Gastroenteritis refers to inflammation of the lining of both the stomach and small intestines. The majority of cases are infectious with viral organisms predominating; however, bacterial and parasitic infections can be a specific concern in the appropriate patient. Non-infectious gastrointestinal inflammation may follow certain ingestions (eg, toxic mushroom ingestion, gluten in patients with celiac disease, dairy in lactose sensitive patients), medications (eg, chemotherapeutic agents, non-steroidal anti-inflammatory medications, certain antibiotics), chemical toxins (eg, anticholinergic toxins, heavy metals, plant substances), and malignancy and can be seen in other conditions such as Crohn’s disease and ischemic bowel disease.

You are nearing the end of a busy shift when a nurse comes up to you and says that there is a family with 3 kids in the next room who are all complaining of nausea, vomiting, and diarrhea. As you enter the room, you note an 8-month-old who is being held in her mom’s arms and her 2 older siblings, ages 5 and 7, none of whom appear toxic. Before you begin, the mom interrupts and states that she has just seen her children’s pediatrician and that her doctor sent her to the ED for blood-work and IV fluid rehydration. You briefly contemplate telling the mom that you are the emergency medicine doctor and you will make the decisions in the ED, but you decide that it would be better to first gain her trust by performing an appropriate history and physical examination and then discussing treatment options regarding rehydration.

Upon completion of this article, you should be able to:
1. Cite the most common etiologies for pediatric diarrheal illness in the emergency department.
2. Identify historical and examination findings that predict the degree of pediatric dehydration.
3. Describe the rationale for the use of oral rehydration therapy in mild and moderately dehydrated children.

Date of most recent review: June 10, 2010
Date of original release: July 1, 2010
Termination date: July 1, 2013
Method of participation: Print or online answer form and evaluation
Prior to beginning this activity, see “Physician CME Information” on page 23.
Although some acute gastroenteritis syndromes consist predominately of either vomiting or diarrhea, most have an element of both, with additional symptoms being variably present such as anorexia, abdominal pain, and fever. Clinicians should be wary of diagnosing children who present with isolated diarrhea or vomiting as having “viral gastroenteritis” until a thorough evaluation of other causes has been completed. A variety of serious conditions such as appendicitis, bacterial enteritis, diabetic ketoacidosis, pyelonephritis, pneumonia, intussusception, and toxic ingestions can present with symptoms identical to gastroenteritis. A thorough clinical examination, selective application of laboratory testing and diagnostic imaging, and documentation of suitable return precautions will prevent misdiagnoses and unexpected outcomes in these patients.

### Epidemiology

Worldwide infectious gastrointestinal illness and dehydration are leading causes of morbidity and mortality, accounting for an estimated 1.5 billion diarrheal episodes per year and 1.5 to 2.5 million deaths annually in patients < 5 years of age. In developed countries, where dehydration is less likely to cause mortality, gastroenteritis is a significant cause of morbidity. Annually, acute gastroenteritis (AGE) is responsible for 3.7 million physician visits, 135,000 to 220,000 pediatric admissions (9%-13% of total hospitalizations for children < 5 years of age), and 150 to 300 deaths among children < 5 years of age in the US.

Societal costs are significant, with approximately $1 billion per year in total costs attributed to rotaviral infection alone.

Pediatric death due to diarrheal illness is related to severe volume depletion and its associated complications. Advancements in the recognition and treatment of dehydration have largely prevented pediatric deaths in the US; however, diarrheal illnesses still claim a significant number of children < 5 years of age annually (1 per 915 to 935 hospitalizations). Risk factors for death from diarrheal illness include age < 1 year, low-birth weight (< 2500 gm); African-American ethnicity, Hispanic-American ethnicity, or American-Indian ethnicity; and illness during the winter months. Additionally, maternal factors such as age < 20 years, failure to complete high school, delay in obtaining prenatal care, and unmarried status are associated with pediatric death from diarrheal illness.

### Risk Factors For Gastroenteritis

Infants and toddlers are at particular risk for gastroenteritis and dehydration due to a relative lack of resistance against gastrointestinal pathogens. This lack of protection stems from an immature gastrointestinal immune system and an absence of prior exposure to infectious pathogens as well as risk-taking behavior (ie, poor hand/foot hygiene combined with exploring objects, including hands and feet, through taste) in children < 2 years of age. Additionally, diarrheal illnesses are seen more frequently in immunocompromised patients, children who are on gastric acid inhibitors (ie, histamine-2 receptor antagonists and proton pump inhibitors), and in children who have not received rotavirus vaccination.

The transition time from breast milk to formula or cow’s milk places children at risk for gastroenteritis. Breastfeeding is thought to confer some degree of protection against gastrointestinal pathogens through the transmission of maternal antibodies, hormones that stimulate gastrointestinal development, anti-inflammatory proteins, and white blood cells. Several trials have shown breastfeeding to reduce the frequency and severity of gastroenteritis in children < 2 years of age. In a prospective cohort study of 674 pairs of mothers and infants, babies who were breast-fed for 13 weeks or more had significantly fewer episodes of gastroenteritis compared to formula-fed infants (2.9% vs 15.7%, P < 0.001; adjusted odds ratio [OR] of 0.09, with a 95% confidence interval [CI], 0.02-0.37). Dewey et al reported that babies who were breast-fed had about half the episodes of diarrheal illness compared to formula-fed infants during the first year of life (0.16 vs 0.33 episodes per 100 days at risk, P < 0.05).
average duration of illness was 3 days in breast-fed infants compared to 6.5 days in formula-fed infants. In both studies, these observations remained consistent after adjustment for several potential confounders (eg, socioeconomic status, use of day care, smoking, etc.).

**Risk Factors For Dehydration**

Children < 2 years of age are prone to dehydration for several physiologic reasons. Infants and toddlers have a relatively large body surface area (compared to body volume), which contributes to fluid loss through skin evaporation. In addition, children have a higher baseline metabolic rate compared to adults and thus have higher baseline insensible losses compared to adults. When pediatric patients develop fever or dehydration, they often compensate by further increasing their heart rate and respiratory rate, both of which increase these fluid losses. Finally, pre-verbal children depend upon their parent or caregiver for fluid intake. This may be problematic if caregivers are not sensitive to the fluid needs of the newborn.

Breast-fed infants are also less likely to become significantly dehydrated or require hospitalization when battling a gastrointestinal infection when compared to non-breast-fed infants. This protection wanes once the decision is made to convert from breast milk to formula or cow’s milk. Fuchs et al reported that formula- or cow’s milk-fed infants had a 6-fold higher risk of dehydration compared to children fed with breast milk. Compared with those still breastfeeding, children who stopped breastfeeding in the previous 2 months were 8 times more likely to develop dehydration from an acute diarrheal illness. The severity and duration of dehydration ultimately affects decisions regarding pediatric hospitalization. A population-based survey in the United Kingdom found the risk of hospitalization for dehydration in children aged 6 months to 5 years was higher in those fed with formula milk compared to those fed with breast milk. Compared with those still breastfeeding, children who stopped breastfeeding in the previous 2 months were 8 times more likely to develop dehydration from an acute diarrheal illness. The severity and duration of dehydration ultimately affects decisions regarding pediatric hospitalization. A population-based survey in the United Kingdom found the risk of hospitalization for dehydration in children aged 6 months to 5 years was higher in those fed with formula milk compared to those fed with breast milk.

<table>
<thead>
<tr>
<th>Publication Year</th>
<th>Organization</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>American Academy of Pediatrics</td>
<td>The management of acute gastroenteritis in young children</td>
</tr>
<tr>
<td>2003</td>
<td>Center for Disease Control and Prevention</td>
<td>Managing acute gastroenteritis among children: oral rehydration, maintenance, and nutritional therapy</td>
</tr>
<tr>
<td>2006</td>
<td>Agency for Healthcare Research and Quality</td>
<td>Evidence-based clinical care guideline for acute gastroenteritis in children aged 2 months through 5 years</td>
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<tr>
<td>2009</td>
<td>National Institute for Health and Clinical Excellence (UK Guidelines)</td>
<td>Diarrhea and vomiting caused by gastroenteritis: diagnosis, assessment and management in children younger than 5 years</td>
</tr>
<tr>
<td>2009</td>
<td>American College of Emergency Physicians – Pediatric Emergency Medicine Committee</td>
<td>The management of children with gastroenteritis and dehydration in the Emergency Department</td>
</tr>
</tbody>
</table>

**Etiology**

There are no studies that have performed a comprehensive evaluation of stool samples in all patients presenting with AGE to the ED. This is not surprising since the ED population is somewhat heterogeneous and includes patients from a variety of demographic groups and socioeconomic strata.
children with minor diarrheal illness for whom stool testing is not justified as well as children with moderate and severe symptoms that require observation and potential hospital admission. The increased use of immunoassays and other microbiological techniques to isolate suspected pathogens is likely to advance our understanding of this disease process.30,35

Clinical Evaluation
Subtracting the current weight from the pre-illness weight and then dividing this number by the pre-illness weight establishes the gold-standard measurement for acute dehydration. Since the pre-illness weight is rarely known, most studies use a post-hydration weight as a substitute for this value. However, post-hydration weights may not accurately reflect the pre-illness weight and are known to vary throughout the day based on fluid/solid intake as well as bowel and bladder habits.

