

# Diagnosis and Management of Dehydration in Children

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The most useful individual signs for identifying dehydration in children are prolonged capillary refill time, abnormal skin turgor, and abnormal respiratory pattern. However, clinical dehydration scales based on a combination of physical examination findings are better predictors than individual signs. Oral rehydration therapy is the preferred treatment of mild to moderate dehydration caused by diarrhea in children. Appropriate oral rehydration therapy is as effective as intravenous fluid in managing fluid and electrolyte losses and has many advantages. Goals of oral rehydration therapy are restoration of circulating blood volume, restoration of interstitial fluid volume, and maintenance of rehydration. When rehydration is achieved, a normal age-appropriate diet should be initiated. (*Am Fam Physician*. 2009;80(7):692-696. Copyright © 2009 American Academy of Family Physicians.)



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Clinical dehydration scales based on a combination of physical examination findings are the most specific and sensitive tools for accurately diagnosing dehydration in children and categorizing its severity. Overdiagnosis of dehydration may lead to unnecessary tests and treatment, whereas underdiagnosis may lead to increased morbidity (e.g., protracted vomiting, electrolyte disturbances, acute renal insufficiency).

Among children in the United States, fluid and electrolyte disturbances from acute gastroenteritis result in 1.5 million outpatient visits, 200,000 hospitalizations, and 300 deaths per year.<sup>1</sup> Additionally, children may become dehydrated because of a variety of other illnesses that cause vomiting, diarrhea, or poor fluid intake.

## Diagnosis

### PARENTAL OBSERVATION

Parental report of vomiting, diarrhea, or decreased oral intake is sensitive, but not specific, for identifying dehydration in children. If parents report that the child does not have diarrhea, has normal oral intake, and has normal urine output, the chance of

dehydration is low. Likewise, when parents are asked about physical signs of dehydration, a number of positive answers suggest dehydration. However, if the parents report normal tear production, the chance of dehydration is low.<sup>2,3</sup>

### PHYSICAL EXAMINATION

Comparing change in body weight from before and after rehydration is the standard method for diagnosing dehydration.<sup>4</sup> To identify dehydration in infants and children before treatment, a number of symptoms and clinical signs have been evaluated and compared with this standard method. Physical examination findings during dehydration represent desiccation of tissue, the body's compensatory reaction to maintain perfusion, or both. The most useful individual signs for identifying dehydration are prolonged capillary refill time, abnormal skin turgor, and abnormal respiratory pattern.<sup>5</sup> However, clinical dehydration scales based on a combination of physical examination findings are much better predictors than individual signs.<sup>5</sup>

In one study, four factors predicted dehydration: capillary refill time of more than two

**SORT: KEY RECOMMENDATIONS FOR PRACTICE**

<i>Clinical recommendation</i>	<i>Evidence rating</i>	<i>References</i>
Children should be assessed for degree of dehydration based on physical examination findings.	C	3-7, 11
ORT is the preferred treatment for mild to moderate dehydration in children.	C	14-17
Use of an appropriate ORT solution corrects and helps prevent electrolyte disturbances caused by gastroenteritis in children.	C	17, 18, 19
A single dose of ondansetron (Zofran) may facilitate ORT in children with dehydration.	B	30

ORT = oral rehydration therapy.

A = consistent, good-quality patient-oriented evidence; B = inconsistent or limited-quality patient-oriented evidence; C = consensus, disease-oriented evidence, usual practice, expert opinion, or case series. For information about the SORT evidence rating system, go to <http://www.aafp.org/afpsort.xml>.

seconds, absence of tears, dry mucous membranes, and ill general appearance; the presence of two or more of these signs indicated a fluid deficit of at least 5 percent.<sup>6</sup> In a similar validated scale, general appearance, degree of sunken eyes, dryness of mucous membranes, and tear production were associated with length of hospital stay and need for intravenous fluids in children with acute gastroenteritis.<sup>7</sup>

Capillary refill time is performed in warm ambient temperature, and is measured on the sternum of infants and on a finger or arm held at the level of the heart in older children. The measurement is not affected by fever and should be less than two seconds.<sup>8</sup> Assessment of skin turgor is performed by pinching skin on the lateral abdominal wall at the level of the umbilicus. Turgor (i.e., time required for the skin to recoil) is normally instantaneous and increases linearly with degree of dehydration.<sup>9</sup> Respiratory pattern and heart rate should be compared with age-specific normal values.

