ORIGINAL PAPER

Comparing the Accuracy of the Three Dehydration Scales in Children with Acute Diarrhea in a Developing Country of Kosovo

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ABSTRACT

Background. Although diarrhea is a preventable disease, it remains the second leading cause of death (after pneumonia) among children aged under five years worldwide. The World Health Organization (WHO) scale, the Gorelick scale, and the Clinical Dehydration Scale (CDS) were created to estimate dehydration status using clinical signs. The purpose of this study is to determine whether these clinical scales can accurately assess dehydration status of children in a developing country of Kosovo. **Methodology.** Children aged 1 month to 5 years with a history of acute diarrhea were enrolled in the study. After recording the data about the patients historical features the treating physician recorded the physical examination findings consistent with each clinical score. Receiver operating characteristic (ROC) curves were constructed to evaluate the performance of the three scales, compared to the gold standard, percent weight change with rehydration. Sensitivity, specificity and likelihood ratios were calculated using the best cut-off points of the ROC curves. **Results.** We enrolled 230 children, and 200 children met eligibility criteria. The WHO scale for predicting significant dehydration (≥5 percent weight change) had an area under the curve (AUC) of 0.71 (95% : CI= 0.65-0.77). The Gorelick scales 4- and 10-point for predicting significant dehydration, had an area under the curve of 0.71 (95% : CI=0.63- 0.78) and 0.74 (95% : CI= 0.68-0.81) respectively . Only the CDS for predicting the significant dehydration above ≥6% percent weight change, did not have an area under the curve statistically different from the reference line with an AUC of 0.54 (95% CI = 0.45- 0.63). **Conclusion.** The WHO dehydration scale and Gorelick scales were fair predictors of dehydration in children with diarrhea. Only the Clinical Dehydration Scale was found not to be a helpful predictor of dehydration in our study cohort.
Key words: Acute diarrhea, clinical dehydration scale, dehydration.

1. INTRODUCTION

Although diarrhea is a preventable disease, it remains the second leading cause of death (after pneumonia) among children aged under five years worldwide (1, 2). The management of acute diarrhea in children is largely based on clinical examination which allows assessment of hydration status (3). In the literature, the established criterion standard for determining the degree of dehydration is retrospectively determined by the percent weight change before and after volume resuscitation (4, 5). However, this is not useful in the emergency department or acute care setting (6). Accurate fluid assessment is of utmost importance in low- and middle-income countries, where many patients travel several hours to reach a healthcare facility, and resources such as IV fluids and hospital beds are scarce (7). Few tools are available to help providers in resource-limited settings predict which children with diarrhea are at risk for severe disease and require hospital admission and intravenous fluids (8).

Several organizations and research institutions have developed scales to estimate dehydration status using clinical signs. To overcome the limited accuracy of individual clinical signs, the World Health Organization (WHO) recommends using a combination of four different clinical signs to identify severe dehydration in children with diarrhea, which is considered the standard of care in many low-income countries (9). Prior research conducted at the Hospital for Sick Children in Toronto resulted in the creation of the Clinical Dehydration Scale (CDS) for use in children from 1 month to 3 years of age (10). The WHO scale classifies children by grouping severity of symptoms, while the CDS has a scoring system. The Gorelick scale (created at the Children's Hospital of Philadelphia), uses binary categorization of symptoms either as no dehydration or moderate/severe dehydration, and severity is determined by the number of physical signs present (11). The aim of this study was to investigate the accuracy of the WHO scale, Gorelick

scale, and Clinical Dehydration Scale (CDS) for predicting significant dehydration in a developing country of Kosovo.

2. METHODOLOGY

Children aged 1 month to 5 years with a history of acute diarrhea were enrolled in the study. This prospective study was conducted at the Pediatric Clinic of the University Clinical Center of Kosovo in Prishtina. It is a tertiary pediatric referral center that serves a population of approximately 2 million inhabitants. Enrollment occurred during the year 2012–2013, and included all children presenting with diarrhea with or without vomiting on weekdays from 7:00 a.m.–3:00 p.m., and occasional nights and weekends based on availability of study staff. Exclusion criteria were: diarrhea of more than 7 days duration, chronic disease (e.g., renal, gastrointestinal, cystic fibrosis), severe malnutrition and large volume fluid administration prior to enrollment. After recording the data about the patients historical features the treating physician recorded the physical examination findings consistent with each clinical score. After admission the patients were weighed on a standard scale (Romed BS 20) and all patients were taken for intravenous hydration, regardless of the severity of the case. Study staff followed all children during their hospitalizations, repeating weight measurements daily, using the same study scale, without clothing, at 7:30 am each morning. Post-illness weight was defined as the first weight with less than 1% of differences between two consecutive daily weight measurements, after diarrhea and vomiting had disappeared. It was calculated as: (post-illness weight – admission weight) / post-illness × 100 for the "gold standard" method (3). Subjects with a percentage weight change of 5% or more were considered to be significantly dehydrated based on standards in the pediatric literature (4, 11, 12, 13). Significant dehydration was defined as moderate (5-10%) and severe (>10%) dehydration combined. The written consent was obtained from the parent or legal guardian.

