Research Article / Özgün Araştırma

DOI: 10.4274/cayd.galenos.2021.65768
J Pediatr Emerg Intensive Care Med 2022;9:85-93

Are the Clinical Evaluation Scales and Laboratory Tests Adequate in Determining Dehydratation Degree in Acute Diarrhea?

Akut İshalde Dehidratasyon Derecesinin Belirlenmesinde Klinik Değerlendirme Ölçekleri ve Laboratuvar Tetkikleri Yeterli mi?

Yaşar Yusuf Can[1], Medine Ayşin Taşar[2], Arife Uslu Gökçeoğlu[3]

[1]İstanbul Sultanbeyli Public Hospital, Clinic of Clinic of Pediatric Intensive Care, İstanbul, Turkey
[2]University of Health Sciences Turkey, Ankara Training and Research Hospital, Clinic of Pediatric Emergency, Ankara, Turkey
[3]University of Health Sciences Turkey, Ankara Training and Research Hospital, Clinic of Pediatric Nephrology, Ankara, Turkey

Abstract

Introduction: The aim is to evaluate the reliability of the "World Health Organization dehydration scale (WHODO)", "clinical dehydration scale (CAS)" and "Gorelick scale (GS)" in determining the true degree of dehydration (DH) in children diagnosed with acute diarrhea, together with laboratory tests.

Methods: This study was conducted on children aged 3 months to 5 years who were diagnosed with acute diarrhea. Patients' admission weight, clinical findings and urea, creatinine, glucose, sodium, potassium, blood gases, and complete urine test results were recorded; DH grades of the patients were evaluated using WHODO, CAS and GS.The weight recorded within 48-72 hours after discharge was accepted as the actual weight of the patient. The gold standard in determining the degree of DH was considered to be the ratio of the patient's weight at admission to the weight after treatment.

Results: One hundred eight children with acute diarrhea were included in the study. WHODO, CAS and GS sensitivity rates, 90%, 52%, 54% for mild DH, 49.4%, 80%, 83% for moderate DH, 96.3%, 86%, 44% for severe DH. Specificity rates are 50%, 75%, 97% in mild DH, 87.5%, 26%, 53% in moderate DH, 44.4%, 73.9% and 96% in severe DH, respectively. In determining patients with DH degree ≥10%, the likelihood ratio of WHODS's positive test result was 11.0, GS's was 14.7. In determining mild DH, the likelihood ratio of the positive test result of GS was found to be 18.0. A significant correlation was found between actual DH degrees and pH, HCO_3, creatinine and urine density ($p<0.05$).

Conclusion: It was determined that WHODS and GS were successful in detecting ≥10% dehydration, GS was successful in determining mild dehydration, and situations where the child's weight was not known could be used. We think that pH and HCO_3, creatinine and

Öz

Giriş: Amaç, akut ishal tanısı alan, çocuklarda, ''Dünya Sağlık Örgütü Dehidratasyon Ölçeği (DSÖDÖ)'', "klinik dehidratasyon ölçeği (KDÖ)" ve "Gorelick ölçeğinin (GÖ)" laboratuvar testleri ile birlikte gerçek dehidratasyon (DH) derecesini saptamadaki güvenirliliklerini değerlendirmektir.

Yöntemler: Bu çalışma, çocuk acil polikliniğinde akut ishal tanısı alan 3 ay-5 yaş arası çocuklarda yapıldı. Hastaların başvuru kilosu, klinik bulgu ve üre, kreatinin, glukoz, sodyum, potasyum, kan gazları, tam idrar tetkiki sonuçları kayıt edildi; hastaların DH dereceleri, DSÖDÖ, KDÖ ve GÖ kullanılarak değerlendirildi. Taburculuk sonrası 48-72. saatte kaydedilen tartı hastanın gerçek kilosu olarak kabul edildi. DH derecesini belirlemede altın standart, hastanın başvurusundaki tartısının, tedavi sonrasındaki tartısına oranı olarak kabul edildi.

Bulgular: Çalışmaya 108 akut ishalli çocuk kabul edildi. DSÖDÖ, KDÖ ve GÖ duyarlılık oranları, hafif DH'de %90, %52, %54, orta derecede DH'de %49,4, %80, %83, ağır DH'de %96,3, %86, %44 olarak saptandı. Özgüllük oranları aynı sıra ile hafif DH'de %50, %75, %97, orta DH'de %87,5, %26, %53, ağır DH'de %44,4, %73,9 ve %96,9 olarak bulundu. DH derecesi ≥%10 olan hastaları belirlemede DSÖDÖ'nün pozitif test sonucu olabilirlik oranı 11,0, GÖ'nün 14,7 idi. Hafif DH belirlemede ise GÖ'nün pozitif test sonucu olabilirlik oranı 18,0 saptandı. Gerçek DH dereceleri ile pH, HCO_3, kreatinin ve idrar dansitesi arasında anlamlı ilişki olduğu tespit edildi ($p<0,05$).