**LABORATORY ASSESSMENT**

Unlike in adults, calculation of the blood urea nitrogen (BUN)/creatinine ratio is not useful in children. Although the normal BUN level is the same for children and adults, the normal serum creatinine level changes with age (0.2 mg per dL [17.68  $\mu$ mol per L] in infants to 0.8 mg per dL [70.72  $\mu$ mol per L] in adolescents). BUN alone and urine specific gravity also have poor sensitivity and specificity for predicting dehydration in children.<sup>10</sup>

In combination with a clinical dehydration scale, a serum bicarbonate level of less than 17 mEq per L (17 mmol per L) may improve sensitivity of identifying children with moderate to severe hypovolemia.<sup>11</sup> Additionally, a serum bicarbonate level of less than 13 mEq

per L (13 mmol per L) is associated with increased risk of failure of outpatient rehydration efforts.<sup>12</sup>

**Treatment****PATHOPHYSIOLOGY**

Most of the volume loss in dehydration is extracellular fluid. The extracellular fluid space has two components: plasma and lymph as a delivery system, and interstitial fluid for solute exchange.<sup>13</sup> The goal of rehydration therapy is first to restore the circulating blood volume, if necessary; then to restore the interstitial fluid volume; and finally to maintain hydration and replace continuing losses, such as diarrhea and increased insensible losses caused by fever.

**ORAL REHYDRATION THERAPY**

The American Academy of Pediatrics recommends oral rehydration therapy (ORT) as the preferred treatment of fluid and electrolyte losses caused by diarrhea in children with mild to moderate dehydration.<sup>14</sup> ORT is as effective as intravenous fluid in rehydration of children with mild to moderate dehydration—there is no difference in failure rate or hospital admission rate between the two treatments.<sup>15</sup> Additionally, ORT has many advantages compared with intravenous fluid therapy. It can be administered at home, reducing the need for outpatient and emergency department visits; requires less emergency department staff time; and leads to shorter emergency department stays. Parents are also more satisfied with the visit when ORT had been used.<sup>16</sup> With ORT, the same fluid can be used for rehydration, maintenance, and replacement of stool losses; and ORT can be initiated more quickly than intravenous fluid therapy.<sup>17</sup>

The principles of ORT to treat dehydration from gastroenteritis apply to the treatment of dehydration from other causes. Altered mental status with risk of aspiration, abdominal ileus, and underlying intestinal malabsorption are contraindications. Cost to the family may be a deterrent to home ORT; therefore, ORT solution provided by the physician's office or emergency department increases the likelihood that parents will use ORT and reduces unscheduled follow-up visits.<sup>16</sup>

Nasogastric rehydration therapy with ORT solution is an alternative to intravenous fluid therapy in patients with poor oral intake. Nasogastric hydration using oral rehydration solution is tolerated as well as ORT. Failure rate of nasogastric tube placement is significantly less than that of intravenous lines, and significant

**Table 1. Approximate Electrolyte Composition of Clear Liquids**

Type of liquid	Carbohydrates (g per L)	Sodium (mEq per L)	Potassium (mEq per L)	Base (mEq per L)	Osmolality (mOsm per L)
Commercial electrolyte solutions for children (e.g., Pedialyte)*	140	45 to 50	20	30	250
Sports drinks (e.g., Gatorade)	255	20	3	2	360
Juice	690	2	30	0	730
Soda	700	3	0	13	750

\*—Only clear liquid recommended for oral rehydration in children with dehydration. Clear sodas and juices are not recommended because hyponatremia may occur.