Clinical scales assessing dehydration are equally problematic and have been shown to both overestimate dehydration in some cases and underestimate it in others. Some newer simplified clinical scales use acidosis as their clinical outcome. Acidosis is not a reliable surrogate for dehydration and is of unclear value in the assessment of these patients.

Laboratory Evaluation
Studies that have looked at the value of blood-work and urine testing for the assessment of pediatric dehydration have yielded conflicting results, with most concluding that routine laboratory testing is not helpful or is marginally helpful for the majority of children with AGE and/or dehydration. Despite findings of specific laboratory abnormalities in some studies, no specific laboratory test or combination of laboratory tests have been shown to be predictive of dehydration severity in place of accurate clinical acumen.

More recent studies have tried to determine the frequency and significance of a “clinically significant laboratory abnormality.” This term is problematic since what is “clinically significant” may vary between medical providers. Furthermore, outpatient management and self-correction of these abnormalities through return of oral fluid and normal food intake is rarely discussed or examined.

Outcome
The outcome variables in many pediatric dehydration articles are inconsistent. Although the majority of studies evaluating the value of the clinical examination and laboratory markers use ≥ 5% dehydration (using the post-hydration weight standard) as their primary outcome, other studies report degree of acidosis, need for intravenous fluid hydration, or need for hospital admission as primary outcomes. Ultimately, these last 2 variables are more clinically relevant than the ability to estimate the level of dehydration.

Etiology
Viruses are the most frequently implicated pathogens causing pediatric AGE in the US. Rotavirus, norovirus, astrovirus, enteric adenovirus, and sapovirus have been recognized as the most common agents responsible for viral diarrhea in pediatric patients in both outpatient, emergency department (ED), and inpatient settings.40-48 Bacterial infection of the gastrointestinal tract is seen in 7% to 10% of ED patients with acute diarrhea illness and is most commonly due to Escherichia coli, Campylobacter species, Salmonella species, Shigella species, and Yersinia enterocolitica.41,42,44,47,49,50 Clostridium difficile infection is a major cause of nosocomial enterocolitis that generally occurs after exposure to antibiotics, healthcare facilities, or infected individuals. Parasitic etiologies to AGE are uncommon in immunocompetent patients that have not come into contact with contaminated food, water, or other infected individuals. The most common parasitic organisms responsible for AGE are cryptosporidium, giardia, and entamoeba histolytica.41,42,44 While certain clinical clues can help suggest the possible microbial etiology of AGE, stool testing is the only reliable way to obtain a definitive etiology.

Rotavirus
Rotavirus is the leading recognized cause of diarrhea-related illness and death among infants and young children.51-52 In the US, before the introduction of a rotavirus vaccine in 2006, this virus was estimated to cause 2.1 to 3.2 million episodes of diarrhea; 400,000 to 600,000 outpatient visits; 160,000 emergency department visits; 50,000 to 70,000 hospitalizations; and 20 to 60 deaths each year among children < 5 years of age.53-56 In US children < 3 years of age, rotavirus is believed to send 1 out of every 11 children to the ED or outpatient clinic and result in the hospitalization of 1 out of every 150 children.61

Rotavirus tends to infect younger children, usually between 6 months and 2 years of age. It predominately has a winter-spring seasonality, with case activity beginning in the western US during December to January, extending across the country and, ending in the Northeast region during May to June. These peaks in rotavirus activity correspond to peaks in gastroenteritis-related visits to the ED.62 Rotavirus infection is less common during the summer months (July-September).

Several studies have tried to distinguish the clinical features of gastroenteritis related to rotavirus infection from other viral gastroenteritis.57,61,63-66 When taken together, these studies show that individually and together, the symptoms of vomiting, diarrhea, and fever seem to be more common and severe in children with AGE due to rotavirus infection. In a population-based surveillance study involving 516 children < 3 years of age (181 inpatients, 201 ED patients, 134 outpatients) in 3 US counties, children with
AGE due to rotavirus were more likely to present with vomiting (95% vs 79%, \( P < 0.001 \)), diarrhea (92% vs 84%, \( P < 0.001 \)), and fever (79% vs 65%, \( P < 0.001 \)) compared to non-rotavirus-related AGE. The presence of all 3 symptoms was found in 70% of children with AGE due to rotavirus compared to 42% with non-rotavirus-related AGE (\( P < 0.001 \)).

Rotavirus diarrhea has been noted to have a distinctive odor, leading experienced practitioners to believe that they can diagnose rotavirus infection by olfactory inspection alone. In a study out of the United Kingdom, a group of 7 experienced pediatric infectious disease nurses were asked to classify 68 stool samples by smell alone from infants < 18 months old who were admitted to the hospital with acute diarrhea. Olfactory inspection of stool for the diagnosis of rotavirus was found to have a positive likelihood ratio of 3.2 (95% CI, 1.2-8.4) and a negative likelihood ratio of 0.7 (95% CI, 0.5-0.9).

Following the introduction of the pentavalent rotavirus vaccine, there has been a delayed onset and diminished magnitude of rotavirus activity in the US. Preliminary sentinel laboratory surveillance data from the Centers for Disease Control and Prevention have noted a 64% drop amongst rotavirus-positive tests in the first year following vaccine release. The Advisory Committee on Immunization Practices recommends routine vaccination of US infants with 3 doses of this rotavirus vaccine administered orally at 2, 4, and 6 months of age. The first dose should be administered between 6 and 12 weeks of age. Subsequent doses should be administered at 4 to 10 week intervals, and all 3 doses should be administered by age 32 weeks.

**Norovirus**

Norovirus is the 2nd most common case of severe childhood gastroenteritis, accounting for approximately 12% of severe gastroenteritis cases among children < 5 years of age. Noroviruses have recently become implicated as the leading cause of AGE due to rotavirus infection by polymerase chain reaction analysis. Outbreaks can involve people of all ages and occur in a variety of settings (eg, long-term care facilities, hospital wards, day-care centers, cruise ships, restaurants, and catered events). In the US, norovirus is estimated to account for > 235,000 clinic visits, 91,000 ED visits, and 23,000 hospitalizations among children < 5 years of age.

Norovirus is a self-limited gastrointestinal infection that lasts 2 to 3 days. Patients often present with vomiting followed by abdominal cramping, fever, and watery diarrhea. Other constitutional symptoms such as headache, chills, and myalgias are variably present. Compared to rotavirus infection, norovirus infection is associated with less intense diarrhea and is less likely to present with a fever. Norovirus-positive-related AGE is less likely to produce clinically-significant dehydration (7% vs 22%, \( P < 0.05 \)) and is less likely to result in the need for intravenous fluid replacement (41% vs 64%, \( P < 0.05 \)), compared to rotavirus-positive-related AGE. Like rotavirus, norovirus has been associated with benign infantile seizures.

**Bacterial And Parasitic Gastroenteritis**

Several studies have examined the ability to distinguish bacterial or parasitic etiologies from viral gastroenteritis on the basis of initial clinical presentation. In a prospective cohort study involving 1626 patients with acute diarrhea who presented to a pediatric ED, multivariate regression analysis demonstrated that fever (OR 2.3; 95% CI, 1.3-4.2), passing of ≥ 10 stools in the previous 24 hours (OR 4.5; 95% CI, 2.7-7.4) and travel outside of the US in the previous 30 days (OR 3.7; 95% CI, 1.7-8.0) were associated with the identification of a bacterial or parasitic pathogen on stool testing. Finkelstein et al reported similar findings in a group of 1035 infants < 1 year of age with diarrhea. In this study, a parental report of blood in the stool, fever (T > 38°C [100°F]), and passing of ≥ 10 stools in the previous 24 hours were associated with bacterial isolation on stool testing (OR 4.5; 95% CI, 2.8-7.3 for fever, unable to calculate OR for other variables). A combination of blood in the stool and temperature > 38°C (100°F) or passing of ≥ 10 stools in the previous 24 hours was associated with significant positive likelihood ratios (LR) to alter management (LR 13.5; 95% CI, 6.4-28.4 and LR 11.8; 95% CI, 4.8-29.2, respectively). Abdominal tenderness was associated with bacterial infection in 2 studies (Klein et al reported a relative risk [RR] of 3.8; 95% CI, 2.4-5.7 and Denno et al reported an OR of 7.1; 95% CI, 1.8-27.1). A strong seasonal variation in pathogen recovery has also been noted, with bacterial organisms more likely to be cultured in the months from May to October and viral organisms more likely to be found during the late fall, winter, and early spring months.

