Respective associations between ureteral obstruction and renomegaly, urine specific gravity, and serum creatinine concentration in cats: 29 cases (2006–2013)

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Objective—To determine the respective associations between ureteral obstruction and renomegaly, urine specific gravity (USG), and serum creatinine concentration and to assess the reliability of abdominal palpation for detection of renomegaly in cats.

Design—Retrospective case series.

Animals—89 client-owned cats with (n = 29) or without ureteral obstruction and with (30) or without (30) kidney disease.

Procedures—Medical records of cats that underwent abdominal ultrasonography at a veterinary teaching hospital from January 2006 through April 2013 were reviewed. Cats were categorized as having ureteral obstruction (obstructed group) or no ureteral obstruction with (KD group) or without kidney disease (NKD group). Renomegaly and renal asymmetry were defined on the basis of mean renal length for NKD cats. Prevalence of renomegaly and renal asymmetry, mean USG and serum creatinine concentration, and abdominal palpation and ultrasonographic findings were compared among the groups.

Results—Renomegaly was identified in 2 obstructed cats and 1 KD cat and was not associated with ureteral obstruction. Renal asymmetry was detected in 18 obstructed cats and 11 KD cats. For obstructed and KD cats, the mean USG was significantly lower and the mean serum creatinine concentration was significantly greater than those for NKD cats. Twenty-eight of 29 cats with ureteral obstruction had hypercreatininemia. Abdominal palpation was not a reliable method for detection of renomegaly.

Conclusions and Clinical Relevance—Results indicated renomegaly was not associated with ureteral obstruction in cats, and abdominal palpation was an unreliable method for detection of renomegaly. The most consistent abnormal finding for cats with ureteral obstruction was hypercreatininemia. (*J Am Vet Med Assoc* 2015;247:518–524)

Ureteral obstruction in cats is an increasingly recognized problem in clinical practice. The first case series[1] of cats with ureteroliths was published in 1998. Since then, the apparent prevalence of the condition has escalated because of advancements in knowledge and diagnostic imaging options such as ultrasound, which are more readily available to general practitioners.[2,3] In cats, most ureteral obstructions are secondary to calcium oxalate uroliths, but can also be caused by tumors, strictures, iatrogenic ligation, blood clots, and dried solidified blood calculi.[4–7] In dogs in which ureteral obstruction was experimentally induced, the duration of obstruction was positively associated with permanent damage to the urinary tract; glomerular filtration rate was decreased by 35% after 7 days of obstruction and 54% after 14 days of obstruction.[8] The dogs used in that study[8] did not have preexisting kidney or ureteral disease; therefore, a worse outcome should be expected for dogs or cats with preexisting kidney disease. Similar studies conducted to investigate the renal response to experimental ureteral obstruction in cats are lacking. The extent of residual renal damage subsequent to ureteral obstruction is an important determinant for long-term survival following removal of the obstruction.[9] Thus, early identification and rapid resolution of ureteral obstruction are likely to be beneficial for survival. Unfortunately, patients with ureteral obstruction frequently have no or nonspecific clinical signs such as lethargy, hyporexia, and weight loss, and clinical signs such as vomiting, polyuria, and polydipsia may only develop secondary to uremia.[1–5] Abnormalities identified during physical examination of patients with ureteral obstruction may include pyrexia and signs of pain or unilateral or bilateral renomegaly during abdominal palpation. However, those abnormalities are not always present, and practitioners may incorrectly rule out ure-

Abbreviation

USG	Urine specific gravity

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teral obstruction in their absence. Although renomegaly is not a well-defined concept, it refers to an abnormally enlarged kidney. Results of a study[10] published in 1987 in which the kidneys of healthy cats were evaluated ultrasonographically suggest that a clinically normal feline kidney should measure from 3.0 to 4.3 cm in length.[10] Given the improvements in ultrasound technology and axial resolution that have been developed since that study[10] was conducted, it is likely that reference interval is outdated. The primary objectives of the study reported here were to describe the association between renomegaly and ureteral obstruction and to determine whether abdominal palpation is a reliable method for detection of renomegaly. The secondary objective was to evaluate USG and serum creatinine concentration in cats with ureteral obstruction.

