

COMPARISON OF THE ACCURACY OF THE CLINICAL DEHYDRATION SCALE AND GORELICK 10-POINT SCALE VERSUS PRE- AND POST-HYDRATION BODY WEIGHT AMONG CHILDREN WITH ACUTE GASTROENTERITIS

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Abstract. Accurate assessment of the percent dehydration of patients is important to guide treatment. The objective of this study was to compare the accuracy of the clinical dehydration scale (CDS), the Gorelick 10-point scale for dehydration assessment versus pre- and post-hydration body weight among children aged 15 years with acute gastroenteritis. The WHO dehydration scale was not tested due to a previous study indicating it was less accurate. The sensitivity, specificity, predictive value and Receiver Operating Characteristics curves were calculated for both the scales evaluated. A total of 220 children were enrolled. The CDS had a sensitivity of 22.1%, a specificity of 86%, a positive predictive value of 45.9%, a negative predictive value of 67.2% and an area under the curve (AUC) of 0.56 (95%CI:0.48-0.64). The Gorelick 10-point scale had a sensitivity of 45.5%, a specificity of 58%, a positive predictive value of 36.8%, a negative predictive value of 66.4% and an (AUC) of 0.52 (95%CI:0.44-0.60) compared to the pre- and post-hydration weight change. The clinical dehydration scale and the Gorelick 10-point scale had a fair correlation with estimating dehydration and were not significantly different from each other ($p = 0.19$). Further studies regarding the clinical usefulness of these dehydration scores need to be conducted to determine if their application results in improved outcomes.

Keywords: acute gastroenteritis, clinical dehydration scale, Gorelick 10-point scale, sensitivity, specificity

INTRODUCTION

Acute diarrhea is the second most common health problem among children

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aged < 5 years and can result in mortality (Wardlaw *et al*, 2010). Tools to assess dehydration severity in children with acute gastroenteritis are important because appropriate treatment depends on the severity of dehydration (Guarino *et al*, 2014). The degree of dehydration estimated by history and physical examination has a low sensitivity and specificity and affected by the physician's experience (King *et al*, 2003). The clinical dehydration scale

(CDS) is an instrument used to quantify dehydration in children aged 1 month to 3 years. A score is given based on the degree of dehydration with a possible score of 0-8 points, with a score of 0 being <3% dehydration, 1-4 being 3-6% dehydration and 5-8 being >6% dehydration (Table 1) (Friedman *et al*, 2004). The Gorelick 10-point scale is another instrument used to quantify dehydration in children aged 1 month to 5 years, with a possible score of 0-10. A score of <3 being <5% dehydration, 3-6 being 5-9% dehydration and >7 being >10% dehydration (Table 2) (Gorelick *et al*, 1997). Jauregui *et al* (2014) compared the CDS, Gorelick 10-point scale and World Health Organization(WHO) scales (WHO,2005) and found the CDS and Gorelick 10-point scale both had an area under the Receiver Operating Curve (ROC) curve (AUC) significantly associated with the severity of dehydration of 0.72 [95% confidence interval (CI): 0.6-0.84] and 0.71 (95%CI: 0.57-0.85), respectively. However, the WHO scale had an AUC of 0.61 (95%CI: 0.45-0.77) not significantly associated with severity of dehydration. Because of this, in this study we chose to evaluate only the CDS and Gorelick 10-point scale.

In this study, we used the pre-and post-hydration weight as the gold standard to compare the 2 studies scales with Duggan *et al* (1996); Gorelick *et al* (1997) and Vega *et al* (1997). Our aim was to determine the accuracy of these scales compared to the pre- and post-hydration weights in order to choose the best scale as a tool in the management of dehydration in children at the study institution.

MATERIALS AND METHODS

Children aged from 1 month to 15 years with a history of acute gastroen-

teritis were enrolled. This study was conducted at the Faculty of Medicine, Vajira Hospital between 1 October 2016 - 31 October 2017. Exclusion criteria were children with chronic disease, such as renal or heart disease and severe malnutrition, diarrhea for longer than 7 days or intravenous fluid administration within 24 hours prior to enrollment. The study was approved by the ethics committee of Faculty of Medicine, Vajira Hospital. This study was a prospective study and informed consent and assent form were obtained.