Interestingly, the presence of vomiting (OR 0.4; 95% CI, 0.2-0.6) and the duration of diarrhea > 10 days (OR 0.3; 95% CI, 0.1-0.9) were negatively associated with the identification of a bacterial or parasitic pathogen on stool testing. In a cohort of 50 patients < 3 years of age seen in pediatric outpatient clinics, persistent diarrhea (ie, diarrhea > 14 days) was seen only in patients with bacteria- and parasite-culture negative stool.

**Pathophysiology**

This section illustrates the pathophysiology behind rotavirus infection to illustrate how viruses typically infect the gastrointestinal system and produce the stereotypical symptoms of vomiting and diarrhea.
Rotaviruses are icosahedral double-stranded RNA viruses that infect the mature absorptive villous epithelium of the upper two-thirds of the small intestine. Following viral replication, virions are released into intestinal lumen and undergo further replication in the distal areas of the small intestine. Nausea and vomiting occur as responses to excess serotonin, which is released following the viral invasion of enterochromaffin cells located in the epithelial lining of the gastrointestinal lumen. Stimulation of central nervous system serotonin receptors results in activation of the chemoreceptor trigger zone and vomiting center.

The manifestation of diarrhea occurs as virions infect and destroy gastrointestinal enterocyte cells. Enterocyte cell lysis changes the shape of intestinal villi causing them to atrophy and fuse, thereby reducing the surface area for electrolyte and carbohydrate absorption. This in turn leads to an osmotic gradient of fluid into the intestinal lumen. Computed tomographic imaging of patients with gastroenteritis demonstrates abnormal bowel wall thickening (> 3 mm), mucosal enhancement, and fluid-filled bowel loops in the small intestine, with no radiographic findings in the stomach, appendix, or colon. The normal villous architecture is restored within 7 to 10 days.

**Differential Diagnosis**

**Diseases That Can Masquerade As Gastroenteritis**

- **Appendicitis** – Symptoms include vomiting that follows abdominal pain, small amounts of watery diarrhea (compared to the voluminous amounts produced as a consequence of gastroenteritis), and mild or absent fever.
- **Bacterial Enteritis** – Symptoms include diarrhea and history suggesting recent consumption of contaminated food, with or without fever. Recent travel suggests Traveler’s Diarrhea. Recent antibiotics suggest Clostridium difficile infection.
- **Pyelonephritis Or Pneumonia** – In children, typical extra-intestinal infections can produce diarrhea. In these patients, the location of the infection should be obvious after selective laboratory testing.
- **Intussusception** – Symptoms include intermittent colicky pain followed by periods of rest or improvement. Diarrhea is a late sign and is often bloody.
- **Malrotation With Volvulus** – Severe abdominal pain or bilious vomiting in a previously healthy infant should prompt consideration for this diagnosis.
- **Toxic Ingestion** – Ingestions of mushrooms, heavy metals, and cholinergic drugs will produce a clinical picture similar to AGE. Ask about accidental toxic ingestions.

- **Malabsorption Disorder** – Patients with celiac disease and lactose intolerance exhibit symptoms that include diarrhea, gas, bloating, and stomach pains that seem to be triggered by certain foods.
- **Diabetic Ketoacidosis** – This condition commonly presents with dehydration and thirst, along with some abdominal pain and nausea and vomiting. Diarrhea is an atypical feature, but in patients with concomitant polyuria and polydipsia, a glucose-point-of-care test is recommended.

**Prehospital Care**

Prehospital care for the pediatric patient with acute gastroenteritis should focus on assessing the level of dehydration and initiation of fluid replacement to correct significant dehydration. Although contemporary pediatric dehydration scales are believed to give a more accurate reflection of the level of dehydration, these scales are far too complex to be of use in the prehospital setting. The most useful individual signs for predicting ≥ 5% dehydration in children are abnormal capillary refill time, abnormal skin turgor, and abnormal respiratory pattern. These signs should be taught to paramedics and assessed in children who are believed to be hypovolemic.

Children with dehydration are at risk for hypoglycemia, the symptoms of which may go unrecognized by medical providers or may be mistakenly ascribed to dehydration. Two recent reports have noted that hypoglycemia is seen in about 10% of children with gastroenteritis who present to the ED. A paramedic point-of-care glucose check is therefore reasonable to obtain in any patient with symptoms of neuroglycopenia, any critically ill patient with acute diarrheal illness, or in any patient requiring intravenous fluid rehydration. Rapid glucose determination will also facilitate the diagnosis of diabetic ketoacidosis. A retrospective study involving 54 children with unrecognized new-onset type I diabetes mellitus noted that 9 out of 54 (16.7%) were diagnosed with gastroenteritis by the initial medical providers.

Mandati and Bachur recently derived a decision rule to predict acidosis (serum bicarbonate ≤ 16 mmol/L or end-tidal CO₂ ≤ 31 mm Hg), a surrogate for dehydration, among 130 children < 7 years of age with a chief complaint of vomiting, diarrhea, or dehydration. High-risk patients (ie, either < 2 years of age or ≥ 2 years of age with dry mucous membranes and > 2 days of illness) were at significant risk for acidosis (OR 8.5; 95% CI, 2.4-3.0). The authors of this rule advocate for its use in assisting triage decisions in the ED; however, these variables are relatively easy to obtain and may assist prehospital providers in determining the degree of illness in pediatric patients at risk for dehydration.
**ED Evaluation**

The decision to take a child to the ED is a complex process for parents. This decision involves expectations developed from the community and societal-level as well as family-level expectations, child factors, and access to care. A survey of parents who brought their child to the ED for gastroenteritis reported that parents believed their children were “very sick.” Interestingly, physician caregivers, blinded to these results, believed the children they cared for were “not very sick.”

**History**

The clinical history in a child who presents to the ED with gastroenteritis should assess the onset, frequency, quantity, and character (eg, blood, bile, mucous) of the diarrhea and/or vomiting. Additional important historical features include the duration of illness and the presence or absence of abdominal pain and fever. A report of fluid intake (including type of fluid ingested), urine output, and mental status will provide helpful information regarding the hydration status of the patient. If available, the most recent weight of the child should be recorded and compared to the present weight. The past medical history should identify underlying chronic medical conditions, history of recent infections (especially those treated with antibiotics), rotavirus vaccine status, and current medication use.

The predictive value of the parental history in determining the degree of dehydration has been examined in 4 prospective studies involving a total of 550 children. The most comprehensive of these trials involved a 132 parent-child pairs that presented to an ED with a chief complaint that included the terms vomiting, diarrhea, or decreased intake of fluids. Parents were asked to complete a computer-based interview that covered 9 historical items related to pediatric dehydration (eg, decreased oral intake, decreased urine output, and history of vomiting or diarrhea in past 12 hours). Parent-reported data demonstrated higher sensitivity (range 73%-100%) than specificity (range 0%-49%) for the outcome of ≥ 5% dehydration. None of these variables were individually able to significantly alter pre-test probability to predict ≥ 5% dehydration (ie, all had LR < 2). Parental history was equally poor at predicting acidosis (serum bicarbonate ≤ 16 mmol/L or end-tidal CO₂ ≤ 31 mm Hg) and the more clinically relevant outcomes of need for intravenous fluids and hospital admission. Conversely, 2 reports found parental report of a normal urine output to decrease the likelihood of ≥ 5% dehydration (Porter et al reported a LR of 0.16; 95% CI, 0.01-2.53 and Gorelick et al reported a LR of 0.27; 95% CI, 0.14-0.51).

**Physical Examination**

During the physical examination, the general condition and mental status of the patient should be noted. A review of the heart rate, blood pressure, quality of pulses, depth and rate of breathing, temperature, and room air oxygen saturation should all be noted. The examination should begin with the child across the room in a position of comfort (eg, the parents’ arms or in their lap). Overall appearance, activity, and responsiveness of the child to stimulation should be observed. Next, a head-to-toe physical examination focusing on the signs of dehydration and a general assessment of abdominal pathology should be completed. For the assessment of dehydration specifically, the appearance of the eyes (including the degree to which they are sunken), the presence or absence of tears, and the hydration status of the lips and mouth should be evaluated. Skin turgor should be examined by pinching a small skin fold on the lateral abdominal wall at the level of the umbilicus using the thumb and index finger. The fold should be promptly released and the time it takes to return to normal form measured. Finally, capillary refill should be assessed in the child’s fingertip, with the arm at the level of the heart, in a warm ambient temperature. Pressure should be gradually increased on the palmar surface of the distal fingertip, then released immediately after the capillary bed blanches. The time elapsed until restoration of normal color should be estimated. Several published guidelines on the assessment and treatment of gastroenteritis use a combination of a dozen or so clinical findings to develop a clinical dehydration table. (See Table 2 on page 8.)

The precision and accuracy of the physical examination findings associated with dehydration were assessed in a well-done systematic review. A total of 13 studies used the post-hydration weight standard to determine the degree of dehydration. In general, the interobserver reliability of the signs of dehydration was poor to moderate. (See Table 3 on page 9.)

