Does the Dipstick Meet Medical Needs for Urine Specific Gravity?

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In 1981 the Ames Division of Miles Laboratories, Elkhart, Ind, added a specific gravity test to some of their widely used urinary dipsticks.

Previously available information about the Ames specific gravity dipstick has been divided on its accuracy. Several authors have found that the dipstick is accurate in measuring specific gravity.[1–3] Others, comparing it only with the TS Meter (Reichert Scientific Instruments, Buffalo, NY), have concluded the Ames specific gravity dipstick is not accurate for use in clinical practice.[4,5]

A proper evaluation of the Ames specific gravity dipstick is necessary, with its accuracy being compared with the true specific gravity measured by pycnometry as well as with the TS Meter.

METHODS

Patient's Urine Specimens

Spot urine collections were obtained from 279 consecutive outpatients seen in the Ohio State University Family Practice Center. Analysis followed within two hours of collection, and all urine specimens were evaluated for specific gravity by the TS Meter and the Ames specific gravity dipstick. When the pH was greater than 6.5, the dipstick specific gravity reading was corrected by adding 0.005 to the specific gravity. The urine glucose and protein values were determined with the dipsticks.

Contrived Urine Specimens

Three sets of solutions were prepared that varied in the concentrations of sodium chloride, glucose, and protein, the protein coming from diluted human serum. The pH range was 5.0 to 8.0, and Gifford's buffer was used.[6] The stock acid solution contained 12.4 g of boric acid and 7.4 g of potassium chloride per liter of water, and the stock base solution contained 24.8 g of sodium carbonate in a liter of water. The contrived urine specimens contained increasing amounts of glucose (0, 5, 10, 25, or 50 g/L) or increasing amounts of protein (0.0, 1.5, 3.0, 7.5, 15.0 g/L) or increasing amounts of sodium chloride (0, 5, 10, 25, 50 g/L). All of the contrived urine sets (increasing concentrations of glucose, protein, or sodium chloride) were prepared with a pH of 5.0, 6.0, 7.0, and 8.0.

Measurements of Specific Gravity

The specific gravity of the 60 contrived urine samples was determined using 5-mL pycnometers (No. 8350-B22, Thomas Scientific, Swedesboro, NJ), a TS Meter, and the Ames N-Multistix-SG. The pycnometer determinations were carried out at ambient temperature; the specific gravity of any solution was the ratio of weight of solution to weight of water. For the TS Meter and N-Multistix-SG, the manufacturers' instructions for use were followed.

Twelve patients had urine glucose values equal to or above 1,000 mg/dL (10 g/L), by dipstick; their specific gravity values by the Ames dipstick were generally lower than those obtained by the TS Meter (Figure 1, top graph). An arbitrary correction factor was applied to these 12 specimens, ie, specific gravity of dipstick (corrected for glucose in milligrams per deciliter) = specific gravity by dipstick + glucose/1,000 × 0.005. This correction adds 0.005 specific gravity units to the dipstick specific gravity for each 1,000 mg/dL glucose present. The comparative specific gravity values with the above correction are shown in Figure 1, bottom graph; the correlation coefficient R was increased from 0.88 to 0.92, which suggests that the correction is appropriate but probably academic. Burkhardt et al[1] stated that the specific gravity test on the dipsticks is insensitive to glucose. In general, the Ames specific gravity dipstick values are somewhat lower than those from the TS Meter.

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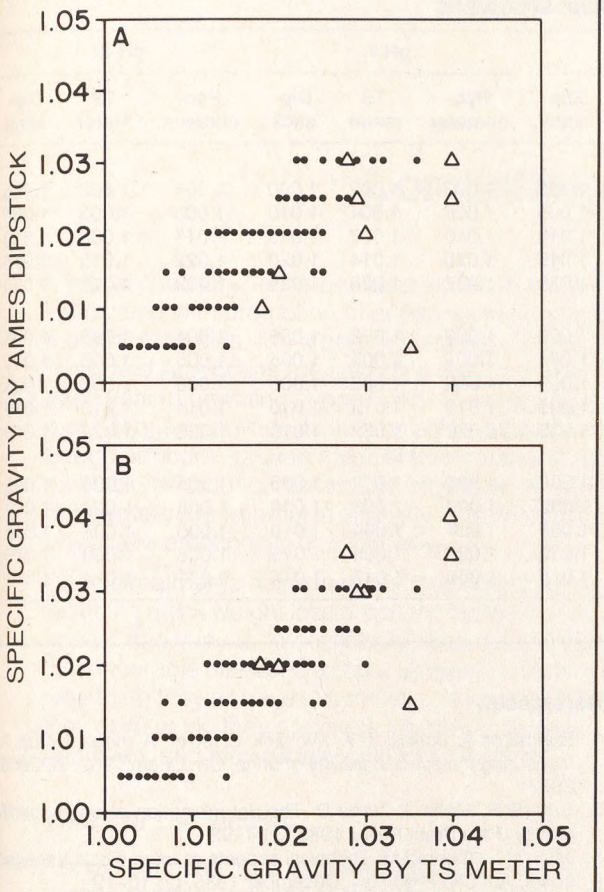

Figure 1. Specific gravity data (top graph) on patients' urine specimens. Δ indicates urine specimens with a glucose > 1,000 mg/dL. Specific gravity for urine specimen (bottom graph) with glucose > 1,000 mg/dL corrected (see text)

Specific gravity data for these specimens are displayed in Table 1. The pycnometer procedure is the reference method and gives results that are closest to the correct values.

