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Comparison of cystocentesis versus home sampling to determine urinary protein: Creatinine ratio and urine specific gravity in cats

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Abstract

Background: Urinalysis is necessary for the diagnostic evaluation of chronic kidney disease in cats. Performing cystocentesis is not always feasible, but data comparing urine obtained by cystocentesis in the clinic with voided samples collected at home are lacking in cats.

Objectives: To compare urinary protein:creatinine ratio (UPC) and urine specific gravity (USG) and to detect clinically relevant changes in proteinuria substage or urine concentration between urine collected at home and in-clinic by cystocentesis in cats.

Animals: Ninety-two healthy and diseased client-owned cats.

Methods: Prospective study. Owners collected voided urine at home and within 1 to 15 hours, cystocentesis was performed in the clinic.

Results: In a subset of motivated owners, 55% succeeded in collecting urine at home. Overall, UPC was higher (mean ±SD difference = 0.09 ±0.22; $P < .001$) and USG was lower (mean ±SD difference = −0.006 ±0.009; $P < .001$) in cystocentesis samples than in voided urine. Substantial agreement existed between sampling methods for UPC (weighted $\kappa = 0.68$) and USG ($\kappa = 0.64$) categories. A different proteinuria substage (UPC < 0.2, 0.2-0.4, >0.4) was present in paired urine samples from 28% of cats. In 18% of cats, urine concentrating ability (USG < or ≥1.035) differed between both samples.

Conclusions and Clinical Importance: Home sampling of urine is a valid alternative to cystocentesis in cats. However, because clinically relevant differences in UPC and USG were present in 28% and 18% of cats, respectively, by the same collection method for monitoring each cat is advised.

KEYWORDS
feline, kidney disease, proteinuria, urine collection method, voided

Abbreviations: CKD, chronic kidney disease; IRIS, International Renal Interest Society; UP, urinary protein concentration; UC, urinary creatinine concentration; UPC, urinary protein:creatinine ratio; USG, urine specific gravity.

1 | INTRODUCTION

The urinary protein:creatinine ratio (UPC) and urine specific gravity (USG) are essential in the diagnostic evaluation of chronic kidney disease (CKD) in cats. According to International Renal Interest Society (IRIS) guidelines, persistent renal proteinuria or inadequate urine concentrating ability (USG < 1.035) could indicate the presence of CKD, even in nonazotemic cats (CKD stage 1 or early stage 2).[1,2] Once CKD is diagnosed, the proteinuria substage is 1 of the factors that determine the prognosis, which is worse for cats with borderline (UPC 0.2-0.4) and overt (UPC > 0.4) proteinuria compared to nonproteinuric cats (UPC < 0.2),[3,4] and there is a need for directed treatment if UPC > 0.4.[1,5] Despite urinalysis being necessary for diagnosing and staging renal disease, a survey of cat owners in the United States showed that a urinalysis had never been performed in 245/1083 (23%) of cats diagnosed with CKD.[6] A similar study in the United Kingdom showed that CKD was diagnosed based on blood tests alone in 312/859 (36%) of cats.[7] When urine is collected from cats, cystocentesis often is performed because it is the best way to ensure a fresh sample without bacterial contamination from the urethra, genital tract, skin, or hair.[8,9] However, the procedure can cause transient (microscopic) hematuria, influencing urinalysis results.[9] Furthermore, transportation of the cat to the clinic[10] and manipulation during cystocentesis may cause stress.[8] Lastly, cystocentesis is not feasible in some cats because of their behavior or poor bladder filling. In these situations, owners may prefer to collect urine at home, improving client compliance for follow-up.

