Development of Correction Formulas for Canine and Feline Urine Specific Gravity Measured Using a Japanese Refractometer

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ABSTRACT. One of the most important functions of the kidney is to concentrate urine through the reabsorption of water. Urine specific gravity (USG) is used in routine tests of urine concentration and can be estimated using a refractometer. However, as the scale of Japanese refractometer is based on experimental data from healthy Japanese people, and human USG obtained by Japanese refractometers show higher values than that by refractometer produced in Europe or the U.S.A. The purpose of this study was to establish correction formulas for the USG of dogs and cats measured using Japanese refractometers. In this study, we found that Japanese refractometers overestimated USG in both dogs and cats. This study shows that the correlation formulas described in this study are useful for the accurate evaluation of USG.

KEY WORDS: refractometer, urine concentration ability, urine specific gravity.

One of the most important functions of the kidney is to concentrate glomerular filtrate via the renal tubules and the collecting duct. Therefore, the ability to concentrate urine is an indicator of renal function. Urine osmolality is an index of urine concentration [1]. Osmolality expresses the total solute concentration as the number of particles in solution per unit weight of solvent [1]. Measuring osmolality requires freeze-point osmometers, and thus is difficult in clinical practice [1]. In most veterinary clinics, urine specific gravity (USG), which is used as a routine test of urine concentration, is estimated using a refractometer [4]. USG, which is the ratio of the weight of 1L of solution to 1L of water, depends on the relative proportions and the molecular weights of all the compounds in solution [6, 11]. Refractometers take advantage of the fact that light is refracted when it passes from air into water. The evaluation of urine concentrations using refractometers has almost completely replaced urine osmolality measurement, due to the advantages of small sample size, short analysis time, better accuracy, and relatively low cost [2, 3]. The specific gravity scale of the refractometer is based on experimental data from normal human urine [8]. The reference method for specific gravity determination is based on comparing the weight of a known volume of urine prior to and after it has been dried to an anhydrous state [4]. Refractometers are reliable for most urine samples [4, 6, 11]. In human urine, refractometric measurement of specific gravity has a close linear correlation to osmolality if samples containing protein and glucose are excluded [2, 12]. Feline urine is more refractive than canine and human urine so feline USG is overestimated by approximately 0.002–0.005 when refractometers designed for human use are used, whereas refractive indexes of human and dog are similar [8]. Thus, the evaluation of feline USG were performed by refractometers made for animals or conversion equation to obtain feline USG from human or canine USG using standard refractometer in the Europe or U.S.A. The excretion of concentrated urine with a USG > 1.030 in dogs or > 1.035 in cats indicates that the animal is able to substantially modify the concentrations of tubular fluid by active tubular reabsorption [11] and these findings were determined on the basis of above methods. However, in Japan, the scale of refractometers is based on experimental data form healthy Japanese people (Japanese Society of clinical pathology nomogram), and human USG obtained by Japanese refractometers show higher values than that by refractometer produced in Europe or the U.S.A. [9]. In many Japanese veterinary clinics, the canine and feline USG may be evaluated using refractometers for human use made in Japan, and thus Japanese veterinarians might overestimate the urine concentration abilities, especially in cats. Therefore, the refractometer made for animals in U.S.A. or conversion equation to derive accurate canine or feline USG from value by Japanese refractometer is necessary to evaluate precise urine concentration in dogs and cats in Japan. The purpose of this study was to determine correction formulas for canine and feline USG measured using Japanese refractometers.