The 3 most useful signs in determining ≥ 5% dehydration are prolonged capillary refill (pooled LR 4.1; 95% CI, 1.7-9.8), abnormal skin turgor (pooled LR 2.5; 95% CI, 1.5-4.2), and abnormal respiratory pattern (pooled LR 2.0; 95% CI, 1.5-2.7). Absence of tears had a pooled LR of 2.3 (95% CI, 0.9-5.8), but the potential of this sign is limited by a wide 95% CI that crosses 1.0. The presence of cool extremities or a weak pulse may also be helpful in determining the degree of dehydration; however, the limited number of studies that evaluated these findings limits pooling of this data. Unfortunately, the findings of poor overall appearance, increased heart rate, sunken fontanelle, sunken eyes, or dry mucous membranes have limited value as individual features in detecting ≥ 5% dehydration.
Clinical Prediction Rules

A limitation of the previously mentioned findings is that the assessment of dehydration is not based on individual historical and physical examination features; rather, clinicians combine multiple historical and examination elements to estimate the degree of dehydration. Vega and Avner asked a group of pediatric physicians to record a clinical estimate of the degree of dehydration in 97 dehydrated children (85% due to AGE) who were judged to require intravenous (IV) fluid hydration (using a 9-item clinical scale for dehydration with items similar to those found in Table 3 as the basis for their estimate).91

Children were classified based on which category of dehydration (ie, mild, moderate, or severe) had the majority of clinical findings. Using this scale, “moderate” dehydration had a LR of 2.1 (95% CI, 0.9-4.8) for the prediction of ≥ 5% dehydration. “Severe” dehydration had a LR of 4.3 (95% CI, 2.4-7.8) for the prediction of ≥ 10% dehydration.83,91

Several studies have developed clinical prediction rules that combine a number of clinical features to aid in determining hydration status.90,92,93 Although derived from separate populations, these rules share several common variables including the presence of dry mucous membranes,90,92,93 general appearance of infant/child,90,93 decreased/absent tears,90,93 and sunken eyes on examination.92,93 Additionally, capillary refill time > 2 seconds,90 abnormal skin turgor,92 and abnormal mental status92 were shown in these trials to predict dehydration. These rules demonstrate that the greater the number of these variables present, the more likely the child is to be ≥ 5% dehydrated using the post-hydration weight standard. The fact that there is significant overlap to the variables in these studies lends credibility to their validity; however, their most serious shortcoming is that they have yet to be validated in external settings. Additionally, the clinical applicability in the determination of the outcome of ≥ 5% dehydration is a matter of debate. Furthermore, none of these publications conform to the standards for the development of prediction rules in emergency medicine.94

Friedman et al derived a clinical prediction rule for dehydration in 137 children < 3 years of age with AGE.93 Four variables (dry mucous membranes, general appearance, sunken eyes on examination, and decreased tears), each assigned 0, 1, or 2 points based on clinical examination, were found to be predictive of dehydration. In a validation study involving 205 children < 5 years of age with AGE, clinical outcomes were found to correlate with the categories of “no dehydration” (total score 0 points), “some dehydration” (total score 1 to 4 points), and “moderate/severe dehydration” (total score 5 to 8 points).95 The ED length of stay in the 3 groups were (mean +/- standard deviation [SD]): no dehydration, 245 +/- 181 minutes; some dehydration, 397 +/- 302 minutes; moderate/severe dehydration, 501 +/- 389 minutes. The need for intravenous fluids in the 3 groups was no dehydration, 15%; some dehydration, 49%; moderate/severe dehydration, 80%.95

Diagnostic Studies

Tests For Dehydration

The utility of laboratory testing in estimating hydration status has been evaluated in multiple studies, with researchers testing about a dozen or so variables to aid in this task. In general, these studies conclude that no single laboratory value has adequate discriminatory power to distinguish clinically-significant dehydration and that the role of these tests is therefore limited.20,32,81,96,97

Table 2: Clinical Assessment Of Dehydration

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mild, 3%-5%</th>
<th>Moderate, 6%-9%</th>
<th>Severe, ≥ 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urine output</td>
<td>Normal to decreased</td>
<td>Decreased</td>
<td>Minimal</td>
</tr>
<tr>
<td>Thirst</td>
<td>Slightly increased; might refuse liquids</td>
<td>Moderately increased</td>
<td>Drinks poorly; unable to drink</td>
</tr>
<tr>
<td>Mental status</td>
<td>Normal</td>
<td>Normal, fatigued or restless, irritable</td>
<td>Apathetic, lethargic, unconsciousness</td>
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<td>Normal</td>
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<td>Deep</td>
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<td>Normal</td>
<td>Slightly sunken</td>
<td>Deeply sunken</td>
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</tr>
<tr>
<td>Mucous membranes</td>
<td>Moist</td>
<td>Dry</td>
<td>Parched</td>
</tr>
<tr>
<td>Extremities</td>
<td>Warm</td>
<td>Cool</td>
<td>Cold, mottle, cyanotic</td>
</tr>
<tr>
<td>Capillary refill</td>
<td>Normal</td>
<td>Prolonged</td>
<td>Prolonged; poor</td>
</tr>
<tr>
<td>Skin turgor</td>
<td>Normal</td>
<td>Recoil in &lt; 2 sec</td>
<td>Recoil in &gt; 2 sec</td>
</tr>
</tbody>
</table>

* Bradycardia may appear in severe cases
Acidosis (serum bicarbonate – variably defined, but generally < 16 mEq/L) has been shown to predict ≥ 5% dehydration,91,98-101 need for significant fluid resuscitation,102 and hospitalization in one earlier study.103 However, more recent studies have not shown a correlation between serum bicarbonate and hospital admission98,104 or between serum bicarbonate and unscheduled return visits.82 Related variables, such as venous pH,98,104 serum anion gap,104 and base deficit,98,103 have all shown variable usefulness in their ability to predict ≥ 5% dehydration. Similar to the findings of studies that evaluated the clinical examination, the bedside value of determining ≥ 5% dehydration is questionable (ie, published clinical guidelines recommend an initial trial of oral fluids in patients with < 10%, not < 5%, dehydration).

Blood urea nitrogen (BUN) and BUN/creatinine levels have been proposed as markers for dehydration.98,99,100,101,104,105 A recent pooled analysis of these trials noted that LRs ranged from 1.4 to 2.9 using BUN various cutoff values ranging from 18 mg/dL to 40 mg/dL.81 Similarly, a BUN/creatinine ratio of 40 had a LR of 2.1 (95% CI 0.5-8.9) to predict ≥ 5% dehydration.91,104

Urine specific gravity and the presence of urine ketones are commonly used to assess for dehydration. Of the 3 studies that we could find related to the use of these indices in the setting of pediatric dehydration from AGE, none of the 3 reported a significant correlation between these variables and ≥ 5% dehydration.100,104,106

### Table 3: Summary Test Characteristics For Clinical Findings To Detect 5% Dehydration81

<table>
<thead>
<tr>
<th>Finding</th>
<th>Number of Studies, Number of Patients</th>
<th>Range of k Values</th>
<th>LR Summary, Value (95% CI) or Range</th>
<th>Present</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor overall appearance</td>
<td>3 studies, 398 patients</td>
<td>0.18-0.61</td>
<td>1.9 (1.0-3.8)</td>
<td>0.5 (0.3-0.6)</td>
<td></td>
</tr>
<tr>
<td>Increased heart rate</td>
<td>3 studies, 462 patients</td>
<td>Not Reported</td>
<td>1.3 (0.8-2.0)</td>
<td>0.8 (0.6-1.1)</td>
<td></td>
</tr>
<tr>
<td>Weak pulse</td>
<td>2 studies, 360 patients</td>
<td>0.15 to 0.50</td>
<td>3.1, 7.2</td>
<td>0.7, 1.0</td>
<td></td>
</tr>
<tr>
<td>Abnormal respiratory pattern</td>
<td>4 studies, 581 patients</td>
<td>-0.04 to 0.40</td>
<td>2.0 (1.5-2.7)</td>
<td>0.8 (0.6-0.9)</td>
<td></td>
</tr>
<tr>
<td>Sunken fontanelle</td>
<td>3 studies, 308 patients</td>
<td>0.10 to 0.27</td>
<td>0.9 (0.6-1.3)</td>
<td>1.1 (0.8-1.5)</td>
<td></td>
</tr>
<tr>
<td>Sunken eyes</td>
<td>4 studies, 533 patients</td>
<td>0.06 to 0.59</td>
<td>1.7 (1.1-2.6)</td>
<td>0.5 (0.4-0.6)</td>
<td></td>
</tr>
<tr>
<td>Absent tears</td>
<td>3 studies, 398 patients</td>
<td>0.12 to 0.75</td>
<td>2.3 (0.9-5.8)</td>
<td>0.5 (0.3-1.1)</td>
<td></td>
</tr>
<tr>
<td>Dry mucous membrane</td>
<td>4 studies, 533 patients</td>
<td>0.28 to 0.59</td>
<td>1.7 (1.1-2.6)</td>
<td>0.4 (0.2-0.8)</td>
<td></td>
</tr>
<tr>
<td>Cool extremity</td>
<td>2 studies, 206 patients</td>
<td>0.23 to 0.66</td>
<td>1.5, 18.8</td>
<td>0.9, 1.0</td>
<td></td>
</tr>
<tr>
<td>Prolonged capillary refill</td>
<td>4 studies, 478 patients</td>
<td>0.01 to 0.65</td>
<td>4.1 (1.7-9.8)</td>
<td>0.6 (0.4-0.9)</td>
<td></td>
</tr>
<tr>
<td>Abnormal skin turgor</td>
<td>5 studies, 602 patients</td>
<td>0.36 to 0.55</td>
<td>2.5 (1.5-4.2)</td>
<td>0.7 (0.6-0.8)</td>
<td></td>
</tr>
</tbody>
</table>

