Chapter

Dehydration

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Abstract

Dehydration is one of the common presentations to the general practice or emergency departments (EDs) in children having acute gastroenteritis (AGE). Assessing the severity of dehydration remains a challenge among physicians, and the dehydration scales currently available are inaccurate. The correct assessment of dehydration is the basis for proper management of acute diarrhea in children. Rapid oral rehydration therapy (ORT) over 3–4 hours remains the cornerstone treatment of AGE with dehydration. It is advisable to reserve intravenous (IV) rehydration therapy for patients with severe dehydration and for those who fail ORT. Rapid standard-volume (20 ml/kg/hour) IV bolus of isotonic solution for 1–4 hours followed by oral fluid intake or maintenance IV fluids seems to be adequate for most cases requiring IV rehydration. A minority of patients may be presented with complications due to diarrheal dehydration, such as dyselectrolytemia, which requires careful calculation of fluids and electrolytes with slow correction approach.

Keywords: gastroenteritis, dehydration, children, rehydration, pediatric, diarrhea

1. Introduction

Dehydration is the main clinical manifestation and the most frequent complication in pediatric patients with AGE. It remains to be a common reason for ED visits, and it can lead to significant morbidity and mortality rates [1]. Management of gastroenteritis is based mainly on the proper assessment of dehydration severity and correction of dehydration.

2. Body water distribution

In newborn babies, 75–80% of the total body weight constitutes the total body water (TBW) (varies with the gestational age), which decreases to 67% of body weight (2/3) after the neonatal period. There is a further decrease that reaches 60% by the end of the first year, and this percentage remains the same during the rest of life. After puberty and in adulthood, TBW is 60% in males and 55% in females. The TBW is divided into two components throughout the body: intracellular fluid compartment (ICF), which constitutes 40% of TBW, and extracellular fluid (ECF), which forms the remaining 20%. The ECF comprises interstitial fluid (IF) (15% of the TBW), and the remaining 5% of the TBW comprises intravascular plasma (**Figures 1** and **2**) [2–4]. This distribution of body fluids can have an impact on the management of pediatric gastroenteritis, as most of the fluid loss in AGE comes from the ECF. This matters because ECF contains a lot of sodium (135–145 mEq), and ICF contains a lot of potassium (150 mEq). In a brief duration of illness

