qualitative renal scintigraphy of anesthetized cats by use of a round, large, high-resolution parallel hole collimator coupled to a dedicated computer with nuclear imaging software. The camera positioned 7 centimeters under the patient and field-of-view gamma camera equipped with a low-energy, high-resolution parallel hole collimator coupled to a dedicated computer with nuclear imaging software. The camera was calibrated before each use with a Cobalt flood centered at the kidneys. Approximately 37 Mbq of 99mTc-DTPA (1 mCi in a volume of approx 1 mL saline solution) was administered by rapid IV injection through the cephalic catheter, followed by 2 mL of heparinized saline solution to flush the catheter. Radioactivity administered to each cat was calculated as the difference between dose activity before injection and residual syringe activity after injection, as measured in a well counter. Injection time (time 0) was recorded, and dynamic imaging was initiated simultaneously with the 99mTc-DTPA injection by use of the following protocol: 10 s/frame for 60 frames (10 minutes total) and a 128 × 128 matrix. Frame numbers 6 to 18 were summed into a static image to draw regions of interest (ROI) around each kidney. Background correction was performed. Individual kidney uptake was calculated by use of the full matrix and the following formula:

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\text{ROI} \times 100 / \text{radioactivity counts in both kidneys (sum of the 2 ROIs)}
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Total GFR was estimated by plasma clearance of 99mTc-DTPA. Three EDTA-anticoagulated blood samples were collected from the central venous catheter at 90, 120, and 180 minutes after 99mTc-DTPA injection. One hundred-microliter aliquots of each plasma sample were analyzed for radioactivity along with an equal aliquot of 99mTc-DTPA standard solution in a single-channel analyzer system attached to a sodium iodide well crystal. The standard solution was prepared by placing approximately 1 mCi of 99mTc-DTPA in a volumetric flask and adding distilled water to make a total volume of 1,000 mL. Activity of each sample was corrected for decay over time. Total GFR was estimated by constructing a 99mTc-DTPA plasma clearance curve by use of a single-exponential, 1-compartment mathematic model. Total GFR results were expressed as milliliter per minute per kilogram of body weight.

Quantitative single-kidney GFR (split kidney function) was estimated by use of the following formula: total GFR (obtained from the plasma clearance analysis)/100 × individual kidney percentage GFR (obtained from the qualitative renal scintigraphy).

Results

Of the 20 cats entering the study, 2 cats (1 from each group) did not complete the study. One nephroto-mycat died from trauma after being stuck by an automobile shortly after the 52-week evaluation. One sham-group cat was lost to follow-up when the adoptive owner declined further participation in the study.

With exception of the 2 cats eliminated from the study, there were no missing data values in the data set. Results of physical examinations, CBC determinations, and serum chemistry profiles were within reference range limits for all cats at all times. With the exception of 1 nephroto-mycat with cystocentesis-induced microscopic hematuria, results of presurgical urin-alysis were within reference range limits. In nephroto-mycats, microscopic hematuria was observed in 7 of 9 cats at postsurgery weeks 3, 12, 26, and 78 and in 8 of 9 cats at week 32. In the 1 nephroto-mycat, microscopic hematuria was observed in only 1 sham-group cat at 12 weeks after surgery and in 2 sham-group cats at 26...
weeks after surgery. Cultures for aerobic bacteria in urine from all cats were negative at all times.

Mean preoperative (time 0) total GFRs for the nephrotomy- and sham-group cats as estimated by plasma clearance of $^{99m}$Tc-DTPA were $3.5 \pm 0.4$ mL/min/kg and $3.5 \pm 0.3$ mL/min/kg, respectively. Mean total GFRs at the final measurement (time 78) for the nephrotomy and sham-group cats were $2.3 \pm 0.2$ mL/min/kg and $2.1 \pm 0.1$ mL/min/kg, respectively. No significant difference was found in mean total GFR between the nephrotomy and sham-group cats at any of the times assessed (time 0, $P = 0.69$; time 3, $P = 0.74$; time 12, $P = 0.48$; time 26, $P = 0.43$; time 52, $P = 0.43$; and time 78, $P = 0.13$; Figure 1). Similarly, repeated-measures, mixed-model analyses did not reveal any significant association between single-kidney GFR and group (both kidneys in nephrotomy-group cats vs both kidneys in sham-group cats) over time ($P = 0.81$; Table 1). However, a significant 34% and 40% decline was found in total GFR between the preoperative measurement (time 0) and final measurement (time 78) in both the nephrotomy- and sham-group cats, respectively ($P = 0.01$ and $P < 0.001$, respectively). Likewise, repeated-measures, mixed-model analyses revealed a significant overall association between single-kidney GFRs and time ($P < 0.001$).