Studies in dogs have reported a strong correlation between UPC results in cystocentesis and voided urine, but voided samples could be taken at the hospital as well, thus eliminating the potential influence of environment.[11,12] Another study in dogs found no significant difference in UPC between samples taken in-hospital versus at home, but these were all voided samples, excluding a potential effect of sampling method.[13] Finally, 2 studies in dogs compared voided samples collected at home with samples collected in-hospital either by cystocentesis or voiding, and found significantly higher in-hospital UPC results.[14,15] Although 1 study in cats found a significant correlation between UPC results in cystocentesis and voided urine, both samples were taken in the clinic and the latter was obtained by manual bladder compression.[16] Manual expression of the bladder may lead to hematuria, bladder rupture, or vesicoureteral reflux of potentially infected urine.[17,18] Studies in cats comparing in-hospital cystocentesis with spontaneously voided urine collected at home, the 2 most frequently used collection methods in cats, are lacking.[17]

The aim of our prospective study was to compare UPC and USG of paired urine samples in cats, namely voided urine collected at home by the owner and cystocentesis urine obtained in the clinic. A second aim was to detect clinically relevant differences in UPC (i.e., different IRIS proteinuria substage) or USG (<1.035 vs ≥1.035).

2 | MATERIALS AND METHODS

Urine samples were prospectively collected from healthy and diseased client-owned cats from September 2019 to November 2021. Signed informed consent from the owner was required for participation. This study was approved by the local ethical committee of the Faculty of Veterinary Medicine, Ghent University, Belgium and the deontological committee of the Belgian Federal Agency for the Safety of the Food Chain (EC 2018/54).

Healthy cats needed to be "healthy for the owner" (i.e., without clinical signs or changes in general behavior and with stable body weight) and free of medication (except preventive medication) for at least 2 months before inclusion. Diseased cats could suffer from renal or other diseases and were presented for routine diagnostic investigations at the Small Animal Department of Ghent University, Belgium.

Owners were asked to collect urine from their cats at home, for which they could choose 1 of 3 commercially available methods: (A) nonabsorbent spherical pellets placed in the empty litter box (Katkor, Rein Vet Products), (B) a shallow plastic container held directly underneath the cat while it is urinating (Cat-i-Noir, Great Premiums Europe B.V.), or (C) plastic wrap firmly pressed on top of the regular cat litter in the litter box (Figure 1). After obtaining a voided sample, owners brought the urine and their cat to the clinic as soon as possible, where a second urine sample was collected by ultrasound-guided cystocentesis using a 22G or 23G needle.

Macroscopic and microscopic evaluation of urine samples and measurement of USG using a handheld refractometer (MASTER-SUR/NM, Atago) were performed on-site immediately after cystocentesis on both urine samples. The sediment for in-house microscopic examination was prepared by centrifugation of 1.5 mL of urine in a conical-tipped tube for 3 minutes at 450×*g*, decanting the supernatant to leave 10% of the original aliquot volume above the sediment pellet. This sediment pellet then was resuspended by flicking the tube several times with the index finger and 2 unstained drops were placed on a clean glass slide and covered with a coverslip. Cells (erythrocytes, leukocytes, epithelial cells) were expressed per high power field (hpf, 40× objective). Microscopic hematuria was considered present with erythrocyte numbers >10/hpf and pyuria with leukocyte numbers >5/hpf.

The remainder of the urine sample was sent overnight at ambient temperature to a commercial laboratory (IDEXX Laboratories in Kornwestheim and Leipzig), where dipstick analysis, manual sediment evaluation, UPC measurement, and bacterial culture were performed. Bacterial culture of cystocentesis urine was considered positive if the result was ≥1000 colony forming units (cfu)/mL. For voided urine samples, a result ≥10 000 cfu/mL was considered positive.[19] For UPC determination, urinary protein (UP) concentration was measured using pyrogallol red and urinary creatinine (UC) concentration using the Jaffe method. Samples with an active urine sediment (microscopic hematuria or pyuria, or positive bacterial culture) were not excluded.