complications of nasogastric tube placement are rare. Nasogastric rehydration therapy is also less expensive than intravenous fluid therapy.<sup>18</sup>

As soon as children with acute gastroenteritis are rehydrated, a regular age-appropriate diet should be initiated. This does not worsen the symptoms of mild diarrhea, and may decrease its duration.<sup>14</sup>

**Preparations.** Use of an appropriate ORT solution, such as commercial electrolyte solutions for children (e.g., Pedialyte), corrects and helps prevent electrolyte disturbances caused by gastroenteritis.<sup>17-19</sup> The World Health Organization ORT solution contains 90 mEq per L of sodium, mimicking the sodium content of diarrhea caused by cholera. Commercial ORT preparations typically contain around 50 mEq per L of sodium, which is more consistent with the sodium content of diarrhea caused by rotavirus.<sup>20</sup> Commercial ORT solutions contain 25 g per L of dextrose, which helps prevent hypoglycemia without causing osmotic diuresis,<sup>21</sup> and 30 mEq per L of bicarbonate, which leads to less vomiting and more efficient correction of acidosis.<sup>19</sup> Commercial ORT solutions are recommended over homemade solutions because of the risk of preparation errors.<sup>22</sup> Clear sodas and juices should not be used for ORT because hyponatremia may occur. *Table 1* compares the electrolyte composition of commercial electrolyte solutions with other clear liquids.

**Administration.** For mild dehydration, 50 mL per kg of ORT solution should be administered over four hours using a spoon, syringe, or medicine cup<sup>14</sup>; this can be accomplished by giving 1 mL per kg of the solution to the child every five minutes. Patients may be treated at home.<sup>14</sup> If the child vomits, treatment should be resumed after 30 minutes.<sup>15</sup> After the four-hour treatment period, maintenance fluids

should be given and ongoing losses assessed and replaced every two hours. Maintenance therapy includes providing anticipated water and electrolyte needs for the next 24 hours in the child who is now euvolemic with expected normal urine output. The Holliday-Segar method (*Table 2*<sup>23</sup>) is a simple, reliable formula for estimating water needs.<sup>24</sup> Based on average weights of infants and children, this method can be further simplified to provide maintenance ORT at home: 1 oz per hour for infants, 2 oz per hour for toddlers, and 3 oz per hour for older children. To replace ongoing losses, 10 mL per kg for every loose stool and 2 mL per kg for every episode of emesis should be administered.

For moderate dehydration, 100 mL per kg of ORT solution should be given over four hours in the physician's office or emergency department.<sup>14</sup> If treatment is successful and ongoing losses are not excessive, the child may be sent home. At home, caregivers should provide maintenance therapy and replace ongoing losses every two hours as described for mild dehydration. ORT is considered to be unsuccessful if vomiting is severe and persistent (i.e., at least 25 percent of the hourly oral requirement) or if ORT cannot keep up with the volume of stool losses.<sup>17</sup>

**Table 2. Holliday-Segar Method for Determining Maintenance ORT in Children**

Body weight	Daily water requirement	Hourly water requirement
≤ 23 lb (10 kg)	100 mL per kg	4 mL per kg
24 to 44 lb (11 to 20 kg)	1,000 mL, plus 50 mL per kg for each kg between 11 and 20 kg	40 mL, plus 2 mL per kg for each kg between 11 and 20 kg
> 44 lb (20 kg)	1,500 mL, plus 20 mL per kg for each kg over 20 kg	60 mL, plus 1 mL per kg for each kg over 20 kg

NOTE: This method can be further simplified to provide maintenance ORT at home: 1 oz per hour for infants, 2 oz per hour for toddlers, and 3 oz per hour for older children.

ORT = oral rehydration therapy.

Information from reference 23.