Materials and Methods

Case selection—Medical records of cats that underwent abdominal ultrasonography at the Faculty of Veterinary Medicine of the University of Montreal, Department of Clinical Sciences, between January 2006 and April 2013 were reviewed. Cats were categorized into 3 groups (cats with ureteral obstruction [obstructed], and cats without ureteral obstruction with [KD] and without kidney disease [NKD]) for analysis purposes. Cats were included in the study if USG and serum creatinine concentration were determined within 48 hours before or after the ultrasonographic examination. Cats were excluded from the study if high-quality transverse and longitudinal ultrasonographic images of both kidneys were unavailable or a concurrent urethral obstruction was diagnosed on the basis of physical or radiographic examination results.

During review of the ultrasonographic findings, a ureteral obstruction was defined as a renal pelvic width > 2 mm[11,12] associated with a dilated ureter proximal to the site of the obstruction regardless of whether the cause of the obstruction was identified. A dilated ureter was identified as an anechoic to echogenic tubular structure.[13] The cause of the obstruction was recorded when it could be identified. A ureteral calculus was defined as a hyperechoic interface that cast an acoustic shadow. A ureteral stricture was defined as an abrupt narrowing or tapering of the ureteral lumen and lack of a visible intraluminal echogenic structure accompanied by distention of the renal pelvis and ureter proximal to the stricture, which distinguished a stricture from normal ureteral peristalsis.

Cats without evidence of ureteral obstruction were categorized as either having or not having kidney disease, and the first 30 cats within each category that met the inclusion criteria were selected to serve as controls for comparison with the cats with ureteral obstruction. Cats with a USG ≤ 1.035 and serum creatinine concentration ≥ 140 mmol/L were classified as having kidney disease, whereas those without abnormal renal ultrasonographic findings (ie, absence of an irregular renal outline, cavitary lesions, solid masses or nodules, segmental or triangular lesions, nephroliths, and medullary rim signs) and with a USG > 1.035 and serum creatine concentration < 140 mmol/L were classified as not having kidney disease.

Medical records review—For each cat enrolled in the study, information extracted from the medical record included identification, signalment, body weight, whether the patient received IV fluids prior to ultrasonographic evaluation, serum creatinine concentration, USG, and physical examination and abdominal palpation results. Asymmetric kidney size on palpation was recorded for any cat in which a size difference was noted between the right and left kidneys during abdominal palpation.

Abdominal ultrasonographic images were reviewed by a board-certified veterinary radiologist (PP). The ultrasound images were obtained by different board-certified veterinary sonographers with the same device. All patients were positioned in dorsal recumbency, the hair was clipped from the ventral aspect of the abdomen, and scanning was performed with a 5- or 8-MHz curvilinear transducer[a] with the aid of acoustic gel. For patients that underwent multiple abdominal ultrasonographic examinations, the only images assessed were those that were obtained at the time ureteral obstruction was diagnosed.

For each kidney, the length, width, and height were measured at the central level of the renal pelvis to ensure that the image was not obtained from an oblique scan. Renal length was measured on longitudinal images, whereas the renal width and height were measured on transverse images obtained at the central level of the renal pelvis as described.[14] For each cat, the respective differences in length, width, and height between the right and left kidneys were calculated. The difference in renal length was calculated as follows: |(length of left kidney – length of right kidney)|/ length of the shortest kidney × 100.

Additional ultrasonographic findings that were recorded included renal contours (regular or irregular); echogenicity of the renal cortex (normal or increased); quality of corticomedullary distinction (good, moderate, or poor); whether diverticular mineralization, hyperechoic perirenal tissue, and retroperitoneal effusion were present or absent; renal pelvic width (in millimeters); site of ureteral obstruction (proximal, middle, or distal third of the ureter); ureteral lumen width proximal to the obstruction (in millimeters); appearance of the cause of the obstruction (hyperechoic structure that cast an acoustic shadow consistent with ureterolith, focal narrowing of the ureteral lumen with no intraluminal cause identified consistent with a stricture, or other undefined cause); and appearance of urine in the pelvis of the kidney with the obstructed ureter (anechoic or nonanechoic).