2.1 | Statistical analysis

The differences in UPC results between urine collected at home vs in clinic were evaluated both numerically and by assessing the number of cats that were differently classified among the proteinuria

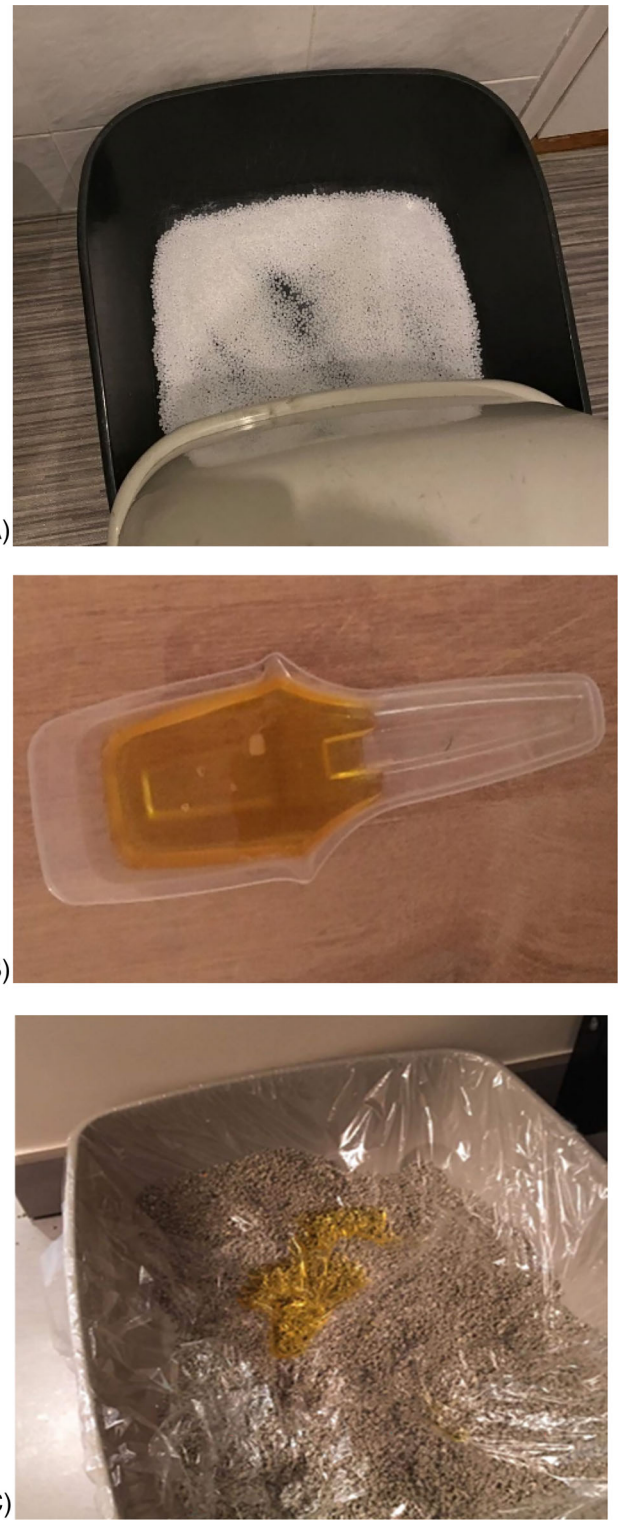

FIGURE 1 Methods cat owners could choose to collect urine at home for the study. (A) Nonabsorbent plastic pellets (KatKor). (B) Shallow plastic container (Cat-i-Noir). (C) Plastic wrap

substages nonproteinuric (UPC < 0.2), borderline proteinuric (UPC 0.2-0.4), or proteinuric (UPC > 0.4). For USG, the difference in numerical values between voided and cystocentesis urine was evaluated, as well as the number of cats being either categorized as having inadequate (USG < 1.035) or adequate (USG ≥1.035) urine concentrating ability.

