PROPER MAINTENANCE
For optimal results, refractometers should be calibrated daily and cleaned after each use.

SKILLS CHECK: CLINICAL PATHOLOGY

Measuring Urine Specific Gravity With a Clinical Refractometer

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Abstract

Urine specific gravity (USG) is useful for evaluating a patient's kidney function, hydration status, and other physiologic functions. USG is a comparison of the concentration of urine with that of serum; thus, units of measure are not used. USG can be measured in the clinic by using either an analog or digital refractometer. Some refractometer scales apply to only 1 species; others, to multiple species. Measurement of specific gravity involves calibrating the refractometer, taking the reading, and interpreting the reading. The refractometer prism should be cleaned after every use.

Take-Home Points

- There are 2 types of refractometers: analog and digital.
- Some refractometer scales are specific for 1 species; others work with multiple species.
- The steps of refractometer use are calibration, reading, and interpretation.
- Refractometer calibration varies by type of refractometer but should be done daily.
- Refractometers should be cleaned between each use.
- Small volumes of urine can yield valuable information regarding an animal's health status.

Clinical refractometers are common in-house screening tools for measuring urine specific gravity (USG) with a minute volume of urine.[1] Veterinarians use USG to determine the concentrating ability of the kidneys, pinpoint the anatomic location of any abnormalities, and assess hydration status.[1-3] This article describes how refractometers work, refractometer types and maintenance, and the steps to follow when measuring USG.

HOW REFRACTOMETERS WORK

Refractometers compare the gravity of urine with that of distilled water, measuring solid particles in the sample as the refractive index.[3] The refractive index correlates with increasing solids within a sample; as light waves pass through the solution, the light is bent depending on the amount of solute within the sample.[3] As light is bent through a prism, the optical density is measured on a scale designed for urine gravity. This scale increases with increased urine concentration and provides a visual indication of the urine:distilled water ratio (**FIGURE 1**).[3]

TYPES OF REFRACTOMETERS

There are many types of refractometers on the market today, including analog and digital models (**FIGURE 2**). Results are typically accurate, although they may be altered by certain factors (**BOX 1**). Some models offer separate scales for samples from different species (multispecies refractometers) (**FIGURES 3 AND 4**), but the advantage over single-scale models is questionable.[5-7] Multispecies refractometers will have one scale for dogs/large animals and a separate scale for cats.[6,7] Compared with multispecies scales, single-scale refractometers tend to provide higher specific gravity values for cats.[3] Both analog and digital refractometer

FIGURE 1. Scale of an analog refractometer. Before a sample is added, scales should be visualized and the eyepiece adjusted to bring the numbers into better view. The urine specific gravity scale, designated U.G., is on the right.

BOX 1

Common Causes of Altered Urine Specific Gravity Readings[1-4]

- Inadequate sample volume
- Calibration error
- Reading incorrect scales (Brix or protein)
- Misreading numbers
- Failure to close cover
- High temperature
- Glucosuria
- Proteinuria

specific gravity readings correlate well with urine osmolality, the gold standard for evaluating dissolved particles in a sample.[2,5,8] To get the most reliable and accurate measurements, always refer to calibration recommendations set forth in the instruction manual for the specific refractometer used. Some refractometers are temperature compensated and do not require frequent calibration.[7] Patient factors that may affect USG results include glucosuria and marked proteinuria (**BOX 1, FIGURE 5**).[2,3,5]

STEPS FOR MEASURING URINE SPECIFIC GRAVITY

Step 1: Calibrate

For analog models, before applying the sample to the prism, bring the scale into clearer view by turning the eyepiece while holding the refractometer in the direction of a light source.[9] Environmental temperatures outside the range of 16 °C to 38 °C (60 °F to 100 °F) may affect the accuracy of readings.[1,2,4,10] If the environmental (workplace) temperature fluctuates more than -15 °C (5 °F), some models may require recalibration[4]; however, sample temperature rarely affects USG readings.[4,6,7] The author's facility calibrates refractometers daily to adjust for any room temperature changes.