Sonuç: DSÖDÖ ve GÖ'nün ≥%10 DH'yi saptamada başarılı oldukları, hafif DH'yi belirlemede GÖ'nün başarılı olduğu ve çocuğun kilosunun bilinmediği durumlarda bu ölçeklerin kullanılabileceği saptandı. Ayrıca pH ve HCO_3, serum kreatinin ve idrar dansitesinin de DH derecesini saptamada yararlı olduğu görüldü.

Address for Correspondence/Yazışma Adresi: Medine Ayşin Taşar, University of Health Sciences Turkey, Ankara Training and Research Hospital, Clinic of Pediatric Emergency, Ankara, Turkey
E-mail: aysintasar@yahoo.com **ORCID ID:** orcid.org/0000-0003-4367-725X
Received/Geliş Tarihi: 02.02.2021 **Accepted/Kabul Tarihi:** 25.04.2021

urine density will be useful in determining the degree of dehydration in cases where the child's weight is not known.

Keywords: Child, acute gastroenteritis, dehydration degree, World Health Organization dehydration scale, clinical dehydration scale, Gorelick scale

Anahtar Kelimeler: Çocuk, akut ishal, dehidratasyon derecesi, Dünya Sağlık Örgütü dehidratasyon ölçeği, klinik dehidratasyon ölçeği, Gorelick ölçeği

Introduction

Diarrhea, which is one of the most common diseases in childhood, is still an important cause of morbidity and mortality today.[1-4] According to the data of the World Health Organization (WHO), it is the second most common cause of death in children under the age of 5 years, and approximately 525,000 children in this age group die from diarrhea each year.[1] In developing countries, it was reported that 1 billion 731 million cases of diarrhea were seen in children under the age of 5 years in 2010, and 36 millions of them had a severe course requiring hospitalization.[5] In the health statistics 2017 data of the Ministry of Health in our country, it was stated that 32.3% of children aged 0-6 years had at least one episode of diarrhea in a six-month period.[6]

Dehydration management and determining the degree of dehydration form the basis of the treatment of a child diagnosed with acute diarrhea.[5,7-9] Overestimation of dehydration may result in unnecessary treatment with intravenous fluids and unnecessary hospitalizations. On the other hand, underestimating dehydration can lead to delayed treatment and progression of symptoms.[7,8] Therefore, it is important to evaluate the degree of dehydration in the patient well. The best indicator of dehydration in a child presenting with acute diarrhea is the loss of body weight as percentage during the illness.[9] Since the pre-disease weight of the child is not usually known at the hospital admission, the physician uses clinical scales to estimate the degree of dehydration and thus to determine the treatment steps. In cases with dehydration, the method known as the "5%, 10%, 15% rule" is used to estimate the body weight lost by using skin turgor, absence of tears, dry mucous membranes, increased heart rate, decreased blood pressure and decreased urine output.[5,7,10]

While clinical scales may produce different results in every population, the accuracy rates of symptoms and signs used to show the degree of dehydration are also very low.[11] Therefore, different scales have been developed to obtain more reliable and valid results. The most commonly known and used scales are the WHO scale for dehydration, the clinical dehydration scale (CDS), and the Gorelick scale (GS).[5,12-14]

There are publications showing that the use of laboratory tests, in addition to clinical observations and the scales used, for the identification of the degree of dehydration in pediatric patients with acute diarrhea and, as a result, for the determination of treatment will give more accurate results.[15-17] However, there are conflicting results regarding whether there is a relationship between biochemical tests and the severity of dehydration.[18,19]

The aim of this study is to reveal the diagnostic accuracy of "WHO" scale for dehydration, "CDS" and "GS" in determining the degree of dehydration in children aged between three months and five years, who were admitted to the pediatric emergency service of our hospital with the complaint of diarrhea and were diagnosed with acute diarrhea, and to evaluate their importance in the detection of the actual degree of dehydration together with laboratory tests. In our country, there is no study evaluating the validity of these three dehydration scales.

Materials and Methods

Our hospital is a tertiary pediatric hospital and serves approximately 150,000 patients annually. This cross-sectional study was carried out in University of Health Sciences Turkey, Ankara Health Application and Research Center, Pediatric Emergency Outpatient Clinic between 1 June 2018 and 1 January 2019. It was carried out in line with the approval of the University of Health Sciences Turkey, Ankara Training and Research Hospital Education Planning and Coordination Board with the decision dated 03.10.2018 and numbered 572. Verbal consent was obtained from all families. Children aged between 3 months and 5 years, who were admitted with the complaint of diarrhea and diagnosed with acute diarrhea, were included in the study.

Diarrhea was defined as three or more defecations per day, stool fluid content higher than normal, or increased defecation frequency.[5,9]

Patients with diarrhea lasting longer than 5 days, those with a history of renal/cardiac failure, those with a disease that might affect the hydration assessment such as diabetes mellitus, those with a history of head, chest and abdominal trauma or surgery in the last 7 days, those receiving intravenous fluid therapy in the last 24 hours, and those with hyponatremia (Na<130) or hypernatremia (Na>150) detected in clinical examination, which might affect turgor assessment, were excluded from the study.