TABLE 1 Number of attempts and successes for each urine collection method

Technique	Attempts	Successes	Success rate
KatKor pellets	83	53	64%
Cat-i-Noir	36	17	47%
Plastic foil	43	19	44%
Total	162	89	55%

Numerical results obtained for urine samples (i.e., UPC, UP, UC, and USG), collected using the 2 collection techniques, were compared by use of a mixed model with cat as random effect and collection technique as fixed effects factor. To evaluate the effect of other covariates (i.e., sampling technique, hematuria), these covariates and their interaction with collection technique were added to the model as fixed effects factors. Values of $P < .05$ were considered significant. The (weighted) kappa statistic was used for the categorized UPC and USG response variables. The strength of agreement as determined by κ was interpreted as follows: almost perfect: 0.81 to 1.00, substantial: 0.61 to 0.80, moderate: 0.41 to 0.60, fair: 0.21 to 0.40, slight: 0.00 to 0.20, and poor: <0.00.[20]

SAS version 9.4 (Copyright [c] 2020 by SAS Institute Inc., Cary, North Carolina) was used for all analyses.

3 | RESULTS

3.1 | Study population

The numbers of total and successful attempts per collection method are shown in Table 1. Of 162 attempts to collect urine at home, 89 were successful (55%). Owners of 3 more cats collected urine from their cats from the floor, leading to a total of 92 included cats (43 healthy, 49 diseased). Time between urination at home and cystocentesis in the clinic ranged from 1 to 15 hours (median, 6 hours). Median age of included cats was 10 years (range, 1-17 years). Forty-eight cats were female (all spayed) and 42 cats were male (41 neutered). Cat breeds that were represented more than once were Domestic Shorthair or Longhair (n = 69), British Shorthair (n = 6), Siamese (n = 3), Ragdoll (n = 2), Balinese (n = 2), and Sphynx (n = 2). Diseases diagnosed in >1 sick cat were hyperthyroidism (n = 28), CKD (n = 15), cardiac disease (n = 2), and diabetes mellitus (n = 2).

3.2 | UPC and proteinuria substage

In cystocentesis samples, median (range) UPC was 0.24 (0.06-5.08) vs 0.19 (0.00-4.01) in voided samples. The difference in UPC between paired cystocentesis and voided samples ranged from −0.47 to 1.48. The mean ±SD difference between UPC results obtained by both

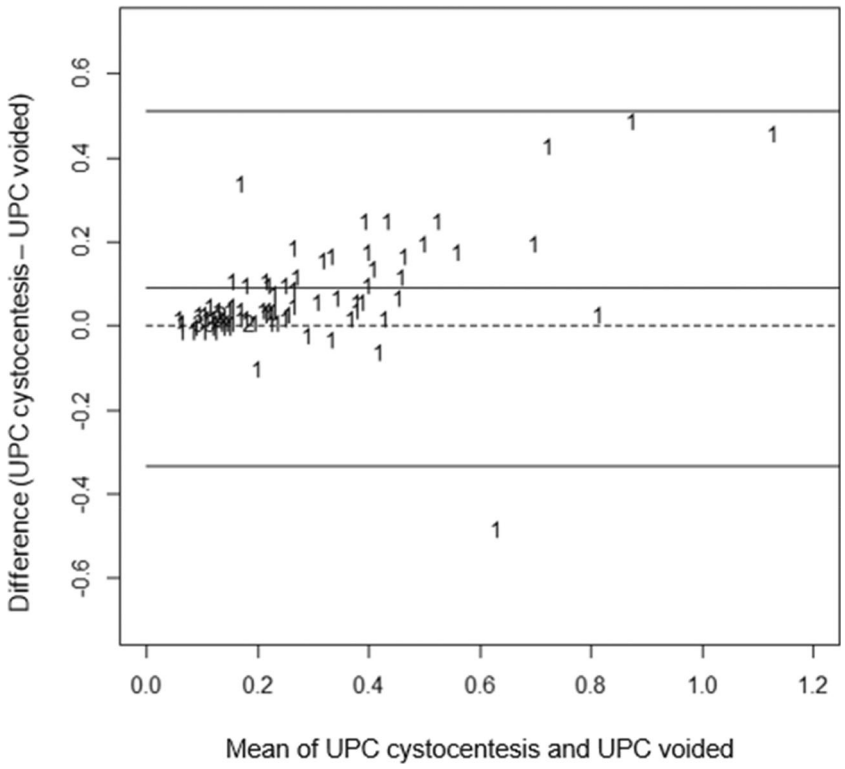

FIGURE 2 Bland–Altman plot to assess the level of agreement for UPC results between cystocentesis and voided urine samples in 92 healthy and diseased cats. Overall, the UPC in cystocentesis samples was higher than the UPC in samples collected at home. The numbers 1 and 2 refer to the number of cats depicted at that specific location in the figure.