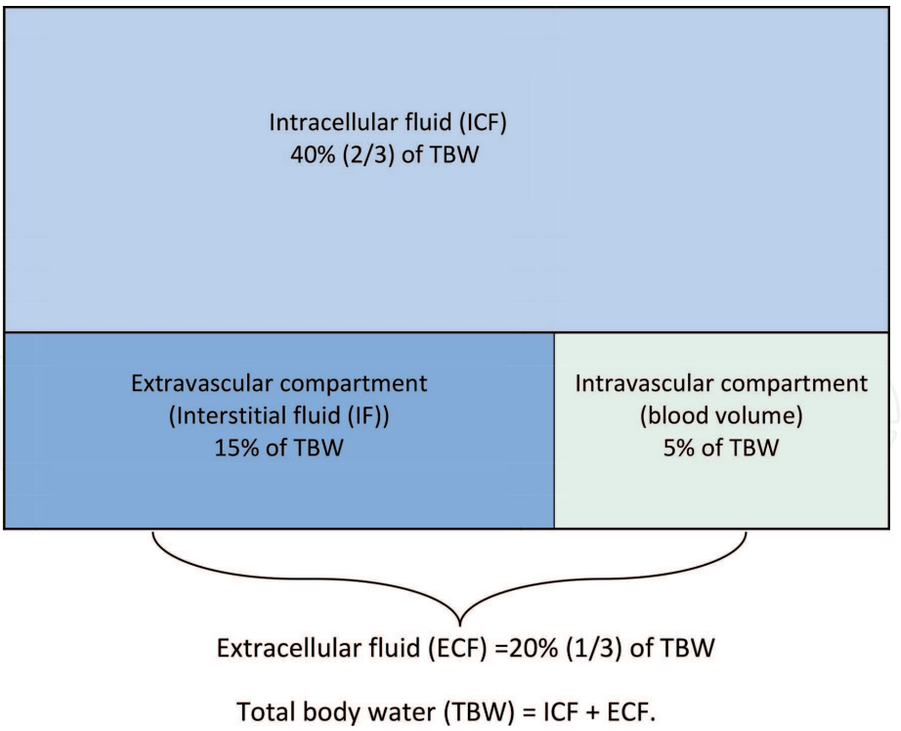

Figure 1.
The percentage distribution of body fluids in the various compartments in a 1-year-old infant [2].

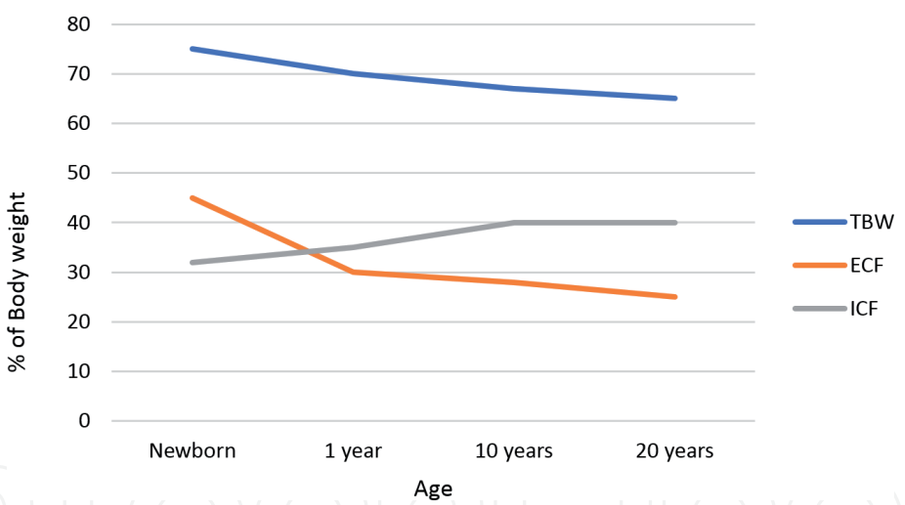

Figure 2.
Body water compartments in relation to age [2–4].

(<3 days), 80% of the deficit is typically from the ECF. After more than 3 days of illness, the deficit from the ECF decreases to 60%. Fluid losses for longer than 7 days are equally lost from ECF (50%) and ICF (50%) [5].

3. Assessment of dehydration

Accurate and quick assessment of the degree of dehydration is important for proper treatment and disposition of infants and children with AGE [6]. The percentage of weight loss is the best measure to assess the degree of dehydration, as shown in Eq. (1). However, this method is impractical because in most patients the pre-illness weight is not known [7].

$$\%\ of\ dehydration = \frac{[(pre - illness\ weight\ in\ kg) - (illness\ weight\ in\ kg)] \times 100}{pre - illness\ weight\ in\ kg} \quad (1)$$

3.1 Clinical assessment of dehydration

Current validated dehydration scales may help in assessing the versatile presentations of dehydration more objectively. Most of them illustrate clinical signs that can be assessed easily and rapidly, which can facilitate stratification of patients into dehydration categories. There are three clinical scales designed to estimate dehydration severity in children below 5 years of age: the World Health Organization (WHO) scale (**Table 1**), the Gorelick scale (**Table 2**), and the Clinical Dehydration Scale (CDS) (**Table 3**) [8–10].