After admission, the patients were evaluated for the degree of dehydration by a physician according to his or her experience and the data were recorded in the CDS (Table 1) and Gorelick 10-point scale (Table 2). Treatment depended on the severity of dehydration: mild, moderate, or severe dehydration were treated with fluid replacement as maintenance plus 3%, 6% and 10% deficit, respectively. Patients were weighed bare before and after treatment using the same scale (SECA, model 727 for children aged <1 year; Tanita model WB 3007351 for children aged ≥1 year).

The pre- and post-hydration weight (gold standard) were used to calculate dehydration as follows:

$$\text{Percent post-hydration weight gain} = \frac{(\text{Final weight} - \text{Initial weight})}{\text{Final weight}} \times 100\%$$

Initial weight = body weight before treatment. Final weight = body weight after hydration when the patient stops having diarrhea and vomiting (Duggan *et al*, 1996; Gorelick *et al*, 1997; Vega *et al*, 1997).

If the percent post-hydration weight gain was 3-5% the patient was considered to have mild dehydration.

Table 1
Clinical dehydration scale.

Characteristic	Dehydration scale		
	0 points	1 points	2 points
General appearance	Normal	Thirsty, restless or lethargic but irritable when touched	Drowsy, limp, cold, sweaty, possibly comatose
Eyes	Normal	Slightly sunken	Very sunken
Mucous membranes (tongue)	Moist	Sticky	Dry
Tears	Tears	Decreased tears	Absent tears

0 points= <3% dehydration; 1-4 points= 3-6% dehydration; 5-8 points= > 6% dehydration.

Table 2
Gorelick 10-point scale.

Characteristic	No or minimal dehydration	Moderate to severe dehydration
General appearance	Alert	Restless, lethargic, unconscious
Capillary refill	Normal	Prolonged or minimal
Tears	Present	Absent
Mucous membranes	Moist	Dry, very dry
Eyes	Normal	Sunken, deeply sunken
Breathing	Present	Deep, deep and rapid
Quality of pulses	Normal	Weak or not palpable
Skin elasticity	Instant recoil	Slow return, return take >2 secs
Heart rate	Normal	Tachycardia
Urine output	Normal	Reduced, not passed in many hours

Score of moderate to severe dehydration column < 3 = < 5% dehydration, 3-6 = 5-9% dehydration, >7 = > 10% dehydration.

If the percent post-hydration weight gain was 5-9% the patient was considered to have moderate dehydration.

If the percent post-hydration weight gain was > 10% the patient was considered to have severe dehydration.

Statistical analysis

The sample size was calculated by using the clinical dehydration scale (CDS) with sensitivity of 62% and prevalence of 41% from the study by Hall *et al* (2011) as the equation shown:

$$N = \frac{Z_{\alpha/2}^2 P (1 - P) \times 100}{e^2 \times \text{Prevalence}}$$

N = sample size, P = sensitivity, $Z_{\alpha/2}$ = value for alpha level(0.05) at 95% confidence interval = 1.96, e = precision of the estimation = 0.1, N (from sensitivity)

$$= \frac{1.96^2 \times 0.62(1 - 0.62) \times 100}{0.1^2 \times 41} = 220$$

The receiver operating characteristics (ROC) curve was constructed to compare the performance of the CDS score and

Table 3
Dehydration categories of the study subjects.

Degree of dehydration	Number (%) of subjects
No dehydration (<3% dehydration)	143 (65)
Mild dehydration (3-5% dehydration)	27 (12.3)
Moderate dehydration (5-10% dehydration)	34 (15.5)
Severe dehydration (\geq 10% dehydration)	16 (7.2)

the Gorelick 10-point score with the gold standard (post-hydration weight gain) (Duggan *et al*, 1996; Vega *et al*, 1997; Gorelick *et al*, 1997).