A significant decrease in single-kidney GFR was identified in the nephrotomy kidneys, compared with their contralateral controls, over the 78-week study period (repeated-measures, mixed-model analyses, $P > 0.001$; Table 2; Figure 2). Mean pretreatment (time 0) single-kidney GFRs for the nephrotomy kidneys and their contralateral controls were $1.7 \pm 0.2$ mL/min/kg and $1.8 \pm 0.2$ mL/min/kg, respectively. Mean single-kidney GFRs at the final measurement (time 78) for the nephrotomy kidneys and their contralateral controls were $1.0 \pm 0.1$ mL/min/kg and $1.2 \pm 0.1$ mL/min/kg, respectively. Overall, this represented a 10% to 20% relative reduction in single-kidney GFR of nephrotomy kidneys, compared with their contralateral control kidneys. This relative reduction in single-kidney GFR was most evident at 26 ($P = 0.11$), 52 ($P = 0.02$), and 78 ($P = 0.10$) weeks after surgery. In contrast, no significant differences in mean single-kidney GFRs were identified over time for sham kidneys.
kidneys, compared with their contralateral controls (Figure 3), and nephrotomy kidneys, compared with sham kidneys (Figure 4). Mean single-kidney GFRs of nephrotomy contralateral controls were increased, compared with sham contralateral controls, at 26 (P = 0.10), 52 (P = 0.04), and 78 (P = 0.04) weeks after surgery (Figure 5).

Superimposition of the colon on kidneys precluded radiographic assessment of both renal silhouettes in the lateral or ventrodorsal view in 19 of 54 (35%) radiographs. However, mineralization of the renal pelvis was observed radiographically in 1 nephrotomized kidney at 78 weeks after surgery. No additional radiographic abnormalities were observed in any of the kidneys during the study period.

Ultrasonography did not reveal any significant differences in the length of individual kidneys at any of the times assessed (P ≥ 0.2). Morphologic changes in the kidneys observed by ultrasonography included mineralization and dilatation of renal pelves and hydronephrosis. Renal pelvis hyperechogenicity with distant shadowing, likely attributable to mineralization, was observed in 6 of 9 (67%) nephrotomized kidneys at postsurgery week 78. Renal pelvis hyperechogenicity was not observed in any of the control kidneys. Renal pelvis dilatation extending in the direction of the surgical approach was observed in 4 of 9 (44%) nephrotomized kidneys. Of these, 2 had mild, 1 had moderate, and 1 had severe renal pelvis dilatation. No abnormalities were observed in the contralateral kidneys of the nephrotomy- or sham-group cats.

It is also notable that severe unilateral hydronephrosis developed in 1 cat following nephrotomy. Ultrasonographic and scintigraphic findings consistent with obstruction were first observed in this cat 3 weeks after surgery; however, the cause of the obstruction was not evident. The hydronephrosis progressed over the next 12 months and was accompanied by a compensatory increase in renal size and single-kidney GFR in the contralateral kidney (data not shown). No changes in the results of blood and urine tests were noted, and the cat was clinically normal. Unfortunately, this cat died from trauma after being stuck by an automobile shortly after the 52-week evaluation; therefore, data from this cat were excluded from all statistical analyses.

