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Brief Report

CLINICAL UTILITY OF NONINVASIVE METHOD TO MEASURE SPECIFIC GRAVITY IN THE PEDIATRIC POPULATION

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☐ **Abstract—Background: Clinicians rely on any combination of signs and symptoms, clinical scores, or invasive procedures to assess the hydration status in children. Noninvasive tests to evaluate for dehydration in the pediatric population are appealing. Objective: The objective of our study is to assess the utility of measuring specific gravity of tears compared to specific gravity of urine and the clinical assessment of dehydration. Methods: We conducted a prospective cohort convenience sample study, in a pediatric emergency department at a tertiary care children's hospital. We approached parents/guardians of children aged 6 months to 4 years undergoing transurethral catheterization for evaluation of urinary tract infection for enrollment. We collected tears and urine for measurement of tear specific gravity (TSG) and urine specific gravity (USG), respectively. Treating physicians completed dehydration assessment forms to assess for hydration status. Results: Among the 60 participants included, the mean TSG was 1.0183 (SD = 0.007); the mean USG was 1.0186 (SD = 0.0083). TSG and USG were positively correlated with each other (Pearson Correlation = 0.423, $p = 0.001$). Clinical dehydration scores ranged from 0 to 3, with 87% assigned a score of 0, by physician assessment. Mean number of episodes of vomiting and diarrhea in a 24-hour period were 2.2 (SD = 3.9) and 1.5 (SD = 3.2), respectively. Sixty-two percent of parents reported decreased oral intake. Conclusion: TSG measurements yielded similar results compared with USG. Further studies are needed to determine if TSG can be used as a noninvasive method of dehydration assessment in children.** © 2017 Elsevier Inc. All rights reserved.

☐ **Keywords—dehydration; pediatric emergency medicine; pediatrics; specific gravity; tears; urine**

INTRODUCTION

Dehydration is likely to complicate any illness commonly seen in the pediatric population, including acute gastroenteritis (AGE). In 2013, the AGE-coded emergency department (ED) visit rate was 382 per 10,000 and the AGE hospitalization rate was 34 per 10,000 for children under 5 years of age (1–3). Dehydration risk can increase in light of decreased oral intake or in combination with the inability to keep up with ongoing oral or diarrheal losses. This risk is further heightened in children younger than 2 years of age, and especially in neonates. Rapid identification and management of dehydration in the pediatric population is essential to decrease morbidity and to prevent mortality.

Clinicians rely on any combination of signs and symptoms, clinical scores, or invasive procedures to assess the hydration status of children (4–6). Venipuncture to measure serum markers such as blood urea nitrogen or other electrolytes or transurethral catheterization to measure urine specific gravity (USG) have been utilized to objectively measure dehydration, but studies vary on their accuracy in predicting clinical dehydration (6–9). Noninvasive tests to evaluate for dehydration in the

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pediatric population are appealing, as they would reduce the need for painful procedures such as venipuncture and transurethral catheterization, especially in the younger child. Urine osmolarity, USG, and urine color have been used to assess hydration status, with USG having a specificity of 91% and sensitivity of 89%, similar to urine osmolarity (8). The use of tears for assessing hydration status is plausible because the renin angiotensin aldosterone system has comparable effects on the concentrating abilities of both the kidney and the eyes (10). Tear osmolarity (Tosm) has been found to be comparable with plasma osmolarity and USG in healthy adult volunteers (11). Further, Tosm has been shown to be a good indicator of changes in hydration status in athletic males in exercise and post-exercise rehydration (12). Given the comparability of Tosm with USG, we believe that tear specific gravity (TSG) will also correlate similarly to USG.

The use of the TSG as a noninvasive method to evaluate the hydration status of children should be explored. This has the potential to guide clinician decision-making in a rapid and meaningful manner. The objective of our study is to assess the utility of measuring TSG compared with USG and to compare these with the clinical assessment of dehydration in children.

MATERIALS AND METHODS

Study Design, Setting, and Participants

We conducted a prospective cohort study utilizing a convenience sample of pediatric ED patients in a tertiary care children's hospital between September 2014 and April 2015. Children ages 6 months to 4 years being evaluated for possible urinary tract infection were identified and were eligible for study participation. We chose 6 months as the lower age limit because the ability of the kidney to concentrate urine reaches that of adult capacity as early as 6 months (13). As part of the routine evaluation for urinary tract infection, ED nurses collected urine via transurethral catheterization from children unable to void spontaneously. The evaluation of these children included a chemical urinalysis (dipstick method), which provided indices for specific gravity as well as markers of infection. We assumed that children having transurethral catheterization for urine testing would spontaneously cry, thus producing tears for which the chemical urinalysis could be used to test the TSG. This study was approved by the Institutional Review Board.

Data Collection, Tear Sample Collection, and Tear Specific Gravity Measurement

After we obtained informed consent, we collected data including: presence and duration of vomiting or diarrhea, temperature at home, and history of recent oral intake. We collected tears into a specimen cup if the patient produced them during transurethral catheterization, as described earlier. No additional means of inducing crying was utilized. We excluded patients if they did not produce tears. Prior to tear collection, we cleaned the patient's face with an alcohol wipe and tears were collected as close to the eye as possible to avoid specimen contamination. We characterized tear quantity at the time of sampling as none, reduced, or large. We tested tears for specific gravity using Siemens Multistix® 10 SG Reagent Strips for Urinalysis (Siemens Healthcare Diagnostics, Inc., Tarrytown, NY) prior to obtaining the USG results. Although the Siemens Multistix® 10 SG Reagent Strips have not been previously used to study TSG, due to previous findings supporting the strong relationship between tear osmolarity and USG, a consensus was reached among the study team to use this method (11). The study investigative team obtained the TSG result manually by performing a visual comparison of the reagent strip to the urinalysis chart attached to the Siemens Multistix® 10 SG Reagent Strips for Urinalysis container and documented the TSG results prior to reviewing the medical record for USG results.

Urine Specific Gravity Measurement

Registered nurses or ED patient care technicians analyzed urine obtained via transurethral catheterization using Siemens Multistix® 10 SG Reagent Strips for Urinalysis and the Clinitek Status®+ Analyzer by Siemens. The analyzer uploaded the final USG result to the electronic medical record and printed a copy of the results for the treating physician. The USG measurement was recorded on the data collection form after the documentation of the TSG result.

Clinician Assessment of Hydration

The treating physician was asked to complete a validated clinical dehydration scale (CDS) for children (14,15). The CDS assesses the characteristics of general appearance, eyes, mucous membranes, and tears. Each characteristic is assigned a score of 0, 1, or 2 by the physician. The total score ranges from 0 to 8. The completion of the CDS was made prior to knowledge of USG or TSG results. CDS components are detailed in Table 1.

Statistical Analysis

Patient characteristics were analyzed using descriptive statistics. The correlation between USG and TSG was tested using Pearson Correlation. Linear regression was