To calibrate the refractometer, first gather the necessary supplies (**BOX 2, FIGURE 6**). Then place a sample-equivalent volume of distilled water on the prism and close the cover before checking the reading. On an analog model, if the reading is not on the 1.000 line of specific gravity (**FIGURE 7**), use a screwdriver on the calibration screw to set the line exactly on the mark while viewing the scale (**FIGURE 8**).[4,7,9] Digital models are calibrated with the press of a button.[6,10] After calibration is complete, wipe the prism dry with a soft cloth or optical tissue paper.[6,7,9,10]

FIGURE 2. Various types of refractometers. Left to right: Reichert multispecies analog (**reichert.com**), Westover analog, Jorvet analog (**jorvet.com**), Fisher digital (**fishersci.com**).

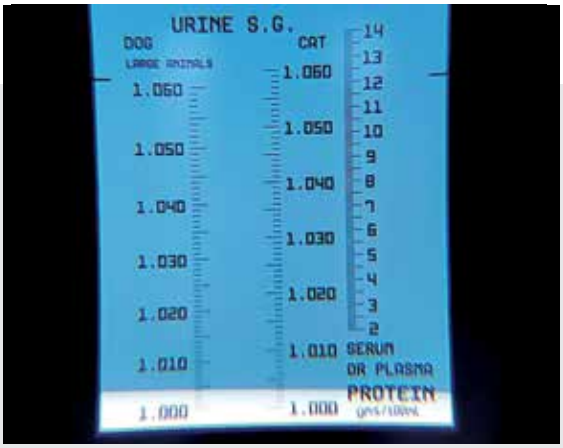

FIGURE 3. Reichart analog model refractometer (**reichert.com**) showing separate scales for different species. The dog and large animal scales are to the far left and the cat scales are in the middle.

FIGURE 4. Misco digital model refractometer (**misco.com**), showing separate cat-specific scales. This reading of 1.024 may indicate inadequate concentrating ability, depending on the hydration status of the cat.

Step 2: Reading Urine Specific Gravity

When taking a sample reading, place 1 to 5 drops of urine on the refractometer prism, similar to the distilled water in the calibration step. For accurate readings, be sure to add an adequate amount of sample to the prism (**FIGURE 9**).[4] Urine samples may be well mixed by gently swirling or inverting the sample, or the supernatant of a centrifuged sample may be used for measurement.[5,8] To read analog models, close the sample cover and read the interface between the blue and white color; for digital models, read the numbers displayed.[4,6,7,9,10] The advantage of digital models is minimization of recording errors.[8] For samples that exceed the USG scale, dilute the sample by adding 1 drop of distilled water to 1 drop of urine, mix well, and then multiply the results past the decimal point by 2. Commonly, USG is merely reported as greater than the scale limit (i.e., >1.060).[3] The cutoff value will vary by model. Most models have a USG range from 1.000

BOX 2

Materials Required for Refractometer Calibration[4,6,7,9,10]

- Refractometer
- Disposable gloves for protection against potential zoonotic disease
- 1–5 drops of urine, depending on refractometer model requirements
- Distilled water for calibration, cleaning, and/or diluting specimen (if required)
- Transfer pipettes for dispensing samples
- Soft cloth or optical tissue for cleaning
- Light source

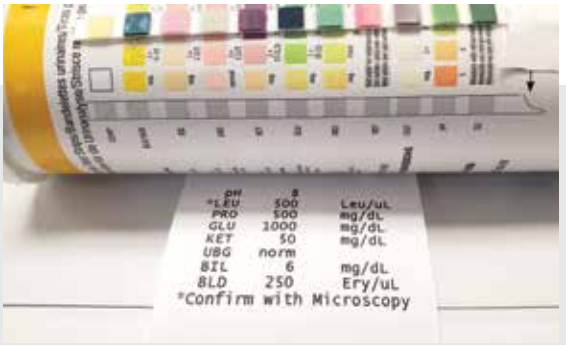

FIGURE 5. Chemical evaluation of a urine sample with elevated glucose and proteinuria, which can falsely elevate urine specific gravity (USG) values. Note that even if USG values are provided on urinalysis chemistry strips, the refractometer measurement is more accurate.

