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Original Article

Urine specific gravity as a diagnostic tool for dehydration in children

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Abstract

Background Using clinical judgment to diagnose dehydration can be highly subjective. To diagnose dehydration, it would be ideal to have an accurate, inexpensive, objective and easy-to-perform diagnostic tool. In cases of dehydration, plasma osmolality rises, causing an increase in antidiuretic hormone (ADH) secretion. The increased ADH reduces urine production and increases urine osmolality. Previous studies have shown that urine osmolality correlates well to urine specific gravity. We investigated if urine specific gravity can be a reliable and objective determination of dehydration status.

Objective To assess the accuracy of using urine specific gravity as a diagnostic tool to determine dehydration status of children with diarrhea.

Methods We conducted the study in the pediatric ward of Sardjito Hospital from September 2009 to December 2009. Using a refractometer we measured urine specific gravity from patients with diarrhea. This measurement was then compared to a standard of acute body weight loss, with dehydration defined as weight loss of 5% or more. The cut-off value for defining dehydration using specific gravity measurements was determined by a receiver-operator curve (ROC).

Results Out of 61 pediatric patients who were recruited in this study, 18 (30%) had dehydration as defined by a body weight loss of 5% or more. Based on the ROC, we determined the cut-off value for urine specific gravity to be 1.022. Using this value, urine specific gravity was 72% sensitive (95% CI 52 to 93), and 84% specific (95% CI 73 to 95) in determining dehydration status.

Conclusion Urine specific gravity is less accurate than clinical judgment in determining dehydration status in children with diarrhea. **[Paediatr Indones. 2010;50:269-73]**.

Keywords: *urine specific gravity, dehydration, refractometer*

Dehydration may be a dangerous condition if it is not recognized and treated in a timely manner. Diarrhea is the main cause of dehydration in children and is still a major pediatric health problem in Indonesia.[1,2] Dehydration status in diarrhea is primarily assessed through clinical evaluation. Clinical evaluation of dehydration using the *Integrated Management of Childhood Illness* (IMCI) methodology is fairly accurate,[3] but there is high variability among observers.[4] Furthermore, patients with malnutrition or obesity present challenges to clinical judgment due to excess body fat and interstitial water composition.[5,6]

In cases of dehydration, increased plasma osmolality results in an increase in antidiuretic hormone (ADH) secretion. ADH reduces urine production and increases urine osmolality.[7] Normal kidneys can concentrate urine to 50-1200 mosm/kg.[7,8] Previous studies have shown that urine osmolality correlates with urine specific gravity.[8-10] Refractometry directly measures the urine's refractive index and is, therefore, an indirect measure for urine specific gravity. For healthy adults, refractometry is

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a more reliable and valid method for measuring urine specific gravity compared to dipstick or hydrometer methods.[11] Using a refractometer to measure urine specific gravity is superior to the dipstick method because refractometers are easy to calibrate, highly reliable and not influenced by urine acidity (pH) or temperature fluctuations. However, accuracy of refractive index measurements is influenced by the presence of glucose and protein in urine.[12,13]

We established the cut-off point for urine specific gravity for dehydration in children to be 1.020 (SD 0.01)[14] based on dipstick examination. In adult populations, a value of 1.030 is more accurate for diagnosing dehydration.[15] However, there is no data on the accuracy of using urine specific gravity measured by refractometry in diagnosing dehydrated children. The aim of this study was to determine the accuracy of using urine specific gravity measurements by refractometer to diagnose dehydration in children with diarrhea.

Methods

We conducted a study in pediatric ward of Sardjito Hospital, Yogyakarta from September 2009 to December 2009. We included children with acute diarrhea of ages greater than 1 month and obtained informed consent from their parents. We excluded subjects with renal disorders, diabetes mellitus, proteinuria, glucosuria, and anuria after one hour of rehydration.

Our aim in the study was to determine if urine specific gravity can be used as a diagnostic tool for assessing dehydration status. We compared urine specific gravity measurements to an IMCI-standard of clinical assessment of dehydration status, as well as the standard of acute body weight loss of 5% or more. Body weights were measured at the time of admission and 24 hours after cessation of diarrhea and vomiting, at which time patients were no longer considered dehydrated.