### Tests For Rotavirus And Bacterial Enteritis

Rotavirus latex agglutination and antibody immunoassay tests have been on the market for over 25 years. These assays can be used to confirm the diagnosis of rotavirus, thereby limiting additional stool testing in pediatric patients. The current generation of tests has sensitivities ranging from 70% to 90% and specificities of 90% to 100%.107

The presence of fecal leukocytes has traditionally been associated with the presumption of a bacterial or parasitic origin to diarrhea. In a systematic review and meta-analysis of the literature from 1970 to 1994, Huicho et al determined the accuracy of several fecal-based tests, including stool white blood cells counts, for predicting the results of stool cultures. Using a receiver operating characteristic curve, a peak sensitivity of 70% for the test was noted at a specificity of just 50%. Using a cutoff to maximize specificity (90%) resulted in a sensitivity of only 40%.108 The test was noted to depend heavily on the time it took for the specimen to be examined after it had been retrieved and also on the experience of the operator. Increasing time results in increasing cell lysis and decreased sensitivity.109

C-reactive protein (CRP) has recently been used to distinguish viral gastroenteritis from bacterial enteritis. Marcus et al studied a bedside CRP test in 44 pediatric patients who presented to the ED with AGE of less than 48 hours duration. Using a cutoff value of 95 mg/L, CRP had a sensitivity of 87% and a specificity of 92%.
Clinical Pathway: Management Of Dehydration In Pediatric Gastroenteritis

What clinical signs of dehydration are present?

NONE

MILD/MODERATE

Start ORT at 50-100 mL/kg, plus replace ongoing losses. (Class II)

Use an oral antiemetic if vomiting is present and likely to impede ORT. (Class II)

Is dehydration resolved?

NO

YES

SEVERE

Admit patient.

Give a 20 mL/kg bolus of normal saline; repeat until stable. (Class II)

Is dehydration resolved?

NO

YES

NONE

MILD/MODERATE

SEVERE

Admit to ward or observation unit.

Admit to PICU.

If previous dehydration was noted, observe for a period of time in the ED.

Continue patient’s regular diet.

Discharge home with hydration instructions and signs of dehydration to look for.

Abbreviations: ORT, oral rehydration therapy; ED, emergency department; PICU, pediatric intensive care unit

This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient’s individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

Class Of Evidence Definitions

Each action in the clinical pathways section of Pediatric Emergency Medicine Practice receives a score based on the following definitions.

Class I
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II
- Safe, acceptable
- Possibly useful
- Considered optional or alternative treatments

Level of Evidence:
- Generally higher levels of evidence
- Non-randomized or retrospective studies: historic, cohort, or case control studies
- Less robust RCTs
- Results consistently positive

Class III
- May be acceptable
- Possibly useful
- Consisted optional or alternative treatments

Level of Evidence:
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate
- Continuing area of research
- No recommendations until further research

Level of Evidence:
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

for predicting culture-confirmed bacterial enteritis.\textsuperscript{110} Before we accept the results of this industry-sponsored trial that used a post-hoc cutoff value to maximize the performance characteristics of this test, further studies are required, especially those that compare the use of CRP to clinical judgment and those that report a change in patient management based on test results.

**Additional Laboratory Abnormalities**
A host of other laboratory abnormalities, such as hyponatremia and hypernatremia,\textsuperscript{82} hypokalemia,\textsuperscript{82} hypoglycemia,\textsuperscript{82,83} hyperamylasemia,\textsuperscript{112} and elevated antidiuretic hormone levels, have been reported with AGE.\textsuperscript{112} A study of 182 children with dehydration noted hypoglycemia (glucose < 60 mg/dL) in 18 patients (10%), hypokalemia (K < 3.5 mmol/L) in 11 patients (6%), and hypernatremia (Na > 150 mmol/L) in 6 patients (3%).\textsuperscript{82} Reid et al reported a hypoglycemia rate of 9% in a retrospective analysis of 196 children < 5 years of age with AGE.\textsuperscript{83} When the authors of the retrospective analysis tried to analyze predictors of hypoglycemia in children with AGE, they found 3 variables on multivariate analysis: female gender (OR 2.6; 95% CI, 1.3-5.0), signs of neuroglycopenia (OR 3.5; 95% CI, 1.4-8.6), and number of vomiting episodes greater than or equal to the number of diarrhea episodes (OR 2.1; 95% CI, 1.0-4.4).\textsuperscript{113}

**Other Considerations**
Several other studies have reported interesting findings with respect to laboratory testing in children with AGE. Hampers et al reported that providing physicians with price information next to laboratory orders resulted in significantly decreasing testing done in the ED, without sacrificing patient care.\textsuperscript{114} This same group also reported nearly equivalent clinical outcomes between physicians that order few tests for children with gastroenteritis compared to physicians that order more tests.\textsuperscript{115} Finally, this group also confirmed that children seen in an ED compared to a “fast-track” type area\textsuperscript{116} and children of families with significant language-barriers\textsuperscript{117} have longer ED stays and additional diagnostic testing performed.

**Treatment**

**Oral Rehydration Therapy**
Worldwide, the use of oral rehydration therapy (ORT) has resulted in significant improvement in pediatric mortality from dehydration over the last 30 years. In developed countries, ORT is used much less often in favor of faster and less labor-intensive IV fluid replacement. Only 15% of emergency physicians stated in a recent study that they would choose ORT in children with moderate dehydration.\textsuperscript{118} The current practice guidelines for gastroenteritis recommended by the Centers for Disease Control and Prevention and endorsed by the American Academy of Pediatrics recommend that treatment should include 2 phases, rehydration and maintenance. For mild to moderate dehydration, administer 50 to 100 mL/kg of oral rehydration solution (ORS) over 2 to 4 hours to replace the fluid deficit with additional ORS to replace ongoing losses. Use a teaspoon or dropper or nasogastric tube if necessary. In cases of severe dehydration, immediate IV rehydration with normal saline or Lactated Ringer’s Solution should be administered at 20 mL/kg until vital signs and mental status return to normal. With frail or malnourished infants, 10 mL/kg should be administered as they may be unable to increase cardiac output in response to rehydration, and rehydration status should be reassessed frequently. For a more detailed look at rehydration, see the January 2010 *Pediatric Emergency Medicine Practice* issue “An Evidence-Based Review Of Dehydration In The Pediatric Patient.”

**Antiemetics**
Traditionally, antiemetic agents have not been used in pediatric patients out of concern for adverse events. One study assessing antiemetic use among emergency medicine, pediatric emergency medicine, and pediatric providers in 2002 indicated that promethazine was the most commonly used antiemetic, and adverse reactions were reported most often with prochlorperazine.\textsuperscript{119} The most commonly reported side effects of prochlorperazine included dystonia/dyskinesia, akathisia, hyperreflexia, and impaired consciousness. Promethazine lacks antidopaminergic actions and thus antipsychotic effects. Its major side effect is CNS depression, possibly due to antihistamine properties. Use of these antiemetics is controversial because of these adverse effects, particularly extrapyramidal side effects and sedation that may interfere with ORT. Dimehydrinate is a combination of diphenhydramine and theophylline in an attempt to decrease the drowsiness caused by diphenhydramine. It is used more often in Canada and Germany than in the US, and while it has been shown to reduce vomiting episodes, it did not improve oral rehydration or clinical outcome.\textsuperscript{120} Ondansetron is a selective serotonin 5-HT3 receptor-blocking agent that previously was indicated for post-chemotherapy and post-surgical nausea and vomiting and has a very good side effect profile. One meta-analysis of 11 articles by Ross Decamp et al published in 2008 reviewed antiemetics in the pediatric population, and the ondansetron studies were the most recently published and achieved the highest quality ratings. Overall, ondansetron compared to placebo reduced hospital admissions (number needed to treat [NNT] 14), reduced the need for intravenous fluid administration (NNT 5), and resulted in cessation of vomiting while in the emergency department.\textsuperscript{121} Indication for intravenous fluid administration varied by study but included persis-
ent emesis, refusal to drink, and persistent dehydration. There was no significant difference in return to care. Freedman et al showed that weight-based, one-time dosing of oral dissolving tablets (ODT) was effective in allowing ORT in a cohort of children from 6 months to 10 years. Oral dissolving tablets are a noninvasive, cost effective way to facilitate ORT in children. Several studies have noted that the benefit of nausea control comes at the expense of prolonging diarrheal episodes during the 48-hour period following administration of the drug. Most studies were done in children > 6 months of age, and use in young infants should be done with caution as the safety and efficacy has not been confirmed.