The symptoms, clinical findings and weights of the patients with the diagnosis of acute diarrhea, who were included in the

study, were recorded at admission. All patients were weighed on the same scale by the responsible researcher. The patient's daily activity, the presence of sunken eyes, the presence of tears if crying, the desire to drink water and the amount of urine in the last 24 hours (the number of wet diapers taken if using diapers), in case of vomititng the amount and number of it, and the amount of liquids that could be given orally to the patient during this time were questioned. The patient's respiratory rate, capillary refill time, heart apex beat, blood pressure, pulse fullness, and skin turgor were evaluated and noted.

The degree of dehydration of the patients at admission was evaluated by the responsible researcher using WHO scale for dehydration, CDS, and GS. According to the results of the evaluation, the treatment of the patient was arranged according to the recommendations of the European Society of Pediatric Gastroenterology, Hepatology and Nutrition.[9] Fluid therapy of the patient was performed considering the formula "pre-admission weight (gr)-weight at admission (gr)/100" if the pre-admission weight was known, or according to the degree of dehydration calculated with the WHO scale for dehydration if it was not known.

The gold standard in determining the degree of dehydration was accepted as the ratio of the patient's weight at admission to that after treatment.[9]

All patients were taken to emergency observation, and their blood and urine samples were evaluated before the treatment. The results of the complete blood count, urea, creatinine, glucose, sodium, potassium, blood gases, and urinalysis were recorded by the researcher.

In monitoring, the clinical condition and weight of the patient were evaluated, and the patient was discharged provided that the need for intravenous fluid was eliminated and the oral fluid intake compensated for the loss. Their weights at discharge were recorded. The patients were called for control examinations after 48-72 hours after discharge; their weights were recorded, and these weights were accepted as pre-disease weights. The difference between the patient's weight at the time of admission and the control weight was recorded in each patient's file as the degree of dehydration.

Height and body weight measurements were evaluated using a baby scale sensitive to 10 grams for children younger than 24 months and a weight scale with stadiometer sensitive to 100 grams for children older than 24 months. The patients' clothes were removed and the measurement was recorded only with clean diapers. Weight loss was calculated by weighing under the same conditions and on the same scale at the control examinations.

Clinical Scales Used in the Study

WHO scale for dehydration: It is a scale that evaluates general appearance, eyeballs, thirst, and turgor (Table 1).[5,20] With the scale, the presence of maximum two findings in parts B and C is evaluated as mild dehydration (<5% loss), the presence of findings more than two in part B is evaluated as moderate dehydration (5-10% loss), and the presence of findings more than two in part C is evaluated as severe dehydration (>10% loss).

Clinical dehydration scale: The scale developed by the center for disease control and prevention evaluates general appearance, eyeballs, mucous membranes, and tears (Table 2).[12] According to the presence of findings, 0,1,2 points are given. The total score is between 0 and 8 points. A score of "0" means no dehydration (<3% loss), "1-4" means moderate dehydration (3-6% loss), and "5-8" means moderate-severe dehydration (>6% loss).

GS: A dehydration scale using 10 findings was developed by Gorelick et al.[13] to define fluid losses of 5% or more (Table 3). With the multiple logistic regression model, they showed that four out of 10 findings were independently associated with dehydration. In the model consisting of four findings, two findings indicate >5% fluid loss, while three or more findings indicate >10% fluid loss. In the model consisting of ten findings, more than three findings indicate >5% fluid loss, and seven or more findings indicate >10% fluid loss.[21,22]

Statistical Analysis

Size of sample was calculated by using the formula developed by Flahaut et al.[22] following the study by Falszewska et al.[21]. One hundred-eight patients were included in the study with 80% sensitivity and 65% lowest acceptability parameters and 10% exclusion assumption.

Data analysis was performed using SPSS (Statistical Package Fort He Social Sciences for Windows 20.0) software. Whether the distribution of continuous and discrete numerical variables was close to normal was investigated using the Kolmogorov-

Table 1. World Health Organization scale for dehydration (5)

	A	B	C
General appearance	Good, active	Restless	Somnolence or unresponsive
Eyes	Normal	Sunken	Sunken
Thirst	No feeling of thirst	Severe thirst	Severe thirst, unwillingness for water
Skin turgor	Fast return to normal	Slow return to normal	Very slow return to normal

Table 2. Clinical dehydration scale (12)

Features	0	1	2
General appearance	Normal	Thirsty, restless or lethargic	Sleepy, limp, cold or sweaty, unconscious
Eyes	Normal	A little sunken	Very sunken
Mucous membranes	Moist	Sticky	Dry
Tears	Normal	Decreased	None

Smirnov test. Descriptive statistics were presented as mean ± standard deviation or median (minimum-maximum) for continuous and discrete numerical variables, and as number of cases and "%" for categorical variables.

After evaluating the normality of the distribution of numerical data, the significance of the difference between the groups in terms of mean values was investigated with the Student's t-test, and the significance of the difference in terms of median values was investigated with the Mann-Whitney U and Kruskal-Wallis Tests. Categorical variables were evaluated with the Pearson's chi-square or Fisher's Exact chi-square tests. For correlation evaluation, the Pearson or Spearman correlation test was used according to data distribution; $p<0.05$ was considered significant.

Whether the dehydration scales were determinative in detecting actual dehydration was evaluated by calculating the receiver operation characteristic (ROC) curve, calculating the area under the curve with different ROC analysis.