We calculated descriptive statistics. Each patient was classified according to the clinical scale (WHO, Gorelick, and CDS). Receiver operating characteristic (ROC) curves were constructed to evaluate the performance of the three scales, compared to the gold standard, percent weight change with rehydration. Sensitivity, specificity and likelihood ratios were calculated using the best cut-off points for the WHO and Gorelick scales that correlated with significant dehydration, defined as ≥ 5% weight change. For the CDS these test characteristics were calculated for those children classified as having ≥6% dehydration. All statistical analyses were performed using SPSS 20.0 (SPSS Inc. Chicago, IL).

3. RESULTS

During the study period, from a total number of hospitalized patients in our clinic (12021), during year 2012, 5723 patients and year 2013, 6298 patients, acute diarrhea accounted for 1024 (18%) and 1153(18%) hospitalization respectively. We approached 230 children for potential enrollment. Fifteen children were missing discharge weights, 5 patients had signs of severe malnutrition, 9 withdrew from the study or were excluded prior to completion of data collection, and one child died prior to discharge. Of the 200 children who achieved a stable weight

Clinical scale	SN (95% CI)	SP (95% CI)	LR+ (95% CI)	LR- (95% CI)
WHO	90% (81- 95)	54% (45-63)	1.98 (1.60-2.44)	0.19 (0.09-0.37)
Gorelick 4	89% (79-94)	52% (43-61)	1.85 (1.51-2.26)	0.22 (0.12-0.41)
Gorelick 10	97% (91-99)	50% (41-60)	1.97 (1.64-2.36)	0.05 (0.01-0.20)
CDS	18% (8.2-33)	91% (85-95)	2.0 (0.91-4.64)	0.90 (0.77-1.04)

Table 1. Test characteristics of clinical scales for predicting significant dehydration using best cut-off points that correlate with dehydration ≥6% weight change for CDS and ≥5% weight change for WHO and Gorelick scales. Abbr.: SN, sensitivity; SP, specificity; LR+, likelihood ratio positive; LR-, likelihood ratio negative.

prior to discharge, the average percent weight change with rehydration was 4.1%. Of these 121 had none or some dehydration (< 5%), while 79 had moderate/severe dehydration (≥ 5%). All children involved in the study were between 1 month and 5 years old and could be classified by the Gorelick and WHO scale, while 192 (96%) children between 1 month and 3 years old could be classified by the CDS. The mean age was 15.62±9.03 months for children 1 month-5 years and 14.54±7.4 months for children 1-36 months. The mean length of stay in hospital for children 1-36 months and 1month-5 years was 3.65±1.84.

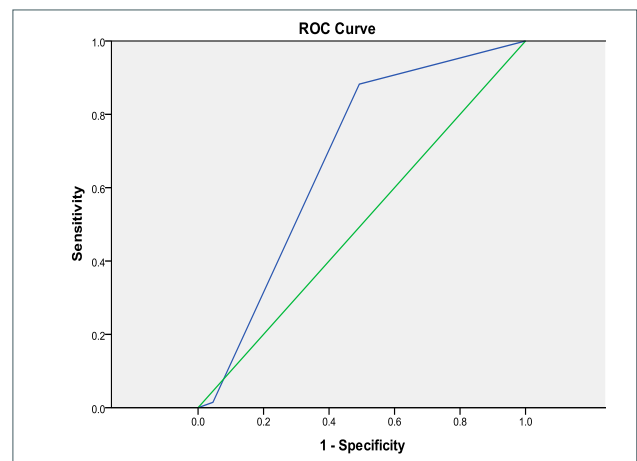The WHO scale for predicting significant dehydration (≥5 percent weight change) had an area under the curve (AUC) of