Changes in pH did not affect the accuracy of the TS Meter and affected the Ames specific gravity dipstick results only at a pH 8, a factor noted by Ames and correctable by adding 0.005 to the specific gravity. Values obtained by TS Meter were modestly but consistently lower than those by either pycnometer or by the Ames specific gravity dipstick. In evaluating these findings, it must be remembered that the pycnometer measures true specific gravity, while the TS Meter estimates specific gravity by refraction. At a sodium chloride concentration of 50 g/L, the TS Meter underestimates specific gravity by about 0.012 units; below this concentration, the error is substantially less and probably unimportant for clinical use. At all sodium chloride concentrations, the Ames specific gravity dipstick gave readings that effectively correlated with the pycnometer.

At all concentrations of glucose and at all values of pH, the TS Meter and pycnometer showed good correlation. The Ames specific gravity dipsticks, however, uniformly underestimated the specific gravity for the solutions with glucose concentrations above 1000 mg/dL (10 g/L). At lower glucose concentrations, however, the specific gravity dipstick readings correlated well with the pycnometer.

With protein, also, the pH did not affect the specific gravity determined by either the pycnometer or TS Meter. When both the TS Meter and the Ames dipstick were compared against the pycnometer, the values correlated well at all concentrations of protein and at all pH values. Therefore, it appears that the accuracy of both TS Meter and the Ames specific gravity dipstick are unaffected by the concentration of protein in the urine.

DISCUSSION

Other evaluations of the Ames specific gravity dipstick have not attempted this comprehensive an evaluation of the product.[1,4,5] Published work by Ames compared their specific gravity dipstick with the TS Meter, the latter being an approximation of the true specific gravity.[3] Other work by Guthrie et al[2] had compared all available methods with the true specific gravity by pycnometer but had not correlated these findings with clinical data.

Coordinating the clinical and experimental data provides solid information for practicing physicians. While the experimental work clearly documents that both the Ames specific gravity dipstick and the TS Meter have inaccuracies in experimental solutions, these inaccuracies occur only with high concentrations of salt, glucose, or protein in urine. The TS Meter specific gravity value is relatively unaffected by changes in pH and modest increases in glucose and protein. The TS Meter shows significant inaccuracies only with high concentrations of sodium chloride, a situation that is uncommon clinically.

While the Ames specific gravity dipstick is affected by high concentrations of glucose and a significantly alkaline pH, these conditions can be easily compensated for in clinical practice. Since all the Ames specific gravity dipsticks also document the urine pH and glucose, a clinician can correct for an alkaline pH (add 0.005 for a pH greater than 6.5) and for a glucose greater than 1 g/dL by the

TABLE 1. COMPOSITION AND SPECIFIC GRAVITY OF CONTRIVED URINE SPECIMENS

Component	pH 5			pH 6			pH 7			pH 8*		
	Pyc-nometer	TS Meter	Dip-stick	Pyc-nometer	TS Meter	Dip-stick	Pyc-nometer	TS meter	Dip-stick	Pyc-nometer	TS Meter	Dip-stick
Sodium chloride (g/L)												
0	1.003	1.002	1.000	1.002	1.002	1.000	1.003	1.002	1.000	1.004	1.003	1.005
5.0	1.006	1.004	1.005	1.006	1.004	1.005	1.006	1.004	1.010	1.008	1.005	1.005
10.0	1.010	1.007	1.010	1.010	1.007	1.010	1.010	1.007	1.015	1.011	1.008	1.010
25.0	1.020	1.014	1.015	1.020	1.014	1.015	1.020	1.014	1.020	1.022	1.015	1.015
50.0	1.037	1.025	1.025	1.037	1.025	1.030	1.037	1.025	1.035	1.039	1.026	1.020
Glucose (g/L)												
0	1.003	1.002	1.000	1.003	1.002	1.000	1.003	1.002	1.005	1.004	1.003	1.005
5	1.005	1.004	1.000	1.005	1.004	1.005	1.005	1.004	1.005	1.006	1.005	1.005
10	1.007	1.006	1.005	1.006	1.006	1.005	1.006	1.006	1.005	1.008	1.007	1.005
25	1.012	1.012	1.005	1.012	1.012	1.005	1.012	1.012	1.010	1.014	1.013	1.010
50	1.022	1.022	1.010	1.021	1.022	1.005	1.022	1.022	1.010	1.023	1.022	1.010
Protein (g/L)												
0	1.003	1.002	1.000	1.003	1.002	1.000	1.003	1.002	1.005	1.005	1.003	1.005
1.5	1.003	1.003	1.005	1.003	1.003	1.005	1.003	1.003	1.010	1.005	1.004	1.010
3.0	1.004	1.004	1.005	1.004	1.004	1.005	1.004	1.004	1.010	1.006	1.006	1.010
7.5	1.006	1.007	1.010	1.006	1.007	1.010	1.006	1.008	1.015	1.008	1.009	1.015
15.0	1.009	1.013	1.010	1.009	1.013	1.010	1.009	1.013	1.015	1.011	1.014	1.015

** Corrected for pH by adding 0.005 to observed value for dipstick method only*

following formula: specific gravity = dipstick reading + glucose/1,000 × 0.005.

These accumulated data lead to the conclusion that the Ames specific gravity dipstick is a useful and clinically accurate method for determining urinary specific gravity in clinical practice. The areas of its inaccuracies can easily be identified and corrected. It is cost effective, increasing the price of each dipstick at an average of 3 to 4 cents, and is extremely convenient and easy to use.

The use of the specific gravity dipstick is therefore recommended in evaluation of urine specimens; it is an accurate, valuable, and extraordinarily useful addition to clinical diagnosis.

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