Results

Among the patients who applied to the pediatric emergency outpatient clinic with the complaint of diarrhea between 1 June 2018 and 1 January 2019 and were diagnosed with acute diarrhea, 116 patients who met the inclusion criteria for the study were included in the study. Three patients were excluded from the study because they left the hospital during the treatment, and five patients were excluded because they did not come for follow-up after treatment. The study was completed with 108 patients.

The mean age of the study group was 22.3±14.7 months (the youngest: 3 months-the oldest: 60 months), and 39 (36.1%) were girls and 69 (63.9%) were boys.

When the clinical findings of the patients were evaluated at admission, it was found that 50.9% (n=55) were restless, 78.7% (n=85) had sunken eyes, and 45.4% (n=49) had decreased tears (Table 4).

The degree of dehydration in the patients was evaluated according to the dehydration scales (Table 5). When the actual degree of dehydration of the patients was evaluated according to their body weight loss, it was found that 69.4% (n=75) of the patients had mild, 22.2% (n=24) had moderate, 8.3% (n=9) had severe dehydration.

Table 3. Gorelick dehydration scale (13)

	Absent or mild dehydration	Moderate to severe dehydration
General appearance	Active, lively	Lethargic, restless
Capillary refill time	≤2 sec	>2 sec
Tears	Normal	None
Mucous membrane	Moist	Dry
eyes	Normal	Sunken
Respiratory	Normal	Deep
Pulse	Normal	Weak
Skin turgor	Normal	Return to normal >2 sec
Heartbeat	Normal	Tachycardia
Urine output	Normal	Decreased

Table 4. Clinical characteristics of the study group

		n	%
General appearance	**Good**	50	46.3
	Restless	55	50.9
	Lethargic	3	2.8
Eyes	**Normal**	20	18.5
	Sunken	85	78.7
	Very sunken	3	2.8
Tears	**Normal**	55	50.9
	Decreased	49	45.4
	None	4	3.7
Skin turgor	**Normal**	28	25.9
	Decreased	77	71.3
	Very decreased	3	2.8
Capillary refill time	**Normal**	103	95.4
	Prolonged (>2 seconds)	5	4.6
Mucous membranes	**Moist**	60	55.5
	Dry	46	42.6
	Very dry	2	1.9
Solunum	**Normal**	104	96.3
	Deep	3	2.8
	Deep-fast	1	0.9
Pulse	**Normal, full**	104	96.3
	Fast, weak	4	3.7
Heart rate	**Normal**	90	83.3
	Tachycardia	18	16.7
Urine	**Normal**	80	74.1
	Decreased	28	25.9

Considering the actual degree of dehydration in the patients, the success of the dehydration scales in detecting the degree of dehydration was evaluated (Table 6, Figure 1).

In identifying the patients with a degree of dehydration greater than 10%, the likelihood ratio of a positive test result

Table 5. Evaluation of the degree of dehydration in the study group according to the World Health Organization scale for dehydration, clinical dehydration scale and Gorelick scale

Scales		n	%
World Health Organization scale for dehydration	Mild	41	38.0
	Moderate	63	58.3
	Severe	4	3.7
Clinical dehydration scale	Normal	8	7.4
	Moderate	96	88.9
	Severe	4	3.7
Gorelick scale	Normal	42	38.9
	Moderate	59	54.6
	Severe	7	6.5

was calculated as 11.0 for the WHO scale for dehydration and as 14.7 for GS; thus, it was found that the WHO scale for dehydration and GS were successful in detecting dehydration greater than ≥10%. In determining mild and/or minimal dehydration, the likelihood ratio of a positive test result for GS was found to be 18.0, and it was found to be successful in detecting mild dehydration (Table 6).

Among the biochemical values of the study group at the time of admission, pH was measured as 7.34±0.07 (min-max: 7.1-7.5), bicarbonate as 16.0±4.1 mmol/L (min-max: 7-24), urea as 27.1±13.2 mg/dL (min-max: 5-74), creatinine as 0.3±0.1 mg/dl (min-max: 0.1-0.9), sodium as 137.8±4.6 mEq/L (min-max: 129-160), potassium as 4.3±0.5 mEq/L (min-max: 2.9-5.8), and urine density as 1019±7 (min- max: 1003-1036).

When the relationship between the actual degree of dehydration (<5%, 5-10%, >10%) and biochemical variables was evaluated, it was determined that as the actual degree of dehydration increased, pH and $cHCO_3$ values decreased, creatinine and urine density increased, and this difference was statistically significant (p=0.013; 0.001; 0.010; 0.009, respectively).