Figure 1. WHO scale predicting significant dehydration ≥5% body weight change. AUC (Area under the curve): 0.71, CI 95%: 0.65-0.77
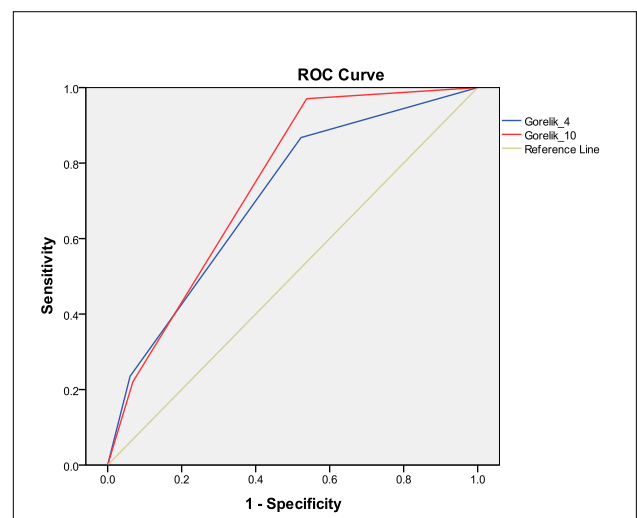

Figure 2. Gorelick 4-point and 10 –point scale predicting significant dehydration ≥5 body weight change. Area under the curve (AUC) for Gorelik 4: 0.71, CI 95%: 0.63-0.78 and for Gorelik 10: 0.74, CI 95%: 0.68-0.81
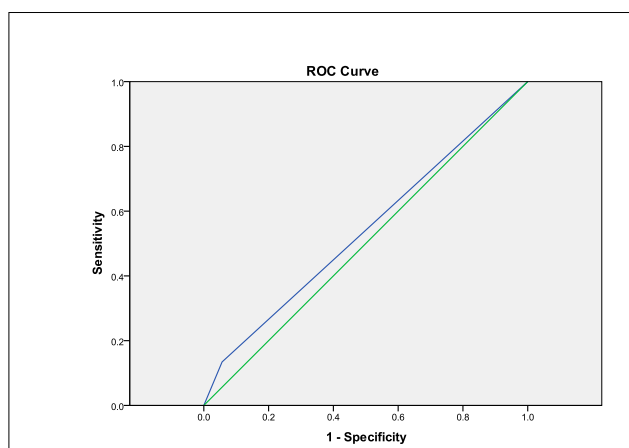
Figure 3. CDS scale predicting significant dehydration ≥6 body weight change AUC (Area under the curve): 0.54, CI 95%: 0.45-0.63

0.71 (95%: CI= 0.65-0.77) (fig.1); sensitivity was 90% (81- 95) and specificity 54% (45-63) ; LR+ was 1.98 (1.60-2.44) and LR- 0.19 (0.09-0.37) (tab.1). The Gorelick scales 4- and 10-point for predicting significant dehydration, had an area under the curve of 0.71 (95% : CI=0.63-0.78) and 0.74 (95% : CI= 0.68-0.81) respectively (fig. 2); sensitivities were 89% (79-94) and 97% (91-99), and specificities were 52% (43-61) and 50% (41-60), respectively (tab.1); LR+ was 1.85 (1.51-2.26) and 1.97 (1.64-2.36) and LR- 0.22 (0.12-0.41) and 0.05 (0.01-0.20) respectively (tab.1). For the prediction of significant dehydration above ≥6% percent weight change the CDS had an area under the curve of 0.54 (95% CI = 0.45-0.63) (fig.3). The sensitivity of the scale was 18% (8.2-33) and the specificity 91% (85-95), with a LR+ 2.0 (0.91-4.64) and LR- of 0.90 (0.77-1.04) (tab.1)

4. DISCUSSION

Dehydration due to acute diarrhea is frequent, costly because of number of hospital admissions required and sometimes serious, even fatal to children in our country. Globally during the past two decades the total annual number of deaths from diarrhea among children under 5 decreased by more than 50 percent – from over 1.2 million to fewer than 0.6 million (14). According to Azemi et al, in year 1989 the mortality rate from acute diarrhea of children less than five year old in Kosovo was 19.23%, whereas nowadays it is only 1% (15). Country case study from Brazil showed that in year 1989 diarrhea accounted for 25% of infant deaths (16) while in 2008 for 2.5% (17). This decline in diarrheal mortality is most likely due to modern case management, better nutrition of infants and children, improved water and sanitary services, promotion of breast feeding and of personal and domestic hygiene. Even though the mortality from diarrhea has fallen substantially in our country, the morbidity has remained still high. Our study shows that acute diarrhea accounted for 18% of hospitalization rate in Pediatric Clinic in Prishtina in year 2012 and 2013. The data from our study are lower than those of Kosek et al. who reported the hospitalization rate in children to be 21% (18). The mean length of hospital stay in our study was 3.65±1.84 days, a little shorter than the 4.8 days reported by Rocha et al (19).