It was determined that we needed a minimum sample size of 61 to achieve a 95% confidence interval, 10% standard deviation, 80% sensitivity and 80% specificity.

Urine specific gravity measurements were obtained using a refractometer from Sur-ne®, Cat No. 2374, Atago Co. Ltd, Japan. Two drops of urine sample were placed in the refractometer prism, and a measurement was taken. The reading between the light and dark areas was interpreted as the urine specific gravity. The value interval was 1.000 to 1.060 **(Figure 1)**. We trained two paramedics (as observers) to assess urine specific gravity by refractometry. They performed a pilot study using 5 urine samples collected from inpatients in the pediatric ward.

For body weight measurements, we used a GEA® body scale for subjects under 20 kg and a Camry® body scale for subjects above 20 kg body weight. The scales had been calibrated by *Balai Metrologi, Dinas Peridustrian, Perdagangan, Koperasi dan Usaha Kecil Menengah Provinsi Daerah Istimewa Yogyakarta*. Urine samples were collected from the patient's first urination within 1 hour of rehydration or admission. A portion of the urine sample was sent to the Clinical Pathology Laboratory for urinalysis to exclude proteinuria or glucosuria. The specific gravity of the remaining sample was assessed by two observers using a refractometer. The observers were blinded to the clinical condition of the subjects.

We evaluated dehydration status in the patients using clinical signs according to IMCI parameters. When patients were not considered dehydrated, a second body weight measurement was taken after 24 hours. Patients were subsequently weighed multiple times, twice in the morning and twice in the evening, until the readings had less than 2% variability. The

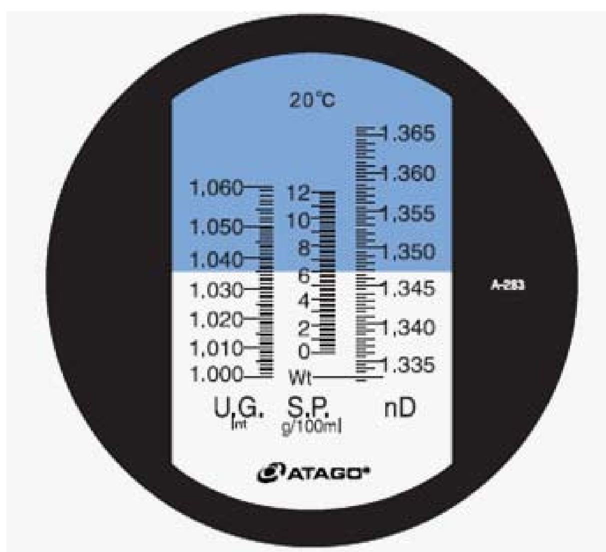

Figure 1. The refractometer ocular lens view.

true body weight was considered to be the average value of the re-weighings.

Results

The study involved 61 children, consisting of 29 boys and 32 girls with median of age of 24 months. Out of the 61 children, 18 (30%) were dehydrated with an average body weight loss of 6.88% (SD 1.3). The control group (the remaining 43 children who were not dehydrated) had an average body weight loss of 1.5% (SD 0.6). No subjects were considered to be severely dehydrated (weight loss ≥ 10%). The mean variability of reweighings was 0.8% (SD 0.7).

The cut-off point for urine specific gravity as a sign of dehydration is shown in a ROC curve (**Figure 2**).

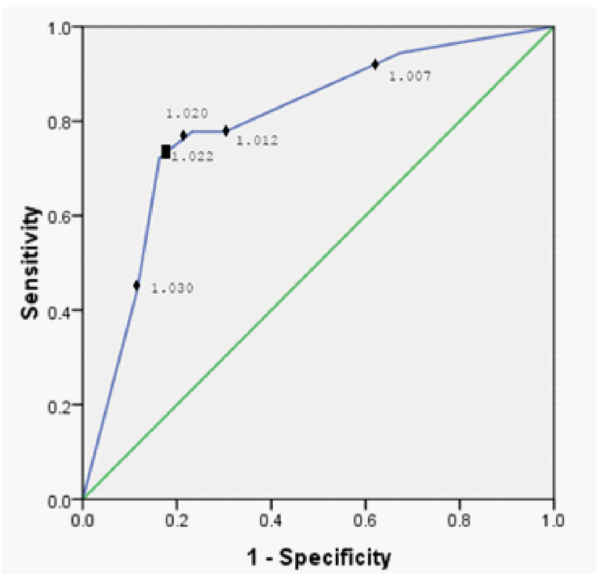

Figure 2. The ROC for urine specific gravity shows that a value of 1.022 has the best sensitivity and specificity combination.