Criteria for renomegaly and asymmetry—For cats in the NKD group, the mean renal length, width, and height were 3.95 cm (range, 3.1 to 5.1 cm), 2.75 cm (range, 2.2 to 3.1 cm), and 2.3 cm (range, 1.6 to 3.3 cm), respectively, and the maximum percentage differences in length, width, and height between the right and left kidneys of an individual cat were 13%, 33.3%, and 35%, respectively. Consequently, renal length appeared to be the most reliable measurement within an individual patient and was used as the criterion for renomegaly, which was defined as a kidney with a length > 5.1 cm, the maximum renal length for cats in the NKD group. Renal asymmetry was defined as the percentage difference between the length of the right and the left kidneys; renal asymmetry < 13% was considered physiologic asymmetry associated with normal anatomic variation, whereas renal asymmetry ≥ 13% was considered pathological asymmetry.

Statistical analysis—Outcomes of interest included age, body weight, sex, whether the patient received fluid therapy prior to ultrasonographic examination, extent of renal asymmetry, renal length, and serum creatinine concentration. The distributions of continuous outcomes were assessed for normality by means of the Anderson-Darling test. With a sample size of approximately 30 subjects/group, sample means follow the normal distribution regardless of whether normality prevails in the samples themselves. Analysis of variance followed by Tukey post hoc analysis was used to compare the mean age and weight among the cats in the 3 groups (obstructed, KD, and NKD). Exact χ^2 tests were used to evaluate the respective associations between group and categorical outcomes such as sex, use of fluid therapy (yes or no), and extent of renal asymmetry (< 13% or ≥ 13%). Linear regression models were used to assess the respective relationships between the length of each kidney and body weight for cats in the NKD group. A Fisher exact test was used to evaluate the association between renomegaly and ureteral obstruction. For cats in the NKD group and cats in the obstructed group that had bilateral ureteral obstruction, a kidney was randomly selected for the analysis.

The mean renal length, maximum difference in length between the right and left kidney, and mean serum creatinine concentration were compared among the 3 groups by the use of ANOVA that accounted for unequal variances among groups, followed by Tukey post hoc analysis. The analysis for mean renal length was performed for both the unobstructed and obstructed kidneys of cats in the obstructed group. For the unobstructed analysis, 1 kidney was randomly selected for analysis from each cat in the KD and NKD groups, and the unobstructed kidney was analyzed for cats in the obstructed group. The obstructed analysis was performed in the same manner, except the obstructed kidney was analyzed for cats in the obstructed group. Additionally, the length of the obstructed kidney was compared with that of the unobstructed (contralateral) kidney for each cat in the obstructed group by use of a paired *t* test; cats with bilateral ureteral obstruction were excluded from that analysis. Also, the mean serum creatinine concentration for cats in the obstructed group was compared with that for the cats in the KD and NKD groups combined by use of an unequal-variances *t* test. All analyses were performed with commercially available statistical software,[b] and values of $P < 0.05$ were considered significant.

Results

Cats—Review of the medical records revealed that ureteral obstruction was diagnosed in 36 cats, of which 29 met the inclusion criteria for the study. Thus, the obstructed group consisted of 29 cats and included 14 spayed females, 1 sexually intact female, 13 neutered males, and 1 sexually intact male. Breeds represented in this group included domestic shorthair (n = 19), Siamese (5), and Himalayan, Persian, Ragdoll, Scottish Fold, and Tonkinese (1 each). Nineteen (65%) of those cats had unilateral ureteral obstruction, and the remaining 10 (35%) cats had bilateral ureteral obstruction.

The 30 cats in the KD group included 11 spayed females, 3 sexually intact females, and 16 neutered males. Breeds represented in this group included domestic shorthair (n = 24), Siamese (2), and Abyssinian, Manx, Persian, and Sphinx (1 each).