FIGURE 6. Materials required for measuring urine specific gravity: refractometer, distilled water, calibration screwdriver for analog models, urine sample, transfer pipette, laboratory optical tissue or a soft cloth, gloves, and natural or artificial light.

FIGURE 7. Calibrated refractometer scale of the Jorvet analog refractometer (**jorvet.com**).

FIGURE 8. Calibration screw. While distilled water under the prism is viewed, the calibration screw is turned to adjust the calibration according to the refractometer instructions.

FIGURE 9. An adequate volume of urine is required. Right: Proper sample volume. Left: Inadequate sample volume. An inadequate sample volume will result in a blurred interface between the white and blue areas, leading to the potential for reporting inaccuracies. Either more sample can be applied to the prism or the cover can be gently pressed to ensure complete coverage of the prism with the sample.

to 1.060, and on some digital models, USG on the feline setting can be read up to 1.120.[4,6,7,9,10]

After each use, clean the refractometer with a soft cloth or laboratory optical tissue and distilled water. Do not use abrasive cleaners or cloths on the prism as doing so will damage the surface and impede readings.[4,6,7,9,10]

Step 3: Reporting and Interpreting Urine Specifc Gravity Results

Because USG is a ratio of urine to distilled water, no units of measure are used. USG is described both in terms of concentrating ability compared with the expected specific gravity of plasma or glomerular ultrafiltrate. USG references ranges vary widely. Categories of USG are as follows (**TABLE 1**)[1-3]:

- Hyposthenuric indicates dilute urine, often resulting from renal tubule inability to concentrate or from excessive water consumption by the patient.
- Isosthenuric (**FIGURE 10**) may result from renal dysfunction in dehydrated and azotemic animals, indicating an inability to either dilute or concentrate urine.
- Hypersthenuric (**FIGURE 11**) indicates concentrated urine, usually resulting from dehydration.

TABLE 1 Urine Specific Gravity interpretation[1-3]

READING	INTERPRETATION
<1.008	Hyposthenuria
1.008–1.012	Isosthenuria
>1.012	Hypersthenuria

SUMMARY

Refractometers are valuable tools for accurately determining USG readings for veterinary patients. Small volumes of urine can yield valuable information

FIGURE 10. Isosthenuric specific gravity reading of 1.012 on a digital refractometer scale.

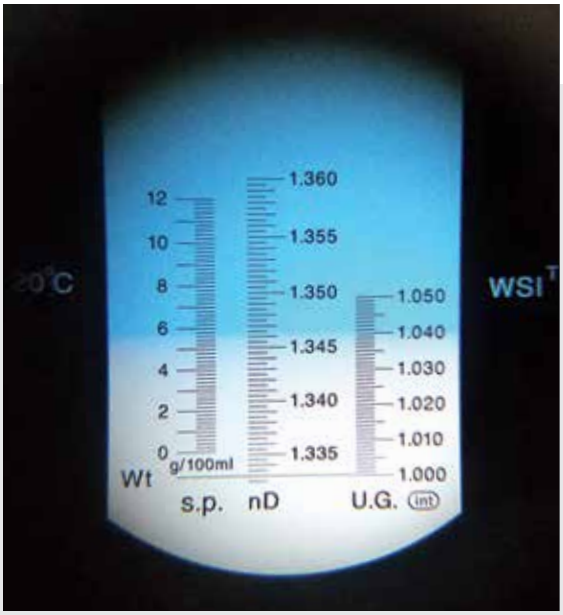

FIGURE 11. Hypersthenuric specific gravity reading of 1.040 on an analog refractometer scale. The urine specific gravity scale is on the right. The line between the blue and white and numbers is clear, making the result easy to read.

regarding an animal's health status. Veterinary nurses increase the value of results by properly calibrating, reading, and maintaining refractometers. TVN

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Barbie teaches clinical pathology and laboratory animal courses in the veterinary technology program at Murray State University as well as continuing education at state and national conferences. Before full-time teaching, she worked at the Breathitt Veterinary Center diagnostic laboratory. She currently serves as secretary of the Academy of Veterinary Clinical Pathology Technicians. She resides in western Kentucky where she loves to hike with her 2 sons and husband. She shares her home with 2 dogs, 4 cats, and an assortment of feathered and scaled animals.