methods was 0.09 ±0.22, with cystocentesis samples yielding a significantly higher result than voided samples ($P < .001$; Figure 2). There was no statistically significant effect of the method used for home sampling, the time between collecting urine at home and performing cystocentesis, the presence of microscopic hematuria in cystocentesis samples, or bacterial urine culture results on the difference between both sampling techniques. When evaluating UP and UC separately, mean difference between cystocentesis and voided urine for protein concentration (13.3 ± 29.7 mg/dL) was significant ($P < .001$), whereas the mean difference in creatinine concentration (2.5 ± 83.2 mg/dL) was not ($P = .77$). A significant effect of iatrogenic microscopic hematuria on the observed difference between UP results in voided and cystocentesis urine was identified ($P < .001$). For cats without microscopic hematuria (n = 23), the mean ±SD difference in UP between cystocentesis and voided urine was 6.8 ±16 mg/dL whereas for cats with microscopic hematuria in cystocentesis urine (n = 68), the mean difference in UP between cystocentesis and voided samples was 32.5 ±47 mg/dL.

Based on cystocentesis, 39/92 (42%) cats were considered nonproteinuric, 30/92 (33%) borderline proteinuric, and 23/92 (25%) overtly proteinuric. In voided samples, no proteinuria was found in 49/92 (53%) cats, borderline proteinuria in 30/92 (33%), and overt proteinuria in 13/92 (14%) cats. The weighted kappa coefficient was .68, corresponding to substantial agreement on proteinuria category between both sampling methods. Specifically, UPC ratios of paired urine samples resulted in classification in the same IRIS proteinuria substage in 72% of cats. This finding means a different decision concerning proteinuria substage could be made in 26/92 (28%) cats depending on whether urine was collected at home or in the clinic. In most of these cases, the UPC category was higher for cystocentesis than for voided urine (23/26 = 88% of discordant cases; Table 2).

TABLE 2 Contingency table comparing the proteinuria substage assigned to each cat with 2 urine sampling methods, namely voided urine at home and in-clinic cystocentesis

		Voided urine		
Cystocentesis	UPC	<0.2	0.2–0.4	>0.4
	<0.2	38	1	–
	0.2-0.4	11	17	2
	>0.4	–	12	11

Note: Paired urine samples for UPC determination were available in 92 cats.
Abbreviation: UPC, urinary protein:creatinine ratio.

3.3 | USG and urine concentrating ability

Median (range) USG was 1.036 (1.008-1.060) in cystocentesis samples vs 1.043 (1.007-1.064) in voided samples. The difference in USG between paired cystocentesis and voided samples ranged from −0.048 to 0.012. The mean (±SD) difference for USG was −0.006 (±0.009) with USG overall being highest in samples collected at home ($P < .001$). Again, there was no statistically significant effect of the method used for home sampling, the time between collecting urine at home and performing cystocentesis, the presence of microscopic hematuria in cystocentesis samples, or bacterial urine culture results on the difference between both sampling techniques.

Of the 82 cats for which USG was determined in-house on paired samples, 43 (52%) had USG ≥1.035, and 39 (48%) had USG < 1.035 based on their cystocentesis samples. Home sampling resulted in USG ≥1.035 in 54 (66%) cats and USG < 1.035 in 28 (34%) cats. The kappa coefficient was 0.64, indicating substantial agreement between sampling methods for USG category. Specifically, 82% cats were assigned the same urine concentration category based on both paired urine samples. Hence, a different decision regarding urine concentrating ability could be drawn when a different sampling method was used in 15/82 (18%) of cats. In most of these cases, USG was higher in voided than in cystocentesis samples (13/15 = 87% of discordant cases; Table 3).