The 30 cats in the NKD group included 13 spayed females, 16 neutered males, and 1 sexually intact male. Breeds represented in this group included domestic shorthair (n = 23), Bengal (2), British Shorthair (2), and Angora Turk, Himalayan, and Maine Coon (1 each). Other select descriptive and renal variables for the study cats were summarized (**Table 1**).

Cats in the KD group were significantly older than the cats in the obstructed and NKD groups. The sex distribution ($P = 0.83$) and mean body weight ($P = 0.82$) did not differ significantly among the 3 groups. The number of cats that received fluid therapy in the obstructed group was significantly ($P = 0.010$) greater than the number of cats that received fluid therapy in the KD and NKD groups.

Renal measurements and characteristics—Linear regression results indicated that the renal length of

Table 1—Select descriptive and renal variables for cats with ureteral obstruction (obstructed; n = 29) and cats without ureteral obstruction with (KD; 30) and without (NKD; 30) kidney disease.

	Group		
Variable	**Obstructed**	**KD**	**NKD**
Age (y)	6.1 (1–15)[a]	10 (3–14)[b]	6.6 (1–14)[a]
Body weight (kg)	4.6 (2.7–9.0)	4.6 (2.19–9.0)	4.8 (1.8–11.7)
Received fluid therapy (No.)	18[a]	8[b]	9[b]
Renal length (cm)	4.03 (1.6–7.0)	3.7 (1.9–5.7)	3.95 (3.1–5.1)
Renomegaly (No. of kidneys)*	2	1	0
Renal asymmetry (No.)†	18[a]	11[a]	0[b]
USG	1.022 (1.008–1.041)[a]	1.017 (1.008–1.031)[a]	1.049 (1.035–1.060)[b]
Serum creatinine (mmol/L)	561 (87–2,321)[a]	301 (145–841)[a]	117.3 (70–139)[b]

Values represent the mean (range) unless otherwise specified.
*Renal length > 5.1 cm. †A difference in length ≥ 13% between the right and left kidneys.
[a,b]Within a row, values with different superscripts differ significantly ($P < 0.05$).

both the right and left kidneys was positively associated with body weight, and body weight explained 42% to 48% of the variation in renal length. For the 19 cats with unilateral ureteral obstruction, the mean length of the kidneys on the unobstructed (contralateral) sides was 3.65 cm (range, 1.6 to 5 cm), which did not differ significantly ($P = 0.15$) from the mean renal length for the cats in the KD and NKD groups. The mean length of the kidneys on the obstructed sides for the cats in the obstructed group was 4.26 cm (range, 1.7 to 7.0 cm), which was significantly ($P = 0.04$) greater than the mean renal length for the cats in the KD and NKD groups. The length was < 3.1 cm for 1 kidney on an obstructed side, 4 kidneys on contralateral sides, and 10 kidneys of cats in the KD group.

Renomegaly (renal length > 5.1 cm) was detected in 1 kidney in a cat in the KD group. For cats in the obstructed group, renomegaly was detected in the kidney on an obstructed side in 2 cats (Table 1); 1 cat had unilateral ureteral obstruction, and the other had bilateral ureteral obstruction. Renomegaly was not significantly ($P = 0.61$) associated with ureteral obstruction.

Renal asymmetry (≥ 13% difference in length between the right and left kidneys) was detected in 18 of the 29 (62%) cats in the obstructed group and 11 of the 30 (36.7%) cats in the KD group. The number of cats with renal asymmetry did not differ significantly ($P = 0.070$) between the obstructed and KD groups. Similarly, the mean extent of renal asymmetry for cats in the obstructed group (36%; range, 0% to 194%) did not differ significantly ($P = 0.21$) from that for cats in the KD group (19.6%; range, 0% to 105%).