We calculated the sensitivity, specificity, likelihood ratio, predictive value and area under the curve. A p -value <0.05 is regarded as statistical significance. Statistical analysis was performed using Statistical Package for the Social Sciences (SPSS) version 22.0 (IBM, Armonk, NY).

RESULTS

Two hundred twenty children were enrolled in the study. The median age of study subjects was 39 months. Fifty point five percent of subjects were males. The median length of hospital stay was 3 days. The median blood urea nitrogen level was 14 mg/dl [Interquartile range (IQR)= 10-18 mg/dl], the median creatinine level was 0.33 mg/dl (IQR = 0.27-0.40 mg/dl). Seven percent of the subjects were diagnosed with having severe dehydration (Table 3). Two point seven percent of subjects had a lower post-hydration than pre-hydration weight. The CDS had an area under the curve of 0.56 (95%CI: 0.48-0.64) for moderate dehydration (>6% percent weight change). The CDS had a sensitivity of 22.1%, a specificity of 86%, a positive predictive value of 45.9%, a negative predictive value of 67.2%, a positive

likelihood ratio of 1.58 and a negative likelihood ratio of 0.91 compared to the pre- and post- hydration weight change (Table 4). For moderate dehydration (5-9% weight change) the Gorelick 10-point scales had an area under the curve of 0.52 (95%CI: 0.44-0.60), a sensitivity of 45.5%, a specificity of 58%, a positive predictive value of 36.8%, a negative predictive value of 66.4%, a positive likelihood ratio of 1.08 and a negative likelihood ratio of 0.94 compared to the pre- and post- hydration weight change. The CDS and Gorelick 10-point scale had areas under the curve (AUC) of 0.56 (95%CI: 0.48-0.64) and 0.52 (95%CI: 0.44-0.60), respectively, compared to the pre- and post-hydration weight change. The CDS had a slightly greater accuracy than the Gorelick 10-point scale to identify moderate dehydration but this difference was not statistically significant ($p = 0.19$)(Fig 1) .

DISCUSSION

The severity of dehydration is evaluated by a physician's clinical skill, which is based on history and physical examination. Previous studies (Jauregui *et al*, 2014; Hoxha *et al*, 2015) compared the accuracy of the CDS, Gorelick 10-point scale and WHO scale to predict degree of dehydration compared to the pre- and post-hydration weight change as the gold standard.

In clinical practice the pre-illness weight is often not available; therefore, the pre- and post-hydration weight change is substituted for pre-illness weight. Gorelick *et al* (1997) compared the pre- and post-hydration weight change with pre-illness weight and found a good correlation ($r=0.9988$). Therefore, we used this method in our study (Duggan *et al*, 1996; Gorelick *et al*, 1997; Vega *et al*, 1997).

In our study the Gorelick 10-point scale and CDS had areas under the curve (AUC) of 0.52 (95%CI: 0.44-0.60) and 0.56 (95%CI: 0.48-0.64), respectively, for identifying moderate dehydration with no significant difference between the 2 methods ($p=0.19$).

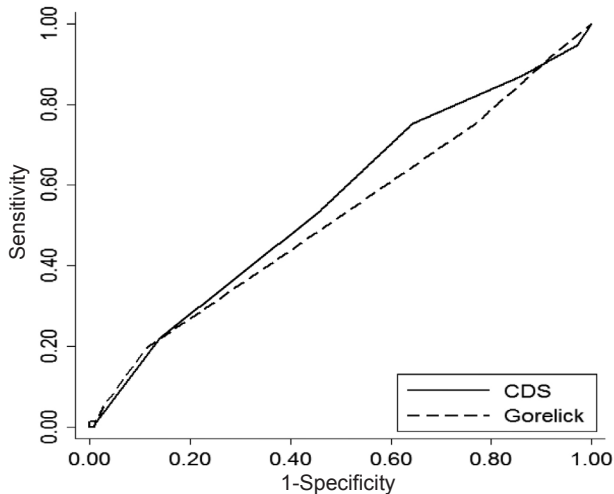
Jauregui *et al* (2014) reported the CDS and Gorelick 10-point scale had areas under the ROC curve (AUC) of 0.72 (95%CI: 0.6-0.84) and 0.71 (95%CI: 0.57-0.85), respectively, significantly associated with dehydration. However, the WHO scale had an AUC of 0.61 (95%CI: 0.45-0.77), which was not significantly associated with severity of dehydration. Hoxha *et al* (2015) reported the WHO scale and Gorelick 10-point scale for identifying significant dehydration had an AUC of 0.71 (95%CI: 0.65-0.77), and 0.74 (95%CI: 0.68-0.81), respectively and the CDS had an AUC of 0.51 (95% CI: 0.45-0.63) which had less accuracy than the WHO scale and Gorelick 10-point scale. The varying degree of accuracy of the Gorelick 10 point scale, CDS and WHO scale for identifying dehydration may depend on the study population and the experience of health care personnel using these scales.