3.4 | Bacterial urine culture

There was 57% agreement between both collection methods for bacterial culture results, with both samples testing either negative (46/90) or positive (5/90; Table 4). Bacterial culture was positive for 5/90 (6%) cystocentesis samples vs 44/90 (49%) voided samples (Table 4). Compared to cystocentesis, which is considered the gold standard method for collecting urine from cats for culture, home collection of urine had a sensitivity of 100% and a specificity of 54% to detect bacteriuria based on a positive urine culture. When evaluating each home collection technique individually, testing voided urine caused a false positive bacterial culture (meaning the cystocentesis sample of the same cat yielded a negative result) in 27/49 (55%) cases where non-absorbent pellets were placed in the litterbox, in 6/17 (35%) of cases where plastic wrap was applied, in 5/17 (29%) of cases where a hand-held container was used, and in 1/2 (50%) cases where urine was aspirated directly from the floor.

TABLE 3 Contingency table comparing the urine concentrating ability assigned to each cat with two urine sampling methods, namely voided urine at home and in-clinic cystocentesis

		Voided urine	
Cystocentesis	USG	<1.035	≥1.035
	<1.035	26	13
	≥1.035	2	41

Note: Paired urine samples for in-house USG determination were available in 82 cats.
Abbreviation: USG, urine specific gravity.

TABLE 4 Contingency table comparing bacterial culture results for each cat with two urine sampling methods, namely voided urine at home and in-clinic cystocentesis

		Voided urine	
Cystocentesis	Bacterial culture	Negative	Positive
	Negative	46	39
	Positive	0	5

Note: Paired urine samples for bacterial culture were available in 90 cats. Culture of voided urine samples was considered positive in case of ≥10 000 cfu/mL, for cystocentesis samples the cut-off was ≥1000 cfu/mL.

TABLE 5 Contingency table comparing the presence or absence of microscopic hematuria with two urine sampling methods, namely voided urine at home and in-clinic cystocentesis

		Voided urine	
Cystocentesis	Microscopic hematuria	Negative	Positive
	Negative	68	0
	Positive	18*	5†

Note: Paired urine samples for sediment analysis were available in 91 cats. Microscopic hematuria was defined as >10 erythrocytes/hpf.
*Macroscopic hematuria in 3/18 cats.
†Macroscopic hematuria in 0/5 cats.

3.5 | Iatrogenic hematuria

Microscopic examination of cystocentesis urine identified microscopic hematuria in 23/91 (25%) cases where urine sediment analysis was performed on both a cystocentesis and voided sample (Table 5). Five of these cats also had microscopic hematuria in the voided urine sample previously collected at home. Therefore, iatrogenic microscopic hematuria was present in 18/91 (19.8%) cases. In 3 cats (3/91 = 3.3%), the hematuria was macroscopically visible in cystocentesis urine, which was not the case in any of the voided samples.

4 | DISCUSSION

Urinalysis is an indispensable part of the diagnosis and follow-up of CKD and other diseases. Presenting owners the option to collect urine at home might help increase the percentage of cats in which urinalysis is performed, when cystocentesis is not desirable or feasible. Fifty-five percent of attempts to collect urine at home were successful in this population of cats, which is lower than the reported success rate of 71% in dogs.[12] This outcome is despite the fact that cat owners participating in our study were motivated owners. Other owners declined because they considered collecting urine at home impossible because their cats only urinated outdoors, having multiple cats that could not be separated, or for other reasons. Hence, collecting urine at home is not a potential alternative to cystocentesis in all cats.