When the relationship between the WHO scale for dehydration, CDS and GS and biochemical variables was examined, it was observed that the WHO scale for dehydration displayed a negative correlation with blood pH (p=0.001, r=-0.392) and HCO_3 (p=0.001, r=-0.367), and a statistically significantly positive correlation with serum creatinine (p=0.004, r=0.27), serum sodium (p=0.007, r=0.26) and urine density (p=0.01, r=0.23). CDS demonstrated a negative correlation with blood pH (p=0.002, r=-0.302) and HCO_3 (p=0.001, r=-0.296), and a statistically positive correlation with serum creatinine (p=0.001, r=0.35), serum sodium (p=0.001, r=0.348) and blood urea (p=0.001, r=0.33) values. GS was found to have a negative correlation with blood pH (p=0.001, r=-0.367) and HCO_3 (p=0.001, r=-0.445), and a statistically positive correlation with serum creatinine (p=0.01, r=0.23), serum sodium p=0.001, r=0.31), and urine density (p=0.001, r=0.31).

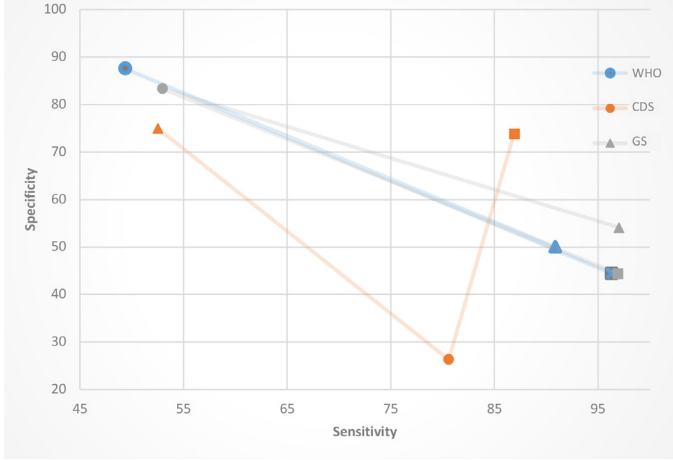

Figure 1. Sensitivity and specificity of scales. Triangles represent mild, round shapes represent moderate, squares represent severe dehydration

WHO: World Health Organization, CDS: Clinical dehydration scale, GS: Gorelick scale

Discussion

Studies have reported that dehydration assessment scales may have different results depending on the demographic structure of the population.[21,23,24] Although our country has a middle income level, our hospital serves the low socioeconomic region. The answer to the question of how to

Table 6. Sensitivity and specificity values of the World Health Organization scale for dehydration, clinical dehydration scale, and Gorelick scale compared to actual degrees of dehydration

	World Health Organization scale for dehydration			Clinical dehydration scale			Gorelick scale		
Degree of dehydration (%)	5	5-10	>10	<3	3-6	>6	5	5-10	>10
Specificity (%)	50	87.5	44.4	75.0	26.3	73.9	54.1	83.3	44.4
Sensitivity (%)	90.9	49.4	96.3	52.5	80.6	86.9	97.0	53.0	96.9
Llikelihood ratio of positive test result	5.56	1.72	11.0	1.56	1.3	5.69	18.0	1.77	14.7
Llikelihood ratio of negative test result	0.55	0.25	0.58	0.48	0.92	0.29	0.47	0.32	0.57
Prevalance (%)	37.4	58.9	3.7	7.0	71.0	22.0	38.3	55.1	6.5

increase the optimal evaluation with laboratory tests and to investigate the diagnostic accuracy of these scales in patients followed up in our hospital for acute diarrhea was sought.

Diarrhea treatment in children is based on determining the degree of dehydration and meeting the losses with appropriate hydration.[5] Overestimating dehydration may lead to overtreatment with intravenous fluids and unnecessary hospitalizations, while underestimating dehydration may lead to delayed treatment and progression of symptoms.[7,8] The gold standard in determining the degree of dehydration is the ratio of the difference between the weights measured before and during the disease to the weight of the patient.[5,9,11]

Since it is very rare to know the pre-disease weight of the patients, the assessment of the severity of dehydration is based on the findings obtained from the clinical examination.[5,11] In the literature, there are publications reporting that the accuracy of each finding used in the evaluation of dehydration is quite low.[12,13,25] Instead, scaling tables consisting of a group of symptoms and clinical findings give more accurate diagnostic results.[12,13,21,25]

Many organizations and research institutes have developed scaling tables consisting of clinical signs and symptoms to estimate dehydration rates. The most important ones are the WHO scale for dehydration developed by WHO, CDS developed by Toronto Children's Hospital, and GS developed by Philadelphia Children's Hospital.[5,12,13,20] The severity of dehydration is determined by the physical signs that are present. It is observed that the degree of dehydration estimated by each scaling table also differs from each other.

The WHO scale for dehydration is used in the evaluation of children aged 1 month to 5 years in terms of dehydration.[5,19] In a meta-analysis evaluating the WHO scale for dehydration, seven studies were evaluated. Of these, four were implemented in low-income countries, while only one had significant data with moderate (5-10%) and severe dehydration (>10%) scaling results.[26] Jauregui et al.[20] conducted a study with 113 patients, and they found the sensitivity of the WHO scale for dehydration in predicting the degree of dehydration as 25% and the specificity as 84%, and they reported that it was not significant. In a study conducted by Falszewska et al.[21] in high-income countries, they reported that the WHO scale for dehydration was not significant in detecting and excluding mild and moderate dehydration, and they could not define its accuracy in recognizing severe dehydration since there were no severely dehydrated patients. In our study, the sensitivity rate of this scale was 90% in mildly dehydrated patients, 49.4% in moderately dehydrated patients, and 96.3% in severely dehydrated patients. In the same scale, the specificity rates were determined as 50%, 87.5%, and 44.4%, respectively. For the WHO scale for dehydration, the likelihood ratio of a positive test result in severely dehydrated patients (>10%) was found to be 11.0, and it was found to be quite reliable in detecting severely dehydrated patients.