### Antibiotics

The question of antibiotic use is more relevant when discussing infectious diarrhea and less with acute gastroenteritis. Because the clinical picture between these two entities can be difficult to distinguish, this article briefly discusses the treatment of infectious diarrhea. Cases that may require antimicrobial therapy are those that have increased potential to develop complications such as sepsis or disseminated intravascular coagulation. This population includes those with HIV, those undergoing chemotherapy, diabetics, neonates and young infants, organ transplants, or those with articular or valve prosthesis. The World Health Organization currently recommends empiric antimicrobial therapy in the setting of febrile acute bloody diarrhea in young children. The use of antibiotics in acute diarrhea has been shown to be a risk factor for developing persistent symptoms.

### Antidiarrheals

There are 3 major classes of antidiarrheal agents. Mechanisms of action include decreasing gut motility, antisecretory, adsorbent, and probiotics. Loper-
amidine is an opiate receptor agonist whose side effects include lethargy, paralytic ileus, toxic megacolon, central nervous system (CNS) depression, coma, and even death. It can also prolong transit time and subsequently bacterial infection. Antisecretory drugs include bismuth subsalicylate and racecodotril (acetorphan). Bismuth subsaliclylate can produce salicylate toxicity. A recent study comparing racecodotril, an inhibitor of intestinal encephalinases that decreases the secretion of water and electrolytes, to placebo found no difference in number of stools and time to resolution of symptoms. Previous studies of racacodotril used in moderate to severe diarrhea in hospitalized children have shown improvement in symptoms. Adsorbents include smectite, a natural hydrated alumino-magnesium silicate that binds to digestive mucus and is used in several countries outside of the US. A meta-analysis of smectite showed a moderate reduction in the duration of diarrhea.

**Special Circumstances**

Antibiotic-associated diarrhea (AAD) is unexplained diarrhea occurring between 2 hours and 2 months after starting antibiotics. The prevalence of AAD in the pediatric population is around 11%. A recent review by Alam et al found that risk factors include children younger than 2 years and type of antibiotic. The risk seems to be higher with antibiotics that act on anaerobes, such as amoxicillin, the combination of amoxicillin/clavulanate, cephalosporins, and clindamycin. Antibiotic-associated diarrhea is associated with altered intestinal microflora, mucosal integrity, vitamin and mineral metabolism, and crampy abdominal pain. Erythromycin accelerates the rate of gastric emptying; amoxicillin/clavunate stimulates small bowel motility. The majority of patients improve with discontinuation of the antibiotics. A recent meta-analysis concluded that probiotics prevent AAD in 1 out of 7 children taking antibiotics.

**Risk Management Pitfalls To Avoid In Pediatric Gastroenteritis**

admission for any infant < 1 year of age with gastroenteritis, especially if the family has limited access to healthcare.

6. “Our QA committee just asked me to justify why I sent home a child with compensated shock. I don’t even know what compensated shock is.”
Compensated shock is a condition where a child displays all the signs of poor peripheral perfusion but is maintaining an adequate central blood pressure. For example, a severely dehydrated child with cool extremities and no urine output who is tachycardic and tachypneic but is able to maintain a minimal blood pressure is likely to be in a state of compensated shock. Children presenting with signs and symptoms consistent with severe dehydration should be admitted to the hospital or a short-stay unit for further observation.

7. “I ended up admitting that kid you signed out to me who developed abdominal pain and diarrhea after starting his antibiotics for a skin infection. Did you consider that he may have *C difficile* colitis?”
Any child with diarrhea following recent antibiotic use should be evaluated for *C difficile* infection. Although mild infection may be self-limited, the presence of fever, leukocytosis, or abdominal tenderness can indicate significant colitis requiring antibiotic treatment with metronidazole or vancomycin.

8. “That kid we just sent home with gastroenteritis is back. His parents now say that he just had a bloody bowel movement.”
Bloody diarrhea is unusual for viral gastroenteritis and is more commonly associated with bacterial enteritis. In the absence of fever, consider intussusception, hemolytic uremic syndrome, inflammatory bowel disease, and pseudomembranous colitis. Once these diagnoses have been eliminated, the diagnosis of intestinal enteritis can be entertained.

9. “Doc, I just roomed a little 2-month-old with bilious vomiting in the next room. Do you want me to get anything started on him?”
Yes. Bilious emesis is always worrisome in an infant and should be considered a surgical emergency until proven otherwise. The top consideration in this child is intestinal malrotation.

10. “The family you asked to come back today is doing fine. They say their daughter is doing much better today.”
Recommend 24-hour follow-up, either in the ED or in a pediatrician’s office, for any child that you are worried about. This is especially true for patients who present with abdominal pain and vomiting only. Although the ultimate diagnosis may be gastroenteritis, the lack of diarrhea should be considered an atypical finding and should be further explored while in the ED.
Sample Discharge Instructions

1. What is gastroenteritis?
   Gastroenteritis is an illness that can cause vomiting and diarrhea and may lead to dehydration in your child. Gastroenteritis is most often caused by a virus infection and typically gets better in a couple of days without any medication. Infrequently, early appendicitis can be misdiagnosed as gastroenteritis. For this reason, if you feel like your child is not improving in 6 to 8 hours, please return to the ED for repeat evaluation.

2. What is dehydration?
   Dehydration is the “drying out” of the body that occurs when a child loses more fluids (through vomiting, diarrhea, and fever) than he or she is able to drink. This can happen very quickly in infants and small children as these children have less “extra” fluid to lose. If your child is diagnosed with gastroenteritis, it is important to recognize and prevent dehydration.

3. How do I prevent dehydration in my child?
   The best way to prevent dehydration in infants is to try to feed your baby (using breast milk or formula) more often. If your child is older, make sure that he or she is drinking enough liquids to replace the fluids that are lost through diarrhea and vomiting. If your child is nauseated (feels like throwing up), use small sips of a commercially prepared oral rehydration solution every few minutes. Drinks that are high in sugar (such as juices or soft-drinks) might make the diarrhea worse and should be avoided.

   There has been much confusion and folklore about optimal foods for children with gastroenteritis. Children who are not dehydrated should continue to eat a regular diet, and infants who are breastfeeding should continue to do so unless you are told otherwise by your pediatrician. Most children with diarrhea tolerate full-strength cow’s milk products. It is not necessary to dilute or avoid milk products. Recommended foods include a combination of complex carbohydrates (rice, wheat, potatoes, bread), lean meats, yogurt, fruits, and vegetables. High fat foods are more difficult to digest and should be avoided. It is not necessary to restrict a child’s diet to clear liquids or the BRAT diet (bananas, rice, applesauce, toast) as these diets are poor in nutritional content.

4. How do I know if my child is getting dehydrated?
   You should consider dehydration if your child had vomiting or diarrhea and has any of the following of these signs:
   - feeling dizzy when sitting or standing up
   - dry lips and mouth
   - urinating less frequently (< 1 wet diaper every 6 hours), especially if the urine looks dark and has a strong smell
   - little or no tears while crying
   - not paying attention to toys or television or being difficult to wake up

5. How do I treat dehydration at home?
   If your child has mild symptoms, you can care for your child at home with help from your doctor. Start by giving your child 1 to 2 teaspoons of an oral rehydration solution every 1 to 2 minutes. This adds up to over 1 cup an hour. If your child does well, you can slowly give bigger sips a little less often - every 5 minutes or so. When your child is no longer dehydrated and is not nauseated or vomiting, begin giving regular foods and drinks again.

6. When should I call my doctor or return to the ED?
   The following is a list of signs and symptoms that are worrisome and require immediate medical attention:
   - bloody diarrhea
   - if an infant refuses to drink anything for more than 3 to 4 hours
   - signs of dehydration
   - abdominal pain that comes and goes or is severe
   - Any fever >102°F (39°C) or a fever >101°F (38.4°C) that persists for more than 3 days
   - behavioral changes, including lethargy or decreased responsiveness
**Clostridium difficile** infection (CDI) is uncommon in children, but according to recent studies the incidence of community-acquired CDI in the pediatric population is increasing. **Clostridium difficile** infection is responsible for somewhere between 5% to 20% of AAD and almost all cases of colitis. Sensitive predictors are severe diarrhea, the presence of blood or mucus, fecal leukocytes > 5/HPF, and the presence of Gram-positive bacilli with oval subterminal spores. Pseudomembranous colitis usually presents with abdominal cramps, fever, leukocytosis, fecal leukocytes, hypoalbuminemia, colonic thickening on CT, and punctate yellow plaques seen on endoscopic examination. Most of these cases are *C difficile* positive. Either metronidazole or vancomycin orally for 10 days is the drug of choice.