The values of urine specific gravity in this study varied from 1.005 to 1.030. **Table 1** shows the accuracy of each urine specific gravity measurement. The values of 1.005 and 1.010 were the most sensitive and the values of 1.025 and 1.030 were the most specific. The value of 1.022 had low positive likelihood ratio 4.46 (95% CI 2.13 to 9.26). Hence, by using this value, pre- and post-test probability will not change significantly.

Discussion

In this study, we investigated the use of urine specific gravity measurement as a tool for assessing dehydration status in children with diarrhea. Urine specific gravity was compared to the use of clinical judgment, as well as to a standard of body weight loss of 5% or more.

Our findings do not pertain to severe dehydration (body weight loss ≥ 10%), since we had no such cases available to us. Based on the ROC curve, the cut-off point for dehydration using urine specific gravity was 1.022. This value has the best combination of sensitivity and specificity, and was similar to the results of a previous study[14] which found that the mean value for urine specific gravity in children with dehydration was 1.020 (SD 0.01). However, compared to clinical judgment by IMCI-based parameters[3], the sensitivity of urine specific gravity was lower (87% vs 91%).

We conclude that clinical judgment is better in establishing an initial diagnosis of dehydration than urine specific gravity. However, consideration should be given to using the urine specific gravity measurements secondarily to exclude the diagnosis of dehydration due to its high specificity. In this scenario, we recommend using the urine specific gravity level of 1.025 to exclude dehydration since this value has

Table 1. The sensitivity and specificity of each urine specific gravity value

Urine Specific Gravity	Sensitivity (%) (95% Confidence Interval)	Specificity (%) (95% Confidence Interval)
1.005	94 (84;100)	28 (15;41)
1.010	94 (84;100)	33 (19;47)
1.015	78 (59;97)	70 (56;83)
1.020	78 (59;97)	77 (64;89)
1.022	72 (52;93)	84 (73;95)
1.025	44 (21;67)	88 (79;98)
1.030	39 (16;61)	88 (79;98)

an even higher specificity than 1.022, albeit lower sensitivity.

Urine specific gravity is an indirect measurement of urine osmolality. In certain conditions, such as obese or malnourished patients, this tool may be of particular value. We did not measure urine osmolalilty in this study. As such, the relationship between urine osmolality and urine specific gravity in our patients was not determined. A wide interval of urine osmolality has been shown to correlate to a relatively narrow interval of urine specific gravity, thus influencing the accuracy of using urine specific gravity to assess dehydration.

A weakness of this study is that we were unable to conclude if urine specific gravity can be used to determine the degree of dehydration, since we had no cases of severe dehydration. Also, we measured the first urination within 1 hour of admission. We assumed that urine production within the first hour of rehydration was still representative of a dehydrated condition.

Diagnosis of dehydration by urine specific gravity can still be useful in patients with diarrhea, post-surgical states or low intake problems. But urine specific gravity is not recommended in diabetics or patients with renal problems. In such cases, disruption of the urine dilution mechanism and proteinuria may increase urine specific gravity, thus leading to a wrong conclusion.

From this study, we conclude that urine specific gravity can be used as a secondary diagnostic tool for dehydration in children, following clinical assessment. A cut off point of 1.025 is recommended for increased specificity. Specificity is decreased if the urine specific gravity cut-off point for excluding dehydration is lowered to 1.022.

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Author's contribution:

KJP: has been involved in drafting the manuscript and revising it critically for important intellectual content.

MJ, DI: have made substantial contributions to conception and design or acquisition of data, analysis and interpretation.

All authors gave final approval of the version to be published.

Conflict of interest

The author(s) declare that they have no competing interests.

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