Ultrasonographic characteristics of ureteral obstructions—Ultrasonographic characteristics of the upper urinary tract of cats in the obstructed and KD groups were summarized **(Table 2)**. Of the 39 ureteral obstructions, 17 (43.6%) were located in proximal third of the ureter, 5 (12.8%) were located in the middle third of the ureter, and 17 were located in the distal third of the ureter. The mean ureteral width proximal to the obstruction was 4.35 mm (range, 2 to 11 mm). Twenty-eight of the 39 (71.8%) obstructed ureters contained a hyperechoic structure that cast an acoustic shadow at the obstruction site and was consistent with a ureterolith, and 5 (12.8%) obstructed ureters had hyperechoic tissue evidence of a stricture. The cause of the obstruction was undefined for the remaining 6 (15.4%) ureters. The urine within the kidneys with the obstructed ureters had an echogenic or anechoic appearance in 14 (35.9%) and 25 (64.1%) kidneys, respectively.

In 12 of 19 cats with unilateral ureteral obstruction, the length of the kidney with the obstructed ureter was greater than the length of the contralateral kidney, with a mean difference of 0.6 cm (range, 0 to 3.25 cm). In the 7 remaining cats with unilateral ureteral obstruction, the length of the kidney with the obstructed ureter was less than or equal to the length of the contralateral kidney **(Figure 1)**. However, the mean length for the kidneys with the obstructed ureters did not differ significantly ($P = 0.09$) from the mean length for the contralateral kidneys.

Eleven of the 19 cats with unilateral ureteral obstruction had renal asymmetry. The kidney with the obstructed ureter was larger than the contralateral kidney for 9 of those cats and smaller than the contralateral kidney for the other 2 cats. The remaining 8 cats with unilateral ureteral obstruction did not have renal asymmetry.

Abdominal palpation—Abdominal palpation results were available for review for all cats. The recorded results indicated that 18 of 178 kidneys palpated were enlarged, and 12 of 89 were determined to have renal asymmetry. When the ultrasonographic findings were used as the gold standard, 3 of 178 kidneys were enlarged, and 29 of 89 were determined to have renal asymmetry. Abdominal palpation results were consistent with ultrasonographic findings in 1 cat with renomegaly and in 8 cats with renal asymmetry. Sensitivity and specificity of abdominal palpation for diagnosis of renomegaly were 33.3% (1/3) and 90.3% (158/175), respectively, and the associated positive and negative predictive values were 5.6% (1/18) and 98.8% (158/160), respectively. Sensitivity and specificity of abdominal palpation for the diagnosis of asymmetric kidneys were 27.6% (8/29) and 93.3% (56/60), respectively, and the associated positive and negative predictive values were 66.7% (8/12) and 72.7% (56/77), respectively.

Table 2—Ultrasonographic characteristics of the upper urinary tract for cats with ureteral obstruction (obstructed; n = 29) and cats with kidney disease without ureteral obstruction (KD; 30).

Characteristic	Obstructed group*: Side with obstructed ureter	Obstructed group*: Contralateral side	KD group†
Renal length (cm)	4.26 (1.7–7.0)	3.65 (1.6–5.0)	3.7 (1.9–5.7)
Corticomedullary distinction			
Good	5 (12.8)	8 (42.1)	5 (8.3)
Moderate	16 (41.0)	9 (47.4)	25 (41.7)
Poor	18 (46.2)	2 (10.5)	30 (50.0)
Irregular kidney contours	25 (64.1)	6 (31.6)	36 (60.0)
Hyperechoic perirenal fat	19 (48.7)	0 (0.0)	6 (10.0)
Retroperitoneal effusion	7 (17.9)	2 (10.5)	2 (3)
Diverticula mineralization	21 (53.8)	9 (47.4)	25 (41.7)
Renal pelvic width (mm)	11.3 (3–40)	1.3 (0–5)	0.94 (0–4.7)

Values represent the mean (range) or number (%) of sides affected.

*Nineteen cats had unilateral ureteral obstruction, and 10 cats had bilateral ureteral obstruction; therefore, 39 obstructed ureters and 19 unobstructed (contralateral) ureters were evaluated along with the accompanying kidneys. †Sixty ureters and their accompanying kidneys were evaluated.