Two hundred and 75 dogs and 110 cats were included in this study. These animals were presented to the Veterinary Medical Teaching Hospital at Nippon Veterinary and Life Science University or one of 44 veterinary hospitals for the evaluation of various diseases. Urine samples were collected using a bladder catheter or cystocentesis, and urinalysis, including dipstick analysis and analyses of the urinary protein: creatinine ratio, USG, and urinary sediment, was performed. The latter two examinations were performed...
after the urine sample had been centrifuged for 5 min at 1,500 rpm. USG was evaluated at room temperature using two different refractometers; one made for human urine in Japan (SUR-JE, ATAGO, Japan) and another designed for use with dogs and cats in the U.S.A. (HSK-VET, HESKA, Colorado). The upper limit of measurement was 1.100 for the SUR-JE and 1.060 (human or dogs) or 1.080 (cats) for the HSK-VET. One drop of urine was placed on the prism of a refractometer that had previously been calibrated at a SG of 1.000 with distilled water. Urine samples that showed evidence of proteinuria (UPC > 0.5 for dogs, >0.4 for cats [5]) and/or glucosuria were excluded from the study. The differences between the USG measured with the Japanese refractometers for human use (Ref-JPN) and those measured by the refractometers for animal use (Ref-Animal) were evaluated using Pearson’s correlation coefficient and Wilcoxon’s signed rank sum test. A nonlinear regression analysis was performed between USG by Ref-JPN and USG by Ref-Animal. All statistical analyses were performed using software (Dr. SPSS II for Windows, SPSS Japan Inc.), and P < 0.05 was considered significant.

In all dogs and cats, USG by Ref-JPN and USG-U.S.A. (median value [range]) were 1.020 (1.002–1.078) and 1.018 (1.002–1.060), respectively. USG by Ref-JPN was significantly correlated with USG by Ref-Anim in both dogs and cats (dogs: r=0.997, P<0.001, cats: r=0.998, P<0.001) (Fig. 1). However, USG by Ref-JPN was significantly higher than USG by Ref-Animal in both dogs and cats (z=−13.07, P<0.001). The mean differences between USG by Ref-JPN and that by Ref-Animal in dogs and cats were 0.000–0.018 and 0.001–0.019, respectively (Fig. 2). In addition, when all urine samples were classified on the basis of USG values obtained from Japanese refractometer (dogs; < 1.015, 1.015–1.030, 1.030–1.050 and > 1.050, cats; < 1.015, 1.015–1.035, 1.035–1.050 and > 1.050), USG by Ref-JPN was signficantly higher than that by Ref-Animal in all groups in both dogs and cats, and the urine concentration is higher, the difference between two USG values is greater (Fig. 2). The relationship between USG by Ref-JPN and that by Ref-Animal was best represented by a second-order polynomial equation. The following linear equations can be used to calculate USG by Ref-Animal from that by Ref-JPN in dogs and cats:

Dogs: USG by Ref Animal = –2.1257 × (USG by Ref-JPN)² + 5.2153 × (USG by Ref-JPN) – 2.0899

Cats: USG by Ref Animal = 0.8674 × (USG by Ref-JPN)² – 1.019 × (USG by Ref-JPN) – 1.1519

When USG by Ref-Animal was calculated from that by Ref-JPN according to the above equation, all samples results were within ±0.004 of the measured value.

Kidney function must be reduced by at least two thirds before tubular concentrating dysfunction lowers USG [3, 7]. USG of > 1.030 for dogs and > 1.035 for cats are considered to suggest that the renal tubules of the animal in question are able to produce well concentrated urine [11]. The evaluation of urine concentration ability may allow detecting the earlier chronic kidney disease. The result in this study shows that Japanese veterinarians may overestimate USG at a maximum 0.018 in dogs or 0.019 in cats. In the patient with USG of near-cutoff value (1.030 or 1.035) [11], the urine concentrating ability would be diagnosed incorrectly. Thus, if the patient has potentially chronic kidney disease, the disease may overlook with the patient. The correlation formulas in this study may help to estimate more accurate urinary concentrating ability in dogs and cats. We could not verify the validity of these formulas, because these were obtained by making a simple comparison between USG values by two refractometers and were not based on the specific gravity by hydrometer. Nevertheless, these formulas obtained this study may have clinical significance in terms of conforming to global standard measurement.

In conclusion, USG measured by refractometers made for human urine in Japan overestimates the urine concentration...
abilities of dogs and cats, especially at USG values > 1.030, which is an important cut-off value for the evaluation of urine concentration ability. This study shows that the correlation formulas provided in this study are useful for accurately evaluating USG.

REFERENCES