Using common tools to evaluate and assess dehydration would be more helpful in day-to-day practice. Consistent evidence supports the CDS which is more useful and easy to use in assessing dehydration. This scale in combination with other criteria should be used to guide the proper medical interventions in individual

Characteristics	No dehydration	Some dehydration (>1 sign)	Severe dehydration (>1 sign)
Alertness	Well, alert	Irritable or drowsy	Lethargic or poorly responsive
Eyes	Normal	Sunken	Sunken
Thirst	Drinks normally	Drinks eagerly	Poor or weak drinking
Skin turgor	Goes back quickly	Goes back slowly (<2 s)	Return very slowly (>2 s)

Table 1.
WHO scale for dehydration in children aged 1 month–5 years old.

Characteristics	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

Table 2.
Gorelick (4-item) scale for dehydration in children aged 1 month–5 years. Scoring: ≥2 clinical signs indicates ≥ 5% loss of body weight from baseline (moderate dehydration), and ≥3 clinical signs indicates ≥ 10% loss of body weight from baseline (severe dehydration). The presence of two or more of these signs had a sensitivity of 79% and a specificity of 87% in predicting 5% dehydration.

Characteristics	Score of 0	Score of 1	Score of 2
General appearance	Normal	Thirsty, restless, or lethargic but irritable when touched	Drowsy, limp, cold, sweaty ± comatose
Eyes	Normal	Slightly sunken	Very sunken
Mouth and tongue	Moist	Sticky	Dry
Tears	Present	Decreased	Absent

Table 3.
Clinical dehydration scale (CDS) for children aged 1 month–3 years. Scoring: ≥2 clinical signs indicates ≥ 5% loss of body weight from baseline (moderate dehydration), and ≥3 clinical signs indicates ≥ 10% loss of body weight from baseline (severe dehydration). The presence of two or more of these signs had a sensitivity of 79% and a specificity of 87% in predicting 5% dehydration.

cases [11]. Clinical dehydration scales are imprecise and of limited diagnostic value in children with gastroenteritis [12]. As a screening test of dehydration, historical points are moderately sensitive. Classification of dehydration into NO, SOME, and SEVERE are recommended by WHO and other groups [1, 8].

Prolonged capillary refill time, abnormal skin turgor, and abnormal respiratory pattern still remain the best three individual examination signs for assessment of dehydration. Increased capillary refill time was the strongest individual sign as an isolated finding to predict dehydration, and the poor predictor of dehydration was reduced urine output. Combinations of signs perform much better than individual signs. History taking and laboratory tests show limited utility [13].

3.2 Laboratory assessment of dehydration

Blood biochemistry is generally not accurate and not routinely required for assessment of dehydration. Commonly done laboratory tests such as blood urea nitrogen (BUN) and bicarbonate concentrations are generally helpful only when the results are markedly abnormal. A normal serum bicarbonate concentration of more than 15 or 17 mEq/L appears to be valuable in reducing the likelihood of dehydration. These laboratory tests done for assessing dehydration should not be considered definitive, which could be reserved for children requiring IV fluids and suffering from severe dehydration, altered conscious state or convulsions, suspected hypernatremia, suspicion of hemolytic uremic syndrome and children with pre-existing medical conditions that predispose to electrolyte abnormalities [14, 15]. Historical points and laboratory tests only have limited utility for assessing dehydration [10]. Laboratory investigations should be performed if the results will influence the management and outcome of a specific patient.

4. Management of dehydration

Oral rehydration should be the first line of treatment for pediatric gastroenteritis with intravenous (IV) fluid therapy being used if the oral route fails [16, 17].

4.1 Oral rehydration therapy (ORT)

Oral rehydration is the preferred method for replacing fluid and electrolyte deficits resulting from dehydration secondary to acute gastroenteritis. ORT is a safe, easy-to-use, efficacious, and cost-effective alternative to intravenous rehydration for uncomplicated gastroenteritis in children [18].