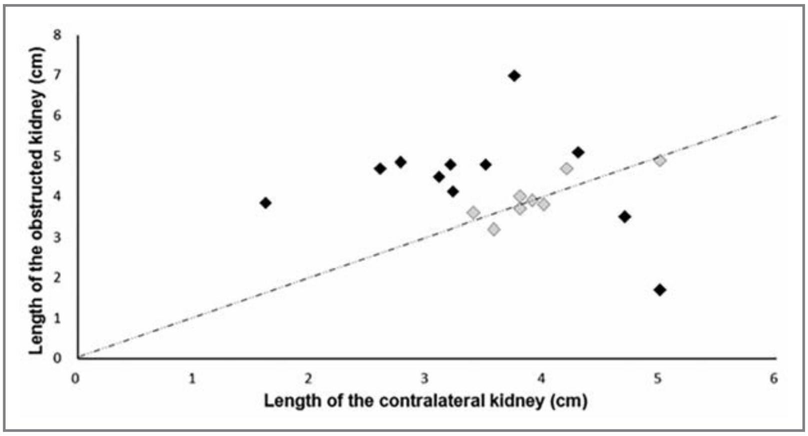

Figure 1—Scatterplot of the length of the kidney with the obstructed ureter (ie, obstructed kidney) versus the length of the contralateral kidney for 19 cats with unilateral ureteral obstruction. Each diamond represents an individual cat; gray diamonds represent cats with a physiologic difference (< 13%) in length between the obstructed and contralateral kidneys, and black diamonds represent cats with a pathological difference (≥ 13%; renal asymmetry) in length between the obstructed and contralateral kidneys. The dashed line represents the identity line (ie, y = x). Notice that in the majority (9/11) of cats with renal asymmetry, the obstructed kidney was longer (ie, larger) than the contralateral kidney. Renal length was measured during review of ultrasonographic images.

USG and serum creatinine concentration—The median USG and serum creatinine concentration for all 3 groups of cats were summarized (Table 1). The reference range for USG was 1.035 to 1.060. The reference range for serum creatinine concentration was 51 to 140 mmol/L, and hypercreatininemia was defined as a serum creatinine concentration > 140 mmol/L. In the obstructed group, only 4 cats had a USG > 1.035 in conjunction with hypercreatininemia (serum creatinine concentrations for those 4 cats were 145, 176, 183, and 221 mmol/L, respectively). The median serum creatinine concentration for cats with bilateral ureteral obstruction (1,078 mmol/L; range, 160 to 2,321 mmol/L) was significantly ($P = 0.008$) greater than that for cats with unilateral ureteral obstruction (311 mmol/L; range, 87 to 1,326 mmol/L). All 10 cats with bilateral ureteral obstruction and 18 of 19 cats with unilateral ureteral obstruction had hypercreatininemia.

Discussion

Results of the present study indicated that renomegaly (renal length > 5.1 cm) was not significantly associated with ureteral obstruction in cats, and renal asymmetry (> 13% difference in length between the right and left kidneys) was not pathognomic for ureteral obstruction, although 11 of 19 cats with unilateral ureteral obstruction and 7 of 10 cats with bilateral ureteral obstruction did have renal asymmetry. Results also suggested that abdominal palpation was an unreliable method for detection of renomegaly and ureteral obstruction in cats. Cats with ureteral obstruction generally had a lower USG and higher serum creatinine concentration, compared with those of cats without kidney disease.

The range for the renal length (3.1 to 5.1 cm) for cats without kidney disease (NKD group) in the present study was broader than that (3.0 to 4.3 cm) reported for 10 healthy young adult cats (5 male and 5 female) in another study.[10] In both studies, the renal length was measured ultrasonographically by use of a 5- or 8-MHz curvilinear transducer. However, the body weight range (1.8 to 11.7 kg [4 to 25.7 lb]) for the cats in the NKD group was also broader than that (2.04 to 4.99 kg [4.5 to 11 lb]) for the cats in that other study,[10] and results of the present study indicated that body weight was positively associated with renal length, accounting for 42% to 48% of the variation in renal length. Results of a study[15] involving healthy Ragdolls likewise indicated a strong positive correlation ($r = 0.71$; $P < 0.001$) between body weight and renal length. These data suggest that the reference ranges for clinically normal feline kidneys should be redefined as a function of body weight in a prospective manner.