The CDS is used to evaluate the dehydration of patients aged one month to three years.[12,14] Kinlin and Freedman[27] evaluated the reliability and validity of CDS in 208 patients aged 3 months to 5 years, who needed intravenous fluids due to the diagnosis of acute diarrhea. They did not find CDS as statistical significant in the evaluation of weight gain (difference between weight at admission and weight after treatment). However, they found a correlation between an increase in the number of defecations per day, a decrease in serum bicarbonate and pH value, and an increase in the length of hospital stay and an increase in the degree of dehydration. However, they showed that it was not valuable in distinguishing between patients without dehydration and mild/moderately dehydrated patients and in determining the need for treatment with intravenous fluids. In the study of Bailey et al.[28], 150 patients aged one month to five years with a diagnosis of acute diarrhea were evaluated. In this study, it was observed that CDS was beneficial in the length of hospital stay, intravenous hydration, and the use of laboratory tests. Gravel et al.[29] conducted a study on 219 patients with a diagnosis of acute diarrhea and reported that they found a significant relationship between this scale and weight loss, serum bicarbonate level, length of hospital stay, and the need for intravenous hydration. In a meta-analysis by Falszewska et al.[23], in which six studies were reviewed, it was reported that while the diagnostic accuracy of CDS was significant in predicting moderate/severe dehydration in high-income countries (likelihood ratio of positive test result: 3.9-11.79), it had limited value in exclusion (likelihood ratio of negative positive test result: 0.55-0.71). In low/middle-income countries, they found that its diagnostic accuracy in recognizing and excluding dehydration was quite low. In our study, the sensitivity rates of CDS were found to be 52% in mildly dehydrated patients, 80% in moderately dehydrated patients, and 86% in severely dehydrated patients. In the same scale, the specificity rates were determined as 75%, 26%, and 73.9%, respectively. The likelihood of positive test result for CDS in detecting dehydration (in mild-moderate-severely dehydrated patients) was found to be low, and it was not found reliable in detecting dehydrated patients.

The GS is used in the evaluation of dehydration in patients aged 1 month to 5 years.[13] In this scale, general appearance, capillary refill time, tears, mucous membranes, eyes, respiration, pulse, skin turgor, heart rate, and urine output are evaluated and dual classification is used as no dehydration or moderate/severe dehydration according to the severity of symptoms. Gorelick et al.[13] stated that the 10-point scale had 82% sensitivity and 90% specificity to predict dehydration

in children. Hoxha et al.[24] found the sensitivity of GS to be 89% and the specificity to be 52% in detecting moderate/severe dehydration (>5%), and they found it significant in detecting whether there was dehydration. Falszewska et al.[21] evaluated 117 patients with GS, and the sensitivity for moderate dehydration (5-10%) was only 10%, while the specificity was 77%. Since there was no severely dehydrated patient group in the study, no evaluation could be made, and they stated that GS had no value in detecting and excluding ≥5% dehydration. In our study, GS sensitivity rates were 54% in mildly dehydrated patients, 83% in moderately dehydrated patients, and 44% in severely dehydrated patients, while specificity rates were 97%, 53%, and 96.9%, respectively. The likelihood ratio of a positive test result of GS was 18.0 in mildly dehydrated patients, and 14.7 in severely dehydrated patients (>10%), and it was found to be quite reliable in detecting mildly and severely dehydrated patients.

In the literature, in a study in which three dehydration clinical scales were compared in countries with middle-low income level, the sensitivity and specificity were found to be18% and 91% for CDS, and 90% and 54% for the WHO scale for dehydration.[24] In the study of Pringle et al.[26], conducted with patients under the age of 18 years with acute diarrhea in low-income countries, it was reported that the WHO scale for dehydration, CDS, and GS were not significant in predicting dehydration. On the other hand, Hoxha et al.[24] found that the WHO scale for dehydration and GS were significant in detecting dehydration in patients with acute diarrhea in developing countries, while CDS was insufficient to detect dehydration. In our study, when the three scales were compared, the WHO scale for dehydration was found to be successful in detecting severely dehydrated patients, while GS was successful in detecting mild and severely dehydrated patients. Although it has been reported that CDS is useful in determining dehydration in developed countries, we did not find it significant in our study.

Various laboratory parameters have been proposed to increase the accuracy of clinical dehydration assessment.[15-19] There are publications that accept and do not accept the importance of these laboratory variables in predicting the degree of dehydration. While the most studied serum urea value was found to be significant in predicting dehydration in some studies, it was found to be insignificant in other studies.[11,18,19]

In the studies, serum sodium, potassium, pH, bicarbonate, glucose, blood urea nitrogen, creatinine and urine density were used to evaluate the degree of dehydration. In the literature, while there are publications reporting that there is a relationship between serum blood urea nitrogen, serum bicarbonate level <15-22 mmol/L and severe dehydration, there are studies reporting no relationship.[15,17,19] In the results of our study, it was determined that there was a significant relationship between the actual dehydration degrees and pH and $cHCO_3$, creatinine and urine density.