The use of ORT is based on the principle of glucose-facilitated sodium transport across the intestinal mucosa. The ORT facilitates the absorption of water and sodium for the compensation of fluid losses. Additionally, the absorption can be adequate for the replacement of significant fluid loss, such as in cholera. The absorption of potassium and bicarbonate is maintained by the osmotic gradient in the intercellular space. Metabolic acidosis, usually associated with dehydration, can be safely corrected by this mechanism. The currently available ORT contains an appropriate amount of sodium, glucose, and other electrolytes and is of appropriate osmolality to maximize clinical efficacy [19].

The WHO, Centers for Disease Control (CDC), and the American Academy of Pediatrics (AAP) all support the use of ORT for some (mild–moderate) dehydration [8, 20, 21]. Rapid ORT in mild dehydration is done by giving 50 ml/kg over 4 hours. For moderate dehydration, 100 ml/kg can be given over the same duration. Generally, children being enterally rehydrated do not require blood tests.

4.2 Ondansetron to facilitate ORT

Children who received oral ondansetron initially were less likely to be administered IV rehydration compared with those given placebo. In addition, both oral and IV ondansetron administration are associated with reduced rate of hospitalization [17]. Ondansetron is contraindicated in children with long QT syndrome, concomitant drugs that prolong QT, and to be used cautiously in children with heart disease.

4.3 Discharge criteria

Children can be discharged home when the following levels of recovery are achieved: satisfactory rehydration status as shown by clinical improvement, IV or NG fluids not required, and no significant losses. Adequate family education, proper instructions, and medical follow-up should be provided.

4.4 Patient/parent education

Inform about the expected natural course of the illness, prevention of transmission and looking at signs of dehydration. Encourage breastfeeding continuation in small babies, early refeeding, and the correct method of preparing ORS. Educate about the importance of giving anti-rotavirus vaccination and of course not to use unnecessary medication in simple AGE.

4.5 Other rehydration methods

Nasogastric route is a safe rehydration technique with minimal adverse effects which has been adequately studied. Many clinical trials showed this method to have similar efficacy compared to IV therapy. Rapid NG rehydration using gastrolyte, 50 ml/kg for fluid deficit replacement over 4 hours, appears to be appropriate for children with mild-to-moderate dehydration [22]. If nasogastric rehydration is required beyond 4 hours, check urea and electrolyte concentration (UEC) and blood glucose level (BGL), and reassess the patient for hydration status.

4.6 Intravenous (IV) rehydration

Intravenous rehydration should be reserved for patients with severe dehydration or shock and for those with some (mild-to-moderate) dehydration who fail ORT. Fluid containing not less than 0.9% sodium chloride is preferred for rehydration [23, 24]. Using hypotonic fluids predisposes for dilutional hyponatremia due to excess antidiuretic hormone (ADH) secretion in children with AGE. Serum electrolytes and BGL are required in children with severe dehydration and/or requiring IV fluid therapy for correction of dehydration.

The WHO recommends IV rehydration to be rapidly completed over 3–4 hours [8]. Rapid replacement of ECF improves gastrointestinal and renal perfusion, allowing earlier oral intake and a faster correction of electrolyte and acid-base abnormalities, which results in excellent recovery rate and decreased length of stay in ED [25].

4.6.1 Resuscitation

Resuscitate shock/near shock with a prompt intravenous infusion of 20 ml/kg of 0.9% sodium chloride solution or Ringer's lactate solution as fast as possible. Reassessing and repeating boluses given, as necessary, are required until the patient is recovered from shock and then followed by maintenance IV fluids [26].

4.6.2 Rapid standard-volume IV rehydration

The clinical standard is to administer 20 mL/kg/h of isotonic crystalloid fluid, such as 0.9% normal saline or lactated Ringer's solution. Reassess the patient after each bolus, and if the patient is still dehydrated, a total of 2–4 fluid boluses may allow rapid restoration of intravascular volume which can bring rapid recovery. Rapid IV rehydration followed by oral fluids is adequate for initial rehydration for most patients requiring IV fluid therapy. For those refusing oral intake, continuous infusion of maintenance IV fluids are to be given until oral fluids are tolerated [27]. Glucose solution should be added once ECF volume has been restored and addition of potassium considered once the child passes urine and serum electrolytes are known [28].