A cut-off of 1.035 is used for USG to determine whether azotemia is renal or nonrenal, and to diagnose IRIS stage 1 CKD in nonazotemic cats.[1] Likewise, a cut-off of 0.4 for UPC is used to determine the need for treatment in cats, and leads to a diagnosis of IRIS stage 1 CKD in nonazotemic cats.[1,2,5] Despite the clear consequences of different UPC and USG categories on clinical decision-making, little is known about the influence of urine sampling method on these urinary variables in cats.

The UPC of cystocentesis urine was significantly higher than that of voided samples. These differences were not only statistically significant but also clinically relevant, because paired urine samples yielded a different IRIS proteinuria substage in 28% of the cats. In 25% of study cats, a higher proteinuria substage was assigned to the same cat when cystocentesis was performed. It is unlikely that protein binding

to the nonabsorbent cat litter caused a decrease in UPC in voided urine, because studies have shown that UPC is not affected by contact with nonabsorbent cat litter.[21,22] The increased storage time (1-15 hours) of voided urine compared to cystocentesis samples also is not thought to be the cause of lower UPC results in voided urine, because a study in cats has shown that the UPC remains stable after storage of urine for 1 day, even at room temperature.[23] Hematuria generally is thought to affect UPC only when it is macroscopically visible[24-26] or urinary sediment contains ≥250 erythrocytes/hpf.[27] Although no significant effect of microscopic hematuria was observed on differences in UPC between sampling methods in our study, the difference in UP was significantly higher when iatrogenic microscopic hematuria (>10 erythrocytes/hpf) was present in cystocentesis samples. Therefore, it is possible that iatrogenic hematuria partly explains the higher UP and consequently UPC in cystocentesis samples compared to voided samples. Another potential reason for the observed differences in UPC between paired samples is the stress related to the transportation to the clinic and the procedure of cystocentesis itself. A study in 36 healthy dogs has shown that stress, as estimated by urinary cortisol: creatinine ratio and owner perception, was significantly higher in the hospital than at home.[13] However, the UPC in these dogs was not significantly different between samples that were collected at home vs in the hospital, and thus, the stress level did not seem to affect UPC results. Direct comparison between that study and our study, however, is difficult because of different study designs. First, all dogs in the previous study were healthy and stress might have a different impact on diseased glomeruli and thus the severity of proteinuria. Second, both paired samples were voided in the dog study, precluding the investigation of a potential effect of sampling method on UPC. A study in 43 cats found no differences in IRIS proteinuria substage between samples that were collected by manual bladder compression vs cystocentesis.[16] However, both paired urine samples for that study were collected in the clinic, preventing investigation of a potential effect of stress on UPC. Furthermore, urine samples containing >5 erythrocytes/hpf were excluded (which was also the case in studies in dogs),[11,12] and so any potential effect of iatrogenic (microscopic) hematuria on UPC in cystocentesis samples was avoided. Lastly, the success rate of manual bladder compression was not mentioned, and no conclusions can be drawn on this method being a potential alternative to cystocentesis for urine collection in cats.

Considering the established differences in UPC results between samples collected by cystocentesis in the clinic and voided samples collected at home, it seems prudent to establish a separate reference interval for UPC in urine obtained by the latter method because the upper reference limit may be lower than for cystocentesis samples. Also, to decrease preanalytical variability, it is advisable always to use the same collection method in the same cat when monitoring the occurrence or progression of CKD, or when assessing the response to antiproteinuric treatment. Other factors also can have an impact on the variability of laboratory results during follow-up of a cat, such as analytical factors (e.g., assay methodology) or biological variability (e.g., day-to-day variability within the same cat). However, because both paired urine samples were analyzed by the same laboratory, analytical variability was minimal considering the previously established excellent intraclass correlation for UPC determination.[28] Furthermore, because both paired urine samples were collected on the same day, biological variability was kept to a minimum.