Hoxha et al.[17] have reported in a study that blood gas, when combined with clinical examination, is the most useful parameter in evaluating the degree of dehydration, and that serum creatinine and urea values are the most specific tests in the diagnosis of severe dehydration although they are insufficient in distinguishing mild and moderate dehydration. In the study of Yilmaz et al.[30], it was found that serum urea and bicarbonate values were useful in determining the degree of dehydration, and their sensitivity and specificity increased when combined with dehydration scales. Vega and Avner[31] showed in their study that an absolute bicarbonate concentration of less than 17 mEq/L was significant in detecting 5% and above dehydration. On the other hand, in the study conducted by Teach et al.[18], it was reported that the increase in uric acid and anion gap was not significant in detecting dehydration. In a meta-analysis by Steiner et al.[11], it was stated that in children with acute diarrhea, the measurement of urine output amount, urine density and ketone amount was not a valid method for determining the degree of dehydration. Yilmaz et al.[30], who investigated the usefulness of laboratory tests in estimating the degree of dehydration in 168 patients with acute diarrhea aged 1-21 months, found that as the degree of dehydration increased, there was an increase in urea and bicarbonate, and there was no relationship between sodium values and the degree of dehydration. Shaoul et al.[15] evaluated 300 children with diarrhea and reported that urea was useful in demonstrating the degree of dehydration, while other laboratory findings were not significant. Mackenzie et al.[32] reported that high urea, low pH and increased base deficit were associated with the degree of dehydration.

In our study, it was determined that the percentage that we accepted as the actual degree of dehydration (weight after disease-weight at admission)/weight after disease x100) was associated with pH, HCO_3, creatinine levels and urine density. However, we believe that it would not be correct to make a decision based on laboratory findings only in estimating the degree of dehydration because although studies show that serum urea, pH and bicarbonate levels are helpful in the evaluation of dehydration, they also state that they are insufficient for a definitive decision.[11,19,30] However, unlike these studies, the most valuable result of our study is that clinical scales can be used together with these biochemical parameters and can guide the physician in determining the degree of dehydration of the patient.

Conclusion

It is the first study in our country to evaluate the WHO scale for dehydration, CDS and GS used to detect acute dehydration. It was determined that the WHO scale for dehydration and GS were successful in detecting ≥10% dehydration, GS was successful in detecting mild dehydration, and these scales could be used in cases when the child's weight was unknown. On the other hand, it was seen that the CDS was not useful. In addition, pH and HCO_3, serum creatinine and urine density were also found to be helpful in determining the degree of dehydration.

Ethics

Ethics Committee Approval: This cross-sectional study was carried out in University of Health Sciences Turkey, Ankara Health Application and Research Center, Pediatric Emergency Outpatient Clinic between 1 June 2018 and 1 January 2019. It was carried out in line with the approval of the University of Health Sciences Turkey, Ankara Training and Research Hospital Education Planning and Coordination Board with the decision dated 03.10.2018 and numbered 572.