### Controversies/Cutting Edge

**End-Tidal CO₂ To Measure Acidosis**

End-tidal CO₂ values have recently been shown to correlate accurately with serum HCO₃⁻ levels among children with vomiting and diarrhea. In a prospective study involving 130 children with gastroenteritis, children were connected to a noninvasive portable handheld end-tidal capnographer with an oral/nasal cannula. After a 60 second stabilization period, the most frequently displayed ETCO₂ value over the next 30- to 60-seconds was recorded. An ETCO₂ ≤ 31 mm Hg correlated well in detecting serum HCO₃⁻ ≤ 15 mmol/L (LR 20.4). An ETCO₂ value ≥ 34 mm Hg was unlikely to be associated with serum HCO₃⁻ ≤ 15 mmol/L (LR 0.04). A correlation between ETCO₂ and serum HCO₃⁻ has been demonstrated in 2 additional studies on pediatric gastroenteritis and in studies of metabolic acidosis.

### Time-Elapsed Digital Photography To Measure Capillary Refill Time

High-speed digital photography can be used to assess capillary refill time. Investigators from Canada took a high-quality digital picture of a child’s finger.

### Cost-Effective Strategies

- Minimize routine blood- and urine-testing in children with non-severe gastroenteritis. Laboratory values rarely change disposition decisions and only occasionally lead to electrolyte management. The most frequent abnormal laboratory test that requires a change in therapy is glucose, a laboratory test that can be checked by doing a point-of-care test. The complete blood count is not helpful in the setting of gastroenteritis. The presence of a leukocytosis may be due to a more serious underlying infection or may be due to stress form vomiting. Electrolyte values, serum bicarbonate, and serum BUN, or BUN/Cr ratio all have limited value in the assessment of dehydration. Similarly, urine studies do not need to confirm the diagnosis of dehydration. Laboratory testing should be reserved for infants < 1 year of age, those with severe dehydration, and patients with an altered mental status at baseline and should be considered in patients with atypical features.
- Eliminate radiographic testing in patients with gastroenteritis. Radiographs are of no use in patients with typical signs and symptoms of gastroenteritis. These can only be helpful if another diagnosis (eg, bowel obstruction) is being entertained.
- Order stool studies selectively. In general, stool studies are expensive, time-consuming, and low yield. Consider obtaining stool cultures in patients with epidemiological risk factors supporting the diagnosis of bacterial enteritis, with temperature > 38.5°C (101.3°F), and in whom empiric antibiotics will be prescribed. It is also reasonable to send cultures on patients with significant white blood cells or red blood cells on stool microscopy. Testing for ova and parasites should be done in immunocompromised patients and in patients that have had recent international travel.
- Oral rehydration is preferred to IV rehydration in most patients able to tolerate oral intake. Hydration with oral fluids has several advantages including cost and patient satisfaction, and it buys you a period of observation in the ED, during which time the parents of the patient are directly observing that their child is able to tolerate oral fluids.
- Oral ondansetron has been shown to be effective in treating nausea in patients with acute gastroenteritis. In the ED setting, ondansetron has been found to be safe and effective at decreasing vomiting and the need for admission. Although some pediatric emergency medicine specialists prefer to only give 1 dose of ondansetron in the ED, others prefer to send patients home with a small prescription for additional tablets in case the symptoms return.
- Implement an evidence-based practice guideline regarding laboratory testing, need for IV hydration, and the use of antiemetic agents in the ED. Implementation of a multidisciplinary evidence-based pathway will likely reduce the need for hospital admissions, laboratory testing, and rehydration using IV fluids. In studies out of Australia and Cincinnati, the implementation of evidence-based guidelines for gastroenteritis resulted in a significant drop in hospital admissions.
tip applied pressure to the fingertip for 5 seconds, and then used high-speed digital photography and computer software to determine how long it took for the finger to return to its baseline color. In a prospective study of 83 children with gastroenteritis, digitally measured capillary refill time performed better than conventional capillary refill and overall clinical assessment in determining dehydration. Digital capillary refill time had an overall sensitivity of 100% (95% CI, 75%-100%) and specificity of 91% (95% CI, 82%-97%) in determining ≥ 5% dehydration.  

**Ultrasound Of The Inferior Vena Cava To Assess Dehydration**

Bedside ultrasound measurement of the inferior vena cava (IVC) and aorta (Ao) has been shown to be useful in objectively assessing children with dehydration. In a prospective case-control study involving a total of 72 pediatric patients, 36 children with clinical evidence of dehydration (56% due to gastroenteritis) requiring IV fluid resuscitation were matched with 36 age-, gender-, and weight-matched controls. Compared to controls, the dehydrated children had a significantly lower IVC/Ao ratio (mean 0.75 vs 1.01, mean difference 0.26 [95% CI, 0.18-0.35, P < 0.001]). These 36 cases were also self-matched after receiving IV hydration with 25 to 50 mL/kg of normal saline (median amount of 20 mL/kg). Compared to post-hydration measurements, the pre-hydration cases had a significantly lower IVC/Ao ratio (mean of 0.75 vs 1.09, mean difference 0.34 [95% CI, 0.29-0.34, P < 0.001]). Using a post-hoc cutoff ratio of 0.72, the test had a sensitivity of 39% and a specificity of 100%. With a cutoff ratio of 1.0, the test has a sensitivity of 97% and a specificity of 58%. In a separate study involving a total of 75 pediatric patients, the finding of complete IVC collapse during inspiration was 25% sensitive and 100% specific for dehydration.

**Dextrose-Containing Fluids For Rehydration**

The addition of dextrose to rehydration solutions stimulates insulin release while inhibiting glucagon release. These actions stop lipolysis and the production of ketone bodies, and thereby decrease nausea and vomiting. Furthermore, utilization of the sodium-glucose cotransport mechanism across the intestinal villi is also thought to enhance rehydration. These observations have led some researchers to believe that early administration of dextrose to patients receiving IV fluid hydration will help terminate vomiting and decrease outpatient treatment failures. A recent retrospective case-control study involving 168 children who received IV fluid in the ED for the treatment of dehydration secondary to acute gastroenteritis reported that the addition of dextrose to rehydration solutions was associated with a decrease in 72-hour return visit for hospital admission.

**Disposition**

The vast majority of children with acute gastroenteritis can be managed as outpatients. (See **Sample Discharge Instructions on page 14.** Hospital admission should be considered in children at high-risk for morbidity (eg, children < 1 year old, very-low birth weight children), children with significant medical comorbidities (especially those affecting the ability to relate thirst and dehydration), children with electrolyte abnormalities that require IV repletion, and children with severe dehydration. Acidosis has been found to correlate with hospital admission in some, but not all studies.

Short stay hospitalization (ie, < 23 hours) or observation units provide adequate time for rehydration for the majority of patients with acute gastroenteritis who need to be admitted for dehydration. A retrospective review of 208 hospitalized patients with dehydration secondary to acute gastroenteritis noted that the time from hospital admission to adequate rehydration (defined as a drop in urine-specific gravity to 1.010 or less) was < 12 hours in 165 out of 208 (79%) patients and < 24 hours in 197 out of 208 (95%) patients.

Observation units have been credited with improving patient satisfaction, lowering patient charges, and having consistently demonstrated quality of care comparable to inpatient units. Optimal use of an observation unit is predicated on selecting a population of patients that will likely improve in < 24 hours. As a quality improvement measure, unplanned inpatient admissions are often reviewed to determine the appropriateness of admission to the observation unit. Mallory et al evaluated the appropriateness of admission of 82 pediatric patients with dehydration secondary to gastroenteritis who were initially admitted to a pediatric observation unit but then had an unplanned inpatient admission. He compared the historical, physical examination, and laboratory characteristics of these patients with 348 pediatric patients admitted with the same diagnosis to the pediatric observation unit who were successfully discharged before 24 hours. No significant differences were found between the 2 groups with respect to these variables.

**Summary**

Acute gastroenteritis is a common illness that can result in significant dehydration in infants and young children. Luckily, most cases are mild and require little more than an adequate clinical examination and oral rehydration. Intravenous fluids are rarely needed and should be reserved for children who present with severe dehydration. Following resolution of the illness, a normal low-fat diet should be resumed.
Case Conclusion

After talking to the mom, you realized that the pediatrician never evaluated the patients and only told the mom by telephone that her kids may need IV hydration. You convinced mom to let you try ODT ondansetron followed by oral hydration therapy. Since none of the kids appeared that ill, you decided not to do any additional testing.