In the present study, the percentage difference between the right and left kidneys of individual patients was lowest for renal length, when compared with those for renal width and height. Therefore, renal length was selected as the key indicator for renomegaly. Investigators of another study[16] reported that the ellipsoid formula commonly used in human patients to estimate renal volume from ultrasonographic images underestimated renal volume by 15% to 28%, compared with that estimated by the disc summation used for MRI images, and underestimated true kidney volume by 20%. In cats, use of the prolate ellipsoid formula to estimate renal volume from ultrasonographic images likewise resulted in proportional bias, and the median percentage that renal volume was underestimated was 18.9%.[17] Other findings of that study[17] indicate that ultrasonographic measurement of renal length accounted for approximately 87% of the variability in renal volume, which suggests that renal length correlated well with renal volume. Consequently, in the present study, a renal length > 5.1 cm (the maximum renal length measured for cats in the NKD group) was used to define renomegaly instead of renal volume. Because the percentage difference in length between the right and left kidneys of the cats in the NKD group varied by as much as 13%, we defined pathological renal asymmetry as a ≥ 13% difference in length between the right and left kidneys.

Cats with ureteral obstruction often have renomegaly or renal asymmetry.[18] In the present study, only 2 cats with ureteral obstruction had renomegaly, and renomegaly was not significantly associated with ureteral obstruction. Consequently, renomegaly should not be used as a criterion for diagnosis of ureteral obstruction in cats. To our knowledge, this was a novel finding. In fact, 1 kidney with an obstructed ureter was < 3.1 cm in length, which suggested that degenerative kidneys may also develop an obstructed ureter. Of the 19 cats with unilateral ureteral obstruction, 11 also had renal asymmetry. Although the kidney with the obstructed ureter was larger than the contralateral kidney in 9 of those cats, it was smaller than the contralateral kidney in 2 cats. Thus, renal asymmetry is not pathognomic for ureteral obstruction, and kidneys with obstructed ureters do not necessarily increase in size.

In 4 of the 19 cats with unilateral ureteral obstruction, the length of the contralateral kidney was < 3.1 cm (the minimum renal length recorded for cats in the NKD group). Ten of 30 cats in the KD group also had at least 1 kidney with a length < 3.1 cm. In a study[5] involving 70 cats with unilateral ureteroliths, the contralateral kidney was subjectively assessed as abnormally small in 39 (56%), clinically normal in 27 (39%), and abnormally large in 4 (6%).

In the present study, the negative predictive value of abdominal palpation for detection of renomegaly was 98.8%, but renomegaly was not significantly associated with ureteral obstruction. Therefore, the sole use of abdominal palpation for diagnosis of ureteral obstruction is not recommended. Moreover, the positive and negative predictive values calculated in the present study should be interpreted with caution because predictive values are extremely sensitive to the prevalence of the condition being assessed. Because of the study design, the prevalence of ureteral obstruction in this particular study population was 33% (29/89), which is much higher than that expected in the general population of cats.

Of the 29 cats with ureteral obstruction, 28 were hypercreatininemic (serum creatinine concentration > 140 mmol/L). The hypercreatininemia was not characterized as prerenal because the USG was < 1.035 in 25 of those cats. In 4 of the 19 cats with unilateral ureteral obstruction, results of the ultrasonographic evaluation indicated that the contralateral kidney was abnormally small with some degenerative changes (moderate to poor corticomedullary distinction or irregular kidney contours). Those findings suggested that cats with ureteral obstruction commonly have concurrent renal parenchymal disease. It is possible that renal fibrosis and hydronephrotic atrophy develop subsequent to prolonged or complete ureteral obstruction but might not develop or may be less severe in cats in which the ureteral obstruction resolves quickly or is incomplete. Therefore, kidneys associated with obstructed ureters may have normal or impaired function when the obstruction is resolved. Recurrent unilateral ureteral obstruction might cause progressive damage to the associated kidney and compensatory hypertrophy of the contralateral kidney, resulting in renal asymmetry.[19] Following ureteral obstruction, acute uremia develops, and its severity is dependent on the extent of the ureteral obstruction (ie, partial or complete) and the function of the contralateral kidney. Alternatively, ureteral obstruction may be secondary to kidney disease. Obstructed ureters associated with abnormally small kidneys support that theory because nephrons lost during chronic kidney disease are generally replaced by fibrosis.[20,21] Hence, one kidney may become smaller because of fibrosis, whereas the other kidney may become enlarged from changes associated with trying to compensate for the diseased kidney. In the present study, ureteroliths were determined to be the primary cause of obstruction in 28 of 39 (71.8%) obstructed ureters. In cats, chronic kidney disease is associated with the presence of uroliths.[c] The lack of renomegaly in some cats with ureteral obstruction might be the result of fibrosis of the renal parenchyma and capsule; the lack of compliance of fibrotic tissue prevents the kidney from increasing in size despite severe dilation of the renal pelvis and increased pressure in the renal urine-collecting system.

