The Accuracy of Clinical Assessment of Dehydration During Diabetic Ketoacidosis in Childhood

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The objective of this study was to examine the accuracy of the assessment of clinical dehydration in children with type 1 diabetes and diabetic ketoacidosis (DKA). DKA remains the single most common cause of diabetes-related death in childhood (1). Accurate assessment and management of dehydration is the cornerstone of DKA treatment (1,2). The assessment of the degree of dehydration has traditionally been according to clinical criteria including peripheral tissue perfusion and indicators of hemodynamic status (3). The clinical assessment of dehydration in children in common nonacidotic states (e.g., gastroenteritis) has been previously shown (4) to overestimate the degree of dehydration by ~3.2%. There have been no comparable studies in either DKA or any other form of metabolic acidosis.

RESEARCH DESIGN AND METHODS

— We studied a random convenience sample of 37 children with type 1 diabetes, newly or previously diagnosed, who presented to the Royal Children's Hospital, Melbourne, with DKA. The patients were all <18 years of age and presented to the emergency department at Royal Children's Hospital between 1996 and 2000. The study entry criteria were pH <7.30 (capillary, venous, or arterial) and/or bicarbonate <15 mmol/l and ketones in the urine on dipstick testing. The following information was recorded by the primary assessing doctor: newly diagnosed or established diabetes, age, sex, date and time seen, heart rate, respiratory rate, blood pressure, pale and/or cool hands and feet, peripheral capillary refill time, reduced skin turgor, level of consciousness (on a rating scale of one to eight), sunken eyes, sunken fontanelle, dry tongue, Kussmaul breathing, blood glucose level, and estimated degree of dehydration (clinical assessment). A second emergency department doctor, who was blinded to the clinical interpretations of the primary doctor, was asked to review the patient before treatment in the emergency department and record their assessment of the same clinical variables. Both doctors were asked to grade dehydration by category (0–2, 3–6, 7–9, 10–12, and >12%).

Following admission, nursing staff recorded daily weights until discharge. The absolute degree of dehydration was calculated from the weight gain from admission to discharge as a percentage of the child's rehydrated weight. For patients admitted for ≥5 days, the average weight of days 4–6 was used. Measured dehydration was converted into the same dehydration categories as those used for the doctors' assessments.

Statistical analysis

Agreement between the doctor's assessments of dehydration and between assessed and measured dehydration were evaluated using κ-statistics (5).

RESULTS

— The greatest number of patients (18 of 37) were between 5 and 10% dehydrated at presentation (as calculated by their weight gains), with a median absolute measure of 8.7% dehydration.

There was a good level of agreement between the primary and secondary assessor ($\kappa = 0.5$). There was agreement between assessors as to the degree of dehydration in 28 of 37 patients. Of the remaining nine patients, there was disagreement of the amount of dehydration of 3% in eight patients and 6% in only one patient.

There was no agreement between assessed and measured dehydration ($\kappa = 0.05$) (Fig. 1). In patients who were <6% dehydrated (measured), the trend was to overestimate dehydration, whereas in patients >6% dehydrated (measured), the trend was to underestimate dehydration. Seventy percent (26 of 37) of the patients had their hydration status incorrectly assessed (24% [9 of 37] overestimated and 46% [17 of 37] underestimated).

Among both the newly diagnosed DKA patients and those with DKA and established diabetes, none of the clinical variables measured by primary and secondary assessors or biochemical variables had a statistically significant independent association with the degree of measured absolute dehydration.

CONCLUSIONS

— Accurate hydration assessment is critical in DKA management. It is a contentious issue whether overzealous rehydration may contribute to cerebral edema in children with DKA

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Abbreviations: DKA, diabetic ketoacidosis.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