4.6.3 Rapid large-volume IV rehydration

Refer to the correction of dehydration using a large volume of fluids over a relatively shorter time (50–60 ml/kg/hour). Ultra-rapid IV rehydration may be associated with electrolyte abnormalities and longer hospital stay or delayed discharge and therefore is not recommended [29, 30].

Children with acute watery diarrhea and severe dehydration, such as cholera, who fail ORT, can benefit from large-volume IV rehydration (100 ml/kg) of Ringer's lactate solution or normal saline over 3–6 hours. Frequent reassessment is required, and if hydration status is not improving, IV fluids should be given more rapidly [31]. Further research investigations are needed to justify the use of rapid large-volume IV rehydration in pediatric gastroenteritis.

5. Electrolyte disturbances

Dyselectrolytemia is a serious complication of AGE with dehydration. The majority of electrolyte disorders associated with AGE in children can be adequately treated using ORT.

5.1 Hypernatremia (serum sodium > 145 mmol/L)

Hypernatremia leads to hypertonicity that can be potentially dangerous as there is a greater likelihood of neurological manifestations. Most frequently, it is due to water deficit from increased water losses in diarrhea and due to reduced water intake during the illness.

As in any type of dehydration, the primary aim should be restoration of hemodynamic stability by administration of isotonic fluids. The gradual replacement of water deficit remains the gold standard treatment for hypernatremic dehydration [32]. The recent advance in management of hypernatremia is to give isotonic (0.9% sodium chloride + 5% glucose) than hypotonic solution to correct the calculated fluid deficit slowly. The more the solution contains free water, the higher the risk of developing hyponatremia during rehydration [23, 33].

5.2 Hyponatremia (serum sodium < 135 mmol/L)

It represents an excess of water in relation to sodium in ECF [34]. Hyponatremia is seldom symptomatic unless the serum Na is <120 or if the hyponatremia occurs quickly [35]. Hyponatremia may be presented with nausea,

vomiting, headache, irritability, lethargy, confusion, muscle cramps, convulsions, disorientation, and reduced consciousness and places the patient at risk of neurologic impairment [36].

The initial goal in treating hyponatremia is the restoration of intravascular volume with isotonic saline and to be followed by a slower correction using 0.9% sodium chloride + 5% glucose. In severe hyponatremia or symptomatic children, the goal is to raise the serum sodium to 120–125 mmol/L or until the seizure stops [35]. As a rule of thumb, IV infusion of 3% NaCl, 3–5 ml/kg over 15–30 min, will raise serum Na by 5 mEq/L.

6. Systematic approach to a child with AGE and dehydration: summary of the assessment and management of AGE with dehydration in children

See **Figure 3**.

Figure 3.
Flow chart for the management of pediatric gastroenteritis with dehydration.

7. Conclusions

The management of a child with a dehydrating gastroenteritis requires careful initial assessment and reassessment of hydration status. The majority of gastroenteritis in infants and children are simple and can be treated by ORT. In children who presented with severe dehydration or those with some dehydration and fail ORT, IV rehydration is required. Rapid IV rehydration using standard boluses of isotonic fluids followed by oral fluid intake or maintenance IV fluids for those refusing oral intake appears sufficient for most patients requiring IV fluids. Patients achieving satisfactory hydration status and tolerating oral intake can be discharge home with proper instructions.

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Conflict of interest

The authors declare no conflict of interest.

Acronyms and abbreviations

AGE	acute gastroenteritis
TBW	total body water
ECF	extracellular fluid
ICF	intracellular fluid
UEC	urea electrolyte concentration
BGL	blood glucose level
ORT	oral rehydration therapy
IV	intravenous
ADH	antidiuretic hormone
NICE	National Institute for Health and Care Excellence
ED	emergency department

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