In cystocentesis samples, USG was significantly lower than in voided samples. Again, this difference was not only statistically significant but could have clinical consequences, because a different urine-concentrating ability was diagnosed in 18% of cats. In 16% of study cats, cystocentesis urine was poorly concentrated whereas voided urine was not. One explanation for the increase in USG in voided urine compared to cystocentesis urine could be evaporation when urine was not immediately placed in a sealed container after urination. A study with 15 dogs identified a significant increase in USG when urine samples were not sealed and remained in contact with nonabsorbent cat litter for 5 hours. However, the mean increase in USG was only 0.004 (range, 0-0.010), which was considered unlikely to be clinically relevant.[29] Differences in USG between voided and cystocentesis urine were much higher in our study, which could be related to the different time of sampling for voided urine (i.e., in the evening, at night, or in the early morning) vs cystocentesis urine (i.e., in the morning or at noon). Contrary to our findings, however, a study in 89 healthy dogs identified a higher USG in morning samples than in evening samples.[30] This finding could be a consequence of lifestyle differences between dogs and cats. Water intake is related to activity in dogs, and dogs are more active during the daytime.[30] Because cats can be active during the night, increased water intake might occur at night compared to dogs. An effect of food intake on water intake in cats in our study is unlikely because owners were asked to fast their cats during the night, but it is possible that not every owner complied with this request. Research in humans has shown that the production of anti-diuretic hormone increases progressively during the night, with a peak between midnight and 4 AM, causing a decrease in urine output.[31] It is unknown whether the same is true in cats, and whether this effect could therefore explain the higher USG in samples collected at night.

Taking both the UPC and USG into account, a different proteinuria substage, urine concentrating ability, or both was diagnosed in paired samples in 45% of cats (when considering all 3 different proteinuria substages) or 32% of cats (when comparing only UPC ≤0.4 vs UPC > 0.4). The latter means that for 1 in 3 study cats, by a different method to obtain a single urine sample resulted in a different decision on renal health (i.e., a diagnosis of CKD IRIS stage ≥1, based on UPC or USG or both).

Our study had some limitations. First, the number of cats with proteinuria based on cystocentesis urine was limited (23/92 [25%]). However, borderline proteinuric and overtly proteinuric cats together accounted for 58% (n = 53) of the study population. Second, participating cats were not evenly distributed between the different methods of urine collection at home. Although the initial goal was to randomize the cats over the 3 collection methods, the protocol was adapted allowing the cat owners to choose freely so as to increase study participation. Third, we investigated 2 preanalytical factors at the same time: sampling environment (home vs hospital) and sampling method (voiding vs cystocentesis). This approach was taken to mimic practice circumstances, where cystocentesis is performed in the

hospital and collection of voided cat urine typically is done at home. Fourth, sampling time was not standardized, neither for the home collection of urine nor for cystocentesis in the hospital, but the latter usually was performed between 9 AM and 1 PM. The reason for the variation in urine collection time at home is that cats had to be given the chance to urinate anytime at night and, in practice, it is impossible to predict when exactly a cat will provide a voided sample. Finally, IRIS guidelines dictate that persistence of (borderline) proteinuria should be confirmed.[1,2] Because of the nature of our study, however, classification of cats was based on urine taken at a single time point only.

In conclusion, it was possible to collect urine at home in 55% of cats. Cystocentesis urine yielded a significantly higher UPC and significantly lower USG than voided urine. Substantial agreement existed between both urine collection methods on both UPC and USG categories, meaning home sampling of urine is a valid alternative to cystocentesis in cats where the latter method is not desirable or feasible. However, because clinically relevant differences in UPC and USG were present in 28% and 18% of cats, respectively, the same urine collection method should be used when monitoring the same cat.

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CONFLICT OF INTEREST DECLARATION

Authors declare no conflict of interest.

OFF-LABEL ANTIMICROBIAL DECLARATION

Authors declare no off-label use of antimicrobials.

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE (IACUC) OR OTHER APPROVAL DECLARATION

Approval granted by the local ethical committee of the Faculty of Veterinary Medicine, Ghent University, Belgium and the deontological committee of the Belgian Federal Agency for the Safety of the Food Chain (EC 2018/54).

HUMAN ETHICS APPROVAL DECLARATION

Authors declare human ethics approval was not needed for this study.

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