Discussion
In both groups of cats, we observed a significant decline in total GFR over the study period. This decline was most evident between the preoperative and 3-week postoperative evaluations. A more gradual...
decline in total GFR was observed over the following 75 weeks. Because the magnitude of change was similar in both groups, factors other than nephrectomy are most likely responsible for the decline in total GFR over time. Factors that may influence GFR include renal injury, gender, advancing age, physiologic variables (eg, diet, hydration, posture, and exercise), and pharmacologic agents.30,31 Although GFR is most accurately estimated in unrestrained animals, the nature of the clearance technique used in our study required that cats remain motionless for a short time; thus, chemical restraint was necessary. Most sedatives and anesthetics are likely to affect GFR by altering renal blood flow or indirectly via changes in the cardiovascular activity, neuroendocrine activity, or both. No standardized anesthetic protocols exist for estimating GFR in cats. Previous studies of renal function in cats involved nonanesthetized animals13,20,31,33 or animals restrained by use of thiopental sodium,12 pentobarbital sodium,13,14 ketamine hydrochloride,15,25 halothane,25 tiletamine hydrochloride and zolazepam hydrochloride (telazol),26 or medetomidine hydrochloride and butorphanol tartrate administration.39 In our study, the first scintigraphic evaluation to estimate preoperative GFR was performed on cats anesthetized by use of isoflurane as a single agent to facilitate catheter placements, collection of samples, and restraint for scintigraphy. No chemical restraint was used during the subsequent 180-minute plasma clearance period. Because many cats had varying degrees of muscular spasm and excitation during recovery from isoflurane anesthesia, premedication with acepromazine and butorphanol was used in all subsequent studies. It is possible that the initial steep decline in total GFR was the result of renal injury induced by anesthesia, surgical procedures, or both. However, preoperative mean total GFRs for the nephrectomy-group cats (3.5 ± 0.4 mL/min/kg) and sham-group cats (3.5 ± 0.3 mL/min/kg) were substantially greater than GFRs estimated by plasma clearance of 125I-ic-DTPA reported in other studies30,32,33 of awake or anesthetized clinically normal adult cats (2.02 ± 0.27 mL/min/kg to 2.6 ± 0.72 mL/min/kg). Furthermore, values for follow-up total GFRs in both groups were well within the reported reference range for clinically normal adult cats.31,32,33 Interestingly, in a study of 20 humans anesthetized with isoflurane, nitrous oxide, lorazepam, and fentanyl, values for mean GFR, renal vascular resistance, and filtration fraction at 1 hour after anesthesia were 27% higher than preanesthesia values.40 This significant increase in postanesthesia GFR was attributed to persistently increased glomerular effluent arteriolar vasoconstriction induced by persistently elevated postanesthesia angiotensin II concentrations.30 Similar studies have not been performed in cats. However, it is possible that the gradual decline in total GFR may reflect a normal physiologic response to maturation. Alternatively, it is possible that progressive renal injury was induced by surgical procedures and repeated anesthetic events. Unfortunately, the long-term nature of our study and requirement that cats be adopted to private homes precluded postmortem light microscopic examination of operated and unoperated kidneys. Further studies are needed to investigate these hypotheses.