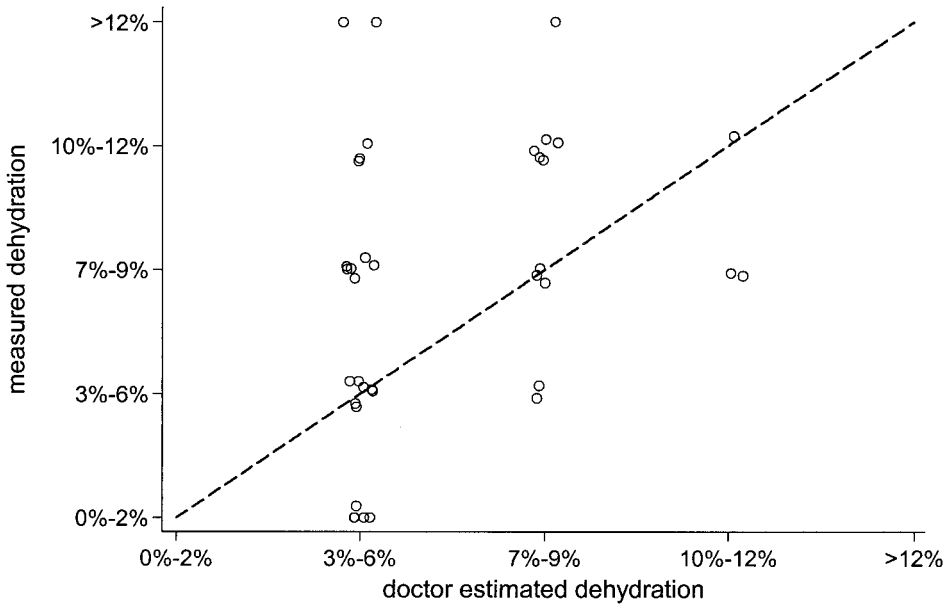

Figure 1—*The relationship between estimated (by doctor 1) and measured dehydration, grouped into five categories.*

(2,6,7). Conventional clinical assessment of the degree of dehydration is based on numerous clinical signs and symptoms (8) and mostly assesses the depletion of extracellular fluid volume. The assessment of dehydration in DKA is complicated by extra- and intravascular dehydration, metabolic acidosis affecting the clinical signs of dehydration, and the overall catabolic state of the patient. Metabolic acidosis can cause a decrease in peripheral vascular resistance, a decrease in cardiac ventricular function, and compensatory hyperventilation (9). Prolonged insulin deficiency is associated with lipolysis and proteolysis and subsequent weight loss. All of these independent effects may interfere with the clinical assessment of dehydration. Thus in patients presenting with DKA, the signs of hemodynamic stability (heart rate and blood pressure), capillary refill, tissue turgor, moistness of oral mucous membranes, and degree of weight loss may not be indicative of only fluid losses per se.

In our study the discrepancy between estimated and true dehydration appears to be an operator-independent phenomenon. Our data show good agreement between the two independent assessing doctors. This is presumably a reflection of the consistency in the training and practice of our medical staff in assessing clinical hydration. Unfortunately, in the clinical context of DKA, such training and practice appears to be erroneous. Other studies (4,10,11) have suggested that the traditional clinical signs of dehydration are poor tools in other nonacidotic conditions such as gastroenteritis. Mackenzie et al. (4) found that in pediatric patients with gastroenteritis the four signs that best predicted dehydration were capillary refill time >2 s, absent tears, dry mucous membranes, and overall appearance of illness. Murphy et al. (11) found that the most valuable signs of assessing dehydration in gastroenteritis were decreased skin turgor, dry oral mucosa, sunken eyes, and altered neurological status. None of these clinical parameters were found to be good predictors in our study of DKA.

The previous assumption of an average overall 10% dehydration in patients with DKA (3,12,13) appears to be a slight overestimate. The median absolute measure of dehydration as calculated by our patients' weight gain was 8.7%. Given that clinical hydration assessment appears to be unreliable when compared with absolute measures of dehydration and that no single clinical parameter appears to be of benefit, we feel that a conservative empirical approach may be advocated. Initial bolus therapy of 10–20 ml/kg body wt of normal saline should be given until the patient is normotensive, with ongoing meticulous care and frequent observations of hemodynamic status. Thereafter, an initial assumption of 7–9% dehydration seems a reasonable figure upon which to base rehydration calculations in most patients. This estimate may be the best compromise between the potentially catastrophic risks of overhydration compared with the lesser risks of prolonged mild underhydration. Rehydration should take place over a 48-h period, with normal or half-normal saline and adequate potassium replacement. Ongoing therapy should of course include estimates of continuing fluid loss and electrolyte status as recommended by the recent ESPE/LWPES (European Society for Paediatric Endocrinology/Lawson Wilkins Pediatric Endocrine Society) guidelines (14).

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