We chose to study the CDS, Gorelick 4- and 10 point and WHO scale because only a few of them have been validated in a low-income country, where patients often present later in the course of their disease, and healthcare providers often lack

specialty training. Accurate assessment of the degree of dehydration can help clinicians guide treatment with either oral or intravenous fluid resuscitation, and is necessary for accurate prognosis and resource management (20). Clinically, the degree of dehydration in children is usually estimated based on historical and physical findings that lack a high degree of sensitivity, specificity and reliability (21). Several previous studies conducted in high- and middle-income countries have assessed the accuracy of clinical scales for predicting dehydration in children with diarrhea using the criterion standard of percent weight change with rehydration (12, 22, 23, 24, 25).

Gorelick, et al. assessed the accuracy of a 4- and 10-point clinical scale in children 1-60 months old with diarrhea presenting to Children's Hospital of Philadelphia. The two scales had sensitivities of 82% and 90% and specificities of 83% and 90%, respectively, for predicting the severity of dehydration (11). Vega, et al. assessed the accuracy of a similar 9-point scale in children presenting to an Academic Medical Center in New York and found a sensitivity of 70% and specificity of 84% for predicting severity of dehydration when performed by an emergency physician (26). The Clinical Dehydration Scale has been prospectively validated against the accepted gold standard of percent weight change with rehydration at a Canadian pediatric referral hospital and found to be a significant predictor of moderate-severe dehydration in that same population of children (10). Additional studies have found the Clinical Dehydration Scale to be a significant predictor of emergency department length of stay, treatment with intravenous fluids, and hospitalization, but not severity of dehydration (12, 23, 25). Pringle at al. have assessed the accuracy of the dehydration scales against an established criterion standard, in a resource-limited setting, conducted in the three hospitals in Rwanda. This pilot study did not find the WHO, Gorelick scale or Clinical dehydration scale to be accurate predictors of significant dehydration when compared with the criterion standard of percent weight change (7). Another study conducted in a resource-limited setting have investigated the accuracy of the three clinical dehydration scales, CDS, Gorelick 10-point and Centers for Disease Control (CDC) scale, for predicting severe disease. They found all three scales to be moderate predictors of severe disease in children with diarrhea, with statistically significant AUCs ranging from 0.72 to 0.80. However, neither of these scales has been externally validated in a North American population from which they were originally derived (8).

To prospectively validate three popular clinical dehydration scales and overall physician gestalt in children with vomiting or diarrhea Jauregui at al. found the CDS and Gorelick scale as fair predictors of dehydration based on the criterion standard of percent weight change with rehydration in a North American cohort. Neither the WHO scale nor physician gestalt was found to be a helpful predictor of dehydration (27). Overall, the clinical scales evaluated provide some improved diagnostic accuracy. However, test characteristics indicate that their ability to identify children both with and without dehydration is suboptimal (28).

In our study, the WHO and the Gorelick scales 4- and 10-point had an areas under the ROC curves (AUC) statistically different from the reference line, and therefore, were moderate predictors of significant dehydration. The CDS did not perform as well in our study population of children in Kosovo as they

did in North America. The scale did not have an area under the curve statistically different from the reference line, therefore, was no better than chance at predicting the severity of dehydration. Our study highlights the need for more research into better methods on developing and validating clinical prediction rules for detecting the severity of dehydration in children with diarrhea in low income countries.

5. CONCLUSION

Clinical dehydration scales when performed by physicians can be used to predict significant dehydration in children with diarrhea in a developing country. The WHO dehydration scale and Gorelick scales were fair predictors of dehydration in children with diarrhea. Only the Clinical Dehydration Scale was found not to be a helpful predictor of dehydration in our study cohort. Due to the high prevalence and significant morbidity associated with diarrhea, further research should focus on developing new diagnostic tools that can be used in a resource-limited setting to accurately evaluate dehydration in children.

CONFLICT OF INTEREST: NONE DECLARED.

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