The present study had several limitations such as the small study population and its retrospective nature. Physical examinations were performed by several veterinarians, and although the ultrasound images were reviewed by only 1 board-certified veterinary radiologist, the ultrasonographic examinations were performed by several sonographers. The number of cats in the obstructed group that received fluid therapy prior to the ultrasonographic examination was significantly greater than the number of cats that received fluid therapy in the other 2 groups. The mean pelvic width of dogs receiving IV fluid therapy is significantly greater than that in dogs with normal renal function not receiving IV fluid therapy,[14] and this is likely true for cats as well. Body weight varied substantially among the study cats. Because there is a strong positive correlation between body weight and renal length,[17] we used the maximum renal length measured for cats in the NKD group (5.1 cm) as the cutoff for determining renomegaly. It is possible that that cutoff was too high to reliably detect renomegaly in smaller patients, and the prevalence of renomegaly might have been underestimated in those patients. It is possible that cats with primary renal pathology (eg, lymphoma) were included in the NKD group if their renal abnormalities were not identified on the ultrasonographic images, USG was > 1.035, and serum creatinine concentration was < 140 mmol/L. Histologic evaluation of renal biopsy or necropsy specimens would have been necessary to definitively rule out renal pathology for the cats in the NKD group; however, such information was unavailable. Finally, the USG and serum creatinine concentration for each individual cat were determined within 48 hours of, instead of concurrently with, the ultrasonographic examination. Fluid therapy administration for 48 hours could certainly have affected USG and serum creatinine concentration, which may have caused misclassification of some cats, particularly between the KD and NKD groups.

Findings of the present study indicated that, in cats, renomegaly was not significantly associated with ureteral obstruction and abdominal palpation was an unreliable method for detection of renomegaly and ureteral obstruction. Although 11 of 19 cats with unilateral ureteral obstruction had renal asymmetry, the presence or absence of renal asymmetry could not be used to definitively rule out ureteral obstruction. Twenty-eight of 29 cats with ureteral obstruction had hypercreatininemia, as did most of the cats with kidney disease. The mean serum creatinine concentration for cats with bilateral ureteral obstruction was significantly greater than that for cats with unilateral ureteral obstruction. Thus, serum creatinine concentration, although nonspecific, was a better indicator than abdominal palpation for detection of ureteral obstruction in cats.

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Correction: Comparison of peak flow velocity through the left ventricular outflow tract and effective orifice area indexed to body surface area in Golden Retriever puppies to predict development of subaortic stenosis in adult dogs

In the report "Comparison of peak flow velocity through the left ventricular outflow tract and effective orifice area indexed to body surface area in Golden Retriever puppies to predict development of subaortic stenosis in adult dogs" (*J Am Vet Med Assoc* 204;245:1367–1374), incorrect values were inadvertently included in the last 2 sentences of the second paragraph in the Discussion section.

Those sentences should read as follows: "Eight of 16 dogs could have been classified as affected (EOAi < 1.46 cm^2/m^2) but only 7 of 22 (32%) as unaffected (EOAi > 2.48 cm^2/m^2) on the basis of EOAi alone. The remaining 8 puppies with SAS and 15 unaffected puppies would have been classified as equivocal on the basis of EOAi alone."