Falzewska *et al* (2018) assessed the diagnostic accuracy of the CDS, WHO scale and Gorelick scale in identifying dehydration in children with acute gastroenteritis and reported the CDS had a sensitivity of

Table 4
Results compared to pre- and post-hydration weight change.

Evaluation scale	% Sensitivity (95% CI)	% Specificity (95% CI)	% Positive predictive value (95% CI)	% Negative predictive value (95% CI)	Positive likelihood ratio (95% CI)	Negative likelihood ratio (95% CI)
Clinical dehydration scale ($\geq 6\%$ dehydration)	22.1 (13.4-33)	86 (79.2-91.2)	45.9 (29.5-63.1)	67.2 (59.9-74.0)	1.58 (0.88-2.83)	0.91 (0.79-1.04)
Gorelick 10-point scale (5-9% dehydration)	45.5 (34.1-57.2)	58 (49.5-66.2)	36.8 (27.2-47.4)	66.4 (57.4-74.6)	1.08 (0.79-1.48)	0.94 (0.73-1.2)

CI, confidence interval.



	Clinical dehydration scale (≥ 6% dehydration)	Gorelick 10-point scale (5-9% dehydration)	p-value
AUC (95% CI)	0.56 (0.48-0.64)	0.52 (0.44-0.60)	0.19

AUC, area under the curve; CI, confidence interval; CDS, clinical dehydration scale.

Fig 1—CDS scale and Gorelick 10-point scale predicting moderate dehydration.

50%, a specificity of 87%, a positive likelihood ratio of 3.9 and a negative likelihood ratio of 0.6 for identifying moderate to severe dehydration. Falzewska *et al* (2018) reported WHO scale to identifying moderate dehydration(> 5% dehydration) had a sensitivity of 36%, a specificity of 69% a positive likelihood ratio of 1.2 and negative likelihood ratio of 0.9, Gorelick scale had a sensitivity of 10%, a specificity of 77%, a positive likelihood ratio of 0.4 and negative likelihood ratio of 1.2. Therefore Falzewska *et al* (2018) found the CDS was the most accurate tools to identify moderate to severe dehydration but the WHO and Gorelick scales were less accurate in identifying dehydration.

In our study, the CDS had a positive likelihood ratio of 1.58 and a negative likelihood ratio of 0.91 and the Gorelick 10-point scale had a positive likelihood ratio of 1.08 and a negative likelihood ratio of 0.94 for identifying moderate dehydration, similar to the result from a study in Rawanda (Pringle *et al* (2011) reported the CDS had a positive likelihood ratio of 1.24 and negative likelihood ratio of 0.7. Both the CDS and Gorelick scales were developed to assess children aged < 5 years, but in our study we used these to evaluate children up to age 15 years which could have had an effect on our results. The varying degrees of accuracy of the CDS and Gorelick 10-point scales in identifying dehydration may be due to the subjective assessment of these tools. New objective tools are needed to identify the degree of dehydration, if possible. Using the pre- and post-hydration weight

change may over- or under-estimate the degree of dehydration. In this study 2.7% of participants had a lower post-hydration weight than pre-hydration weight. The causes of this could be inaccurate scales or weighing methods or discharge prior to adequate hydration or they may reflect actual weight loss.

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