Practice Recommendations

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References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study, will be included in bold type following the reference, where available.

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1. What are the 2 most common viruses that cause gastroenteritis?
   a. Rotavirus and adenovirus
   b. Rotavirus and norovirus
   c. Sapovirus and astrovirus
   d. Norovirus and adenovirus

2. A recent study showed which triad to be present in a higher percentage of rotavirus children versus those without rotavirus?
   a. Vomiting, diarrhea, and fever
   b. Vomiting, diarrhea, and abdominal pain
c. Vomiting, diarrhea, and dysuria
d. Vomiting, bloody diarrhea, and abdominal pain

3. What is the proposed cause of nausea and vomiting in gastroenteritis?
   a. Gastric cell damage
   b. Destruction of gastrointestinal enterocyte cells
   c. Serotonin activation of the vomiting center
   d. There is no proposed mechanism

4. What are the 3 most useful individual signs for predicting ≥ 5% dehydration in children?
   a. Abnormal capillary refill time, sunken eyes, and sunken fontanelle
   b. Abnormal capillary refill time, abnormal skin turgor, and abnormal respiratory pattern
   c. Dry mucous membranes, absent tears, and abnormal skin turgor
   d. Increased heart rate, abnormal respiratory pattern, and hypotension

5. What elements are included in the clinical dehydration score?
   a. Dry mucous membranes, weak pulse, and abnormal respiratory pattern
   b. General appearance, mucous membranes, and tears
   c. General appearance, eyes, mucous membranes, and tears
   d. Prolonged capillary refill, abnormal skin turgor, and abnormal respiratory pattern

6. How should abnormal skin turgor be tested?
   a. Pinch the cheek just lateral to the mouth
   b. Pinch the skin on the dorsum of the hand
   c. Pinch a small skin fold on the lateral abdominal way at the level of the umbilicus
   d. Pinch the skin just superior to the antecubital fossa

7. Which of these children is most likely to be dehydrated?
   a. A child with no history of diarrhea per the parent
   b. A child previously seen by their pediatrician during the same illness
   c. A child presenting for the first time during a particular illness
   d. A child with post-tussive emesis

8. What is the best way to examine the abdomen of an infant or young child?
   a. It is best to surprise them
   b. At the end of the physical examination
   c. When the child is calm, possibly sitting on the parents lap or sleeping
   d. Have the parents do it and give you a detailed description

9. What is the mechanism of action of ondansetron?
   a. Selective serotonin 5-HT3 receptor-blocking agent
   b. Opiate receptor agonist
   c. Decreased gut motility
   d. H1 antagonist

10. Which ORS is recommended by the WHO?
    a. Osmolarity < 270 mOsm/L in which the glucose and sodium content were each reduced to 75 mmol/L to give a total osmolarity of 245 mOsm/L
    b. Osmolarity 310
    c. Polymer-based ORS
    d. Diluted fruit juices or sports drinks

11. How much of an initial PO bolus should be given to a moderately dehydrated child?
    a. The amount of ORS should be based on what the child asks to drink
    b. Administer 50-100 mL of ORS/kg over 2-4 hours to replace the fluid deficit
    c. Administer 100-200 mL of ORS/kg over 12 hours to replace the fluid deficit
    d. Administer 20 mL of ORS/kg in the first hour, then ad lib

12. In which patient population does the WHO recommend antimicrobial therapy?
    a. Setting of febrile acute bloody diarrhea in young children
    b. All children with watery diarrhea
    c. Children under the age of 2 years
    d. If the parents ask for antibiotics

13. Which antibiotics have a higher incidence of antibiotic associated diarrhea?
    a. Gentamycin and vancomycin
    b. Levofoxacin and gentamycin
    c. Amoxicillin, amoxicillin/clavulanate, cephalosporins, and clindamycin
    d. All antibiotics have the same incidence in the pediatric population

14. Which risk factors should alert the emergency medicine clinician that a child with cancer may be at higher risk for typhlitis?
    a. Fever, vomiting, diarrhea
    b. History of chemotherapy in the last 2 weeks, mucositis, stem cell transplantation
    c. Sibling with similar symptoms
    d. Radiation therapy with chemotherapy in the last year
In the seventh volume of The Emergency Medicine Practice Clinical Excellence Series: An Evidence-Based Review of Pediatric Complaints and Concerns you’ll find a collection of previously published articles dating back to 2004 from Pediatric Emergency Medicine Practice with relevant updated material from 2010 including approximately 500 new references. This book provides the reader with evidence-based concepts that can be easily integrated into the daily clinical practice of emergency medicine. The topics for this volume include:

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**Evidence-Based Practice Recommendations**

**Pediatric Emergency Medicine Practice Acute Gastroenteritis — An Update**
Singh A, Fleurat M. July 2010; Volume 7, Number 7

Gastroenteritis refers to inflammation of the lining of both the stomach and small intestines. The majority of cases are infectious, with viral organisms predominating; however, bacterial and parasitic infections can be a specific concern in the appropriate patient. This article will help the reader to cite the most common etiologies for pediatric diarrheal illness in the emergency department, identify historical and examination findings that predict the degree of pediatric dehydration, describe the rationale for the use of oral rehydration therapy in mild and moderately dehydrated children, and describe the risks and benefits for medication use in the treatment of acute gastroenteritis. For a more detailed and systematic look at acute gastroenteritis in the pediatric patient, see the full text article at [www.ebmedicine.net](http://www.ebmedicine.net).

<table>
<thead>
<tr>
<th>Key Points</th>
<th>Comments</th>
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<tr>
<td>The 3 most useful signs in determining ≥ 5% dehydration are prolonged capillary refill, abnormal skin turgor, and abnormal respiratory pattern.</td>
<td>Prehospital care for the pediatric patient with acute gastroenteritis should focus on assessing the level of dehydration and initiation of fluid replacement to correct significant dehydration. Although contemporary pediatric dehydration scales are believed to give a more accurate reflection of the level of dehydration, these scales are far too complex to be of use in the prehospital setting. Prolonged capillary refill, abnormal skin turgor, and abnormal respiratory pattern should be taught to paramedics and assessed in children who are believed to be hypovolemic.</td>
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<td>Most children are not significantly dehydrated and do not require routine laboratory testing or IV hydration.</td>
<td>The utility of laboratory testing in estimating hydration status has been evaluated in multiple studies, with researchers testing about a dozen or so variables to aid in this task. In general, these studies conclude that no single laboratory value has adequate discriminatory power to distinguish clinically-significant dehydration and that the role of these tests is therefore limited.</td>
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<td>Oral rehydration solutions are cost-effective ways to treat mild to moderate dehydration.</td>
<td>For mild to moderate dehydration, administer 50 to 100 mL/kg of oral rehydration solution (ORS) over 2 to 4 hours to replace the fluid deficit, with additional ORS to replace ongoing losses. Use a teaspoon or dropper or nasogastric tube if necessary. In cases of severe dehydration, immediate IV rehydration with normal saline or Lactated Ringer’s Solution should be administered at 20 mL/kg until vital signs and mental status return to normal. With frail or malnourished infants, 10 mL/kg should be administered as they may be unable to increase cardiac output in response to rehydration, and rehydration status should be reassessed frequently.</td>
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<td>Serotonin-receptor blockers (eg ondansetron) can be used in the emergency department to alleviate nausea and vomiting, improve oral hydration, and cut-down on hospital admissions.</td>
<td>Ondansetron is a selective serotonin 5-HT3 receptor-blocking agent that previously was indicated for post-chemotherapy and post-surgical nausea and vomiting and has a very good side effect profile. One meta-analysis of 11 articles by Decamp et al published in 2008 reviewed antiemetics in the pediatric population, and the ondansetron studies were the most recently published and achieved the highest quality ratings. Overall, ondansetron compared to placebo reduced hospital admissions (number needed to treat [NNT] 14), reduced the need for intravenous fluid administration (NNT 5), and resulted in cessation of vomiting while in the emergency department.</td>
</tr>
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<td>Following rehydration, an age-appropriate, unrestricted diet should begin as soon as possible. Partial dilution of formula, restriction of lactose, and use of the BRAT diet are not necessary.</td>
<td>There has been much confusion and folklore about optimal foods for children with gastroenteritis. Children who are not dehydrated should continue to eat a regular diet, and infants who are breastfeeding should continue to do so unless you are told otherwise by your pediatrician. Most children with diarrhea tolerate full-strength cow’s milk products. It is not necessary to dilute or avoid milk products. Recommended foods include a combination of complex carbohydrates (rice, wheat, potatoes, bread), lean meats, yogurt, fruits, and vegetables. High fat foods are more difficult to digest and should be avoided. It is not necessary to restrict a child’s diet to clear liquids or the BRAT diet (bananas, rice, applesauce, toast) as these diets are poor in nutritional content.</td>
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REFERENCES


These references are excerpted from the original manuscript. For additional references and information on this topic, see the full text article at ebmedicine.net.

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