Severe dehydration should be treated with intravenous fluids until the patient is stabilized (i.e., circulating blood volume is restored). Treatment should include 20 mL per kg of isotonic crystalloid (normal saline or lactated Ringer solution) over 10 to 15 minutes.<sup>25</sup> No other fluid type is currently recommended for volume resuscitation in children.<sup>26</sup> Treatment should be repeated as necessary, with monitoring of the patient's pulse strength, capillary refill time, mental status, and urine output. Stabilization often requires up to 60 mL per kg of fluid within an hour.<sup>25</sup> Electrolyte measurement should be performed in all children with severe dehydration and considered in those with moderate dehydration because it may be difficult to predict which children have significant electrolyte abnormalities.<sup>27</sup> After resuscitation is completed and normal electrolyte levels are achieved, the patient should receive 100 mL per kg of ORT solution over four hours, then maintenance fluid and replacement of ongoing losses. If ORT fails after initial resuscitation of a child with severe dehydration, intravenous fluid therapy should be initiated. First, 100 mL per kg of isotonic crystalloid should be administered over four hours, followed by a maintenance solution. This method also may be used when a child with moderate dehydration fails ORT.

The electrolyte content of intravenous maintenance fluid for infants and children with normal serum electrolyte levels should be 5 percent dextrose and 25 percent normal saline, plus 20 mEq per L of potassium.<sup>23,28,29</sup> Intake, output, and vital signs must be checked every four hours, and adjustments made to the therapy as necessary (e.g., in the setting of ongoing losses, such as excessive stool output, or persistent fever). If stool output exceeds 30 mL per kg per day, it should be replaced in an equal volume every four hours with an intravenous solution comparable in electrolytes with the stool (50 percent normal saline plus 20 to 30 mEq per L of potassium), in addition to the volume of maintenance fluid, until ORT can be tolerated. Children with persistent fever may require 1 mL per kg per degree centigrade every hour, in addition to the calculated maintenance therapy. Postoperatively and in children with central nervous system infection or injury, 20 to 50 percent less fluid and fluid with higher sodium content may be needed because of abnormal antidiuretic hormone secretion.<sup>28</sup> These adjustments in fluid rates are guided by regular measurement of urine output and vital signs.

#### MEDICATIONS

Pharmacologic agents are not recommended to decrease diarrhea because of limited evidence and concern for toxicity. Although *Lactobacillus* has no major toxic effects, its

effectiveness in patients with diarrhea has not been demonstrated.<sup>14</sup> A single dose of ondansetron (Zofran) has been shown to facilitate ORT by reducing the incidents and frequency of vomiting and, therefore, reducing the failure of ORT and the need for intravenous fluid therapy.<sup>30</sup> Recurrent dosing of ondansetron has not been studied.

#### Complications

Hypernatremia, hyponatremia, and hypoglycemia occasionally complicate dehydration. Serum electrolyte levels should be measured in children with severe dehydration and in those with moderate dehydration that presents in atypical ways.

Hypernatremia (serum sodium level of greater than 145 mEq per L [145 mmol per L]) indicates water loss in excess of sodium loss. Because sodium is restricted to the extracellular fluid space, the typical signs of dehydration are less pronounced in the setting of hypernatremia, and significant circulatory disturbance is not likely to be noted until dehydration reaches 10 percent. Findings that may aid in the diagnosis of hypernatremia in children include a "doughy" feeling rather than tenting when testing for skin turgor, increased muscle tone, irritability, and a high-pitched cry.<sup>31</sup> Hyponatremia is often caused by inappropriate use of oral fluids that are low in sodium, such as water, juice, and soda. If severe dehydration is present, a child with hypernatremia or hyponatremia should receive isotonic crystalloid until stabilized. If after initial volume repletion, hyponatremia or hypernatremia remains moderate to severe (serum sodium level of less than 130 mEq per L [130 mmol per L] or greater than 150 mEq per L [150 mmol per L]), replacement of the remaining fluid deficit should be altered, with a principal goal of slow correction.

In one study, blood glucose levels of less than 60 mg per dL (3.33 mmol per L) were detected in 9 percent of children younger than nine years (mean age 18 months) admitted to the hospital with diarrhea.<sup>27</sup> History and physical examination findings did not indicate that these children were at risk; therefore, blood glucose screening may be indicated for toddlers with diarrhea.

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