Informed Consent: Informed consent was obtained.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: Y.Y.C., M.A.T., Concept: Y.Y.C., M.A.T., A.U.G., Design: Y.Y.C., M.A.T., Data Collection or Processing: Y.Y.C., M.A.T., Analysis or Interpretation: Y.Y.C., M.A.T., Literature Search: Y.Y.C., A.U.G., Writing: Y.Y.C., M.A.T.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. WHO-Diarrhoeal disease [database on the Internet] 2017. Available at: https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease. Accessed September 09, 2020.
2. Wardlaw T, Salama P, Brocklehurst C, Chopra M, Mason E. Diarrhoea: why children are still dying and what can be done. Lancet. 2010;375:870-2.
3. Liu L, Johnson HL, Cousens S, Perin J, Scott S, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. Lancet. 2012;6736:1-11.
4. Disease burden and mortality estimates [website]. WHO-MCEE estimates for child causes- specific mortality, 2000-2016. Geneva: World Health Organization. Available at: http://www.who.int/healthinfo/global_ burden_disease/estimates/en/index3.html. Accessed October 21, 2020.
5. Kotloff KL. Acute gastroenteritis in children. In: Kliegman RM, Stanton B, Geme J St, Schor N F (eds). Nelson Textbook of Pediatrics: 21 ed: chapter 366, 2019;2012-32.
6. T.C. Sağlık Bakanlığı Sağlık İstatistikleri Yıllığı 2018. Erişim: https://dosyasb.saglik.gov.tr/Eklenti/36134,siy2018trpdf.pdf?0 Erişim tarihi Ekim 10, 2020.
7. Practice parameter: the management of acute gastroenteritis in young children. American Academy of Pediatrics, Provisional Committee on Quality Improvement, Subcommittee on Acute Gastroenteritis. Pediatrics. 1996;97:424-35.
8. Pruvost I, Dubos F, Chazard E, Hue V, Duhamel A, et al. The value of body weight measurement to assess dehydration in children. PLoS One. 2013;8:e55063.
9. Guarino A, Ashkenazi S, Gendrel D, Lo Vecchio A, Shamir R, et al. European Society for Pediatric Gastroenterology, Hepatology, and Nutrition/European Society for Pediatric Infectious Diseases evidence-based guidelines for the management of acute gastroenteritis in children in Europe: update 2014. J Pediatr Gastroenterol Nutr. 2014;59:132-52.
10. King CK, Glass R, Bresee JS, Duggan C, Centers for Disease Control and Prevention. Managing acute gastroenteritis among children: oral rehydration, maintenance, and nutritional therapy. MMWR Recomm Rep. 2003;52:1-16.
11. Steiner MJ, DeWalt DA, Byerley JS. Is this child dehydrated? JAMA. 2004;291:2746-54.
12. Friedman JN, Goldman RD, Srivastava R, Parkin PC. Development of a clinical dehydration scale for use in children between 1 and 36 months of age. J Pediatr. 2004;145:201-7.
13. Gorelick MH, Shaw KN, Murphy KO. Validity and reliability of clinical signs in the diagnosis of dehydration in children. Pediatrics. 1997;99:E6.
14. Goldman RD, Friedman JN, Parkin PC. Validation of the clinical dehydration scale for children with acute gastroenteritis. Pediatrics. 2008;122:545-9.
15. Shaoul R, Okev N, Tamir A, Lanir A, Jaffe M. Value of laboratory studies in assessment of dehydration in children. Ann Clin Biochem. 2004;41:192-6.
16. Hayajneh WA, Jdaitawi H, Al Shurman A, Hayajneh YA. Comparison of clinical associations and laboratory abnormalities in children with moderate and severe dehydration. J Pediatr Gastroenterol Nutr. 2010;50:290-4.
17. Hoxha TF, Azemi M, Avdiu M, Ismaili-Jaha V, Grajqevci V, et al. The usefulness of clinical and laboratory parameters for predicting severity of dehydration in children with acute gastroenteritis. Med Arh. 2014;68:304-7.
18. Teach SJ, Yates EW, Feld LG. Laboratory predictors of fluid deficit in acutely dehydrated children. Clin Pediatr (Phila). 1997;36:395-400.
19. Saç R, Dallar Y, Sarıyıldız E, Aral YZ, Acar B. Akut gastroenteritli çocuklarda klinikte varsayılan ve gerçek dehidratasyonun karşılaştırılması. Ege Tıp Dergisi. 2008;47:187-92.
20. Jauregui J, Nelson D, Choo E, Stearns B, Levine AC, et al. External validation and comparison of three pediatric clinical dehydration scales. PLoS One. 2014;9:e95739.
21. Falszewska A, Dziechciarz P, Szajewska H. Diagnostic accuracy of clinical dehydration scales in children. Eur J Pediatr. 2017;176:1021-6.
22. Flahault A, Cadilhac M, Thomas GJ. Sample size calculation should be performed for design accuracy in diagnostic test studies. J Clin Epidemiol. 2005;58:859-62.
23. Falszewska A, Szajewska H, Dziechciarz P. Diagnostic accuracy of three clinical dehydration scales: a systematic review. Arch Dis Child. 2018;103:383-8.

24. Hoxha T, Xhelili L, Azemi M, Avdiu M, Ismaili-Jaha V, et al. Comparing the accuracy of the three dehydration scales in children with acute diarrhea in a developing country of Kosovo. Mater Sociomed. 2015;27:140-3.

25. World Health Organization [homepage on the internet]. The treatment of diarrhoea: A manual for physicians and other senior health workers, 2005. Available at: https://www.who.int/maternal_child_adolescent/documents/9241593180/en/. Accessed September 1, 2020.

26. Pringle K, Shah SP, Umulisa I, Mark Munyaneza RB, Dushimiyimana JM, et al. Comparing the accuracy of three popular clinical dehydration scales in children with diarrhea. Int J Emerg Med. 2011;4:58.

27. Kinlin LM, Freedman SB. Evaluation of a clinical dehydration scale in children requiring intravenous rehydration. Pediatrics. 2012;129:e1211-9.

28. Bailey B, Gravel J, Goldman RD, Friedman JN, Parkin PC. External validation of the clinical dehydration scale for children with acute gastroenteritis. Acad Emerg Med. 2010;17:583-8.

29. Gravel J, Manzano S, Guimont C, Lacroix L, Gervaix A, et al. [Multicenter validation of the clinical dehydration scale for children]. Arch Pediatr. 2010;17:1645-51.

30. Yilmaz K, Karaböcüoglu M, Citak A, Uzel N. Evaluation of laboratory tests in dehydrated children with acute gastroenteritis. J Paediatr Child Health. 2002;38:226-8.

31. Vega RM, Avner JR. A prospective study of the usefulness of clinical and laboratory parameters for predicting percentage of dehydration in children. Pediatr Emerg Care. 1997;13:179-82.

32. Mackenzie A, Barnes G, Shann F. Clinical signs of dehydration in children. Lancet. 1989;2:605-7.