Nephrectomy resulted in a 10% to 20% relative reduction in single-kidney GFR, compared with contralateral control kidneys. Although single-kidney GFRs of nephrectomy kidneys were consistently lower than those of sham kidneys or sham contralateral control kidneys from 3 to 52 weeks after surgery, these differences were not significant. In contrast to differences in single-kidney GFRs between the nephrectomy kidney and its contralateral control, mean total GFR in nephrectomy-group cats remained similar to that of sham-operated control cats. This disparity most likely reflects the ability of the nonoperated contralateral kidney to undergo compensatory hypertrophy in response to the decreased GFR in the kidney subjected to nephrectomy.17,18,42 This would be consistent with the observation of increases in single-kidney GFR of nephrectomy contralateral control kidneys, compared with the sham nephrectomy contralateral control kidneys. Unlike previous studies11,13,15,43 in other species, we chose to incorporate sham-operated kidneys and their contralateral controls as additional controls. Lack of a demonstrable detrimental effect of nephrectomy on single-kidney GFR, compared with sham-operated kidneys or their contralateral controls, may reflect little or no compensatory response in kidneys of sham-operated cats or a sample size that is inadequate to detect small treatment effects (ie, type II statistical error).30 To our knowledge, there are no previously reported studies of the effects of nephrectomy on renal function in cats. Furthermore, it is difficult to directly compare the results of our study with those of previous studies in other species because of the diversity of surgical techniques, experimental designs, anesthetic protocols, methods of estimating GFR, and lengths of follow-up.41,13,15 Nevertheless, the magnitude of decline in single-kidney renal function observed in our study was within the range of those reported in most other studies. In short-term (9 weeks or less) studies30,13,15,44 of dogs, pigs, and baboons, unilateral nephrectomies closed with only capsular sutures resulted in 0% to
50% reductions in GFR in the operated kidney, compared with the nonoperated contralateral control kidney. In another study, nephrometries were performed on dogs that had previously undergone a unilateral nephrectomy. Nephrometry in the remaining hypertrophied kidneys resulted in a 27% decrease in single-kidney GFR at 3 weeks and a 24% decrease at 6 weeks after surgery, compared with prenephrometry values. However, in a recent study of bilateral nephrometries in dogs, an inexplicable 176% increase in total GFR was observed at 3 days after surgery, compared with presurgery values; no significant changes in total GFR were observed at 1, 2, and 4 weeks after surgery, compared with presurgery values.

Morphologic changes and adverse events associated with nephrometry observed in our study included persistent microscopic hematuria, renal pelvis hypechoegenicity with distant shadowing, dilatation of renal pelvis, and hydropnephrosis. In dogs, nephrometry has infrequently been associated with postoperative hematuria, renal mineralization, nephrolithiasis, supplicative pyelitis, and bacterial urinary tract infection. 

In our study, renal pelvis hypechoegenicity with distant shadowing was observed ultrasonographically in 67% of nephrometized kidneys. Although postmortem examinations were not performed, renal pelvis hypechoegenicity with distinct distant shadow may be associated with mineralization of renal parenchyma, mineralized blood clots in the renal pelvis, or nephroliths. The frequency of postnephrometry renal hypechoegenicity observed in our study was substantially higher than the frequency of dystrophic mineralization reported in short-term studies of dogs (0% to 17%). This disparity may be related to the longer duration of our study. Alternatively, the dynamics of wound healing and long-term tissue responses to renal injury in cats may differ from that of dogs. Interestingly, mineralization was a consistent light microscopic feature of renal biopsy sites in cats at 8 weeks after the procedure. Further characterization of healing responses to renal injury in cats and their long-term effects on renal function require additional investigation.

Dilatation of the renal pelvis was observed in 5 of 10 kidneys that underwent nephrometry. Renal pelvic dilatation most commonly occurs secondary to obstruction or infection. In 4 of 5 kidneys with dilatation, no evidence of obstruction or infection based on results of urinary analyses, bacteriologic urine cultures, ultrasonography, and qualitative renal scintigraphy was found. Renal pelvic dilatation in affected kidneys extended along the incision and was most likely the result of surgical separation of the renal parenchyma. Severe unilateral hydropnephrosis developed in 1 cat following nephrometry. Ultrasonographic and scintigraphic findings consistent with obstruction were first observed in this cat at the first (3-week) postoperative evaluation. Although the exact cause of the obstruction could not be identified, most likely a blood clot forming in the renal pelvis after surgery caused an outflow obstruction resulting in atrophy of functional renal parenchyma. Hydropnephrosis secondary to blood clot formation has been reported as an infrequent complication of renal biopsy in cats and dogs.

In conclusion, our findings suggest that nephrometry in a normal functioning feline kidney results in a modest relative reduction in single-kidney GFR in the operated kidney, compared with its contralateral nonoperated kidney, and a minimal effect on total GFR, compared with that of sham-operated control cats. However, we emphasize that the detrimental effects of nephrometry on renal function may be substantially magnified in cats with diseased kidneys, which may have little or no capacity for repair or compensation. Consequently, careful preoperative evaluation and postoperative monitoring are essential for cats undergoing nephrometry. Additional studies are required to evaluate adverse effects of nephrometry on renal function in cats affected with nephrolithiasis or other renal diseases.

References


