

# Gastroenteritis in Children: Part I. Diagnosis

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Acute gastroenteritis in children is a major cause of morbidity in the United States. Viral infections, primarily from rotavirus, cause 75 to 90 percent of cases. The remaining infections are largely bacterial, with as many as 10 percent of cases secondary to diarrheagenic *Escherichia coli*. The history and physical examination of children with gastroenteritis should focus on assessing for the presence and degree of dehydration and determining the underlying etiology. The child's weight during the illness versus posttreatment is often used to evaluate degree of dehydration retrospectively. The three examination signs that best suggest dehydration in children are an abnormal respiratory pattern, abnormal skin turgor, and prolonged capillary refill time, although parental report of the child's history is also helpful in the assessment. In general, measuring serum electrolyte levels usually is unnecessary in children with mild to moderate dehydration. Laboratory tests are recommended only when severe dehydration is suspected; in such cases, intravenous fluids would be warranted. Although it is not necessary to routinely obtain stool cultures, they should be collected if diarrhea is persistent. (*Am Fam Physician*. 2012;85(11):1059-1062. Copyright © 2012 American Academy of Family Physicians.)



This is part I of a two-part article on gastroenteritis in children. Part II, "Prevention and Management," appears in this issue of *AFP* on page 1066.

**A**cute gastroenteritis in children is often defined as the onset of diarrhea in the absence of chronic disease, with or without abdominal pain, fever, nausea, or vomiting.<sup>1</sup> In the United States, the condition is a major source of morbidity and hospitalization in children younger than five years, accounting for approximately 300 deaths, greater than 1.5 million outpatient visits, and 200,000 hospitalizations annually. These hospitalizations lead to \$250 million in direct medical costs and \$1 billion in indirect costs. Rotavirus infection leads to one-third of all diarrhea-related hospitalizations among children younger than five years.<sup>2</sup> Childhood gastroenteritis also is a major cause of morbidity and mortality worldwide, leading to 2.5 million deaths annually in children younger than five years. However, with the increased use of oral rehydration therapy, worldwide mortality has been cut in half over the past 30 years.<sup>3</sup> This article, part I of a two-part series, focuses on the evaluation of children with gastroenteritis. Part II discusses therapies for the condition.<sup>4</sup>

## Etiology

Acute gastroenteritis in the United States is usually caused by an infection. Viral infections, primarily from rotavirus, cause 75 to 90 percent of infectious diarrhea cases in the industrialized world. Bacterial pathogens cause another 10 to 20 percent of cases, with as many as 10 percent of these occurring secondary to diarrheagenic *Escherichia coli* (e.g., traveler's diarrhea). Parasites such as *Giardia intestinalis* and *Cryptosporidium* cause less than 5 percent of cases.<sup>5</sup> The incidence of different pathogens may be affected by season and climate. Rotavirus infection, for example, is primarily a winter disease. The risk of acute gastroenteritis in children is increased in day cares and in impoverished areas with poor sanitation.<sup>6,7</sup>

The differential diagnosis of acute gastroenteritis in children includes a wide range of gastrointestinal conditions (e.g., inflammatory bowel disease, intussusception, pseudomembranous enterocolitis, appendicitis, food allergy, lactase deficiency) and extraintestinal conditions (e.g., bacterial sepsis,

**Table 1. Pathogens Associated with Acute Gastroenteritis in Children**

**Noninflammatory agents**

Viruses (75 to 90 percent)

*Rotavirus*

Enteric adenovirus

Calicivirus (e.g., *Norovirus* and *Sapovirus*)

*Astrovirus*

**Inflammatory agents**

Bacteria (10 to 20 percent)

*Salmonella*

*Shigella*

*Campylobacter jejuni*

*Yersinia enterocolitica*

Enterohemorrhagic *Escherichia coli* (includes O157:H7)

Other diarrheagenic *E. coli*

*Clostridium difficile*

Parasites (less than 5 percent)

*Giardia intestinalis*

*Cryptosporidium*

NOTE: The agents are listed in the approximate order of most to least common in the United States.

Adapted with permission from Acute Gastroenteritis Guideline Team. Cincinnati Children's Hospital Medical Center. Evidence-based care guideline for prevention and management of acute gastroenteritis in children age 2 months to 18 years. December 21, 2011. <http://www.cincinnatichildrens.org/service/jj/anderson-center/evidence-based-care/gastroenteritis/>. Accessed January 20, 2012.

**Table 2. Red Flags in a Child with Diarrhea Warranting Urgent Physician Evaluation**

Caregiver report of decreased tearing, sunken eyes, decreased urine output, or dry mucous membranes

Fever

≥ 100.4°F (38°C) in infants younger than three months

≥ 102.2°F (39°C) in children three to 36 months of age

Frequent and substantial episodes of diarrhea

History of premature birth, chronic medical conditions, or an accompanying illness

Mental status changes (e.g., apathy, lethargy, irritability)

Persistent vomiting

Poor response to oral rehydration therapy or inability of the caregiver to give adequate therapy

Visible blood in the stool

Young age (younger than six months) or low body weight (less than 17 lb, 10 oz [8 kg])

Adapted from King CK, Glass R, Bresee JS, Duggan C; Centers for Disease Control and Prevention. Managing acute gastroenteritis among children: oral rehydration, maintenance, and nutritional therapy. MMWR Recomm Rep. 2003;52(RR-16):13.

otitis media, pneumonia, meningitis, urinary tract infection). In addition, vomiting by itself can be the first symptom of congestive heart failure, trauma, metabolic disorders, ingestion of a toxic agent, or increased intracranial pressure.

Diarrhea is usually defined as three or more watery or loose stools in 24 hours.<sup>5</sup> The volume of lost fluid per day through bowel movements can range from 5 mL per kg of body weight (normal) to 200 mL per kg or greater.<sup>8</sup> The electrolyte losses and dehydration associated with untreated diarrhea lead to the primary morbidities associated with acute gastroenteritis. Noninflammatory diarrhea is watery without blood and mucus, and fever is usually absent. It often involves the small intestine and does not cause destruction of the mucosa. In contrast, inflammatory diarrhea causes bloody stools that are usually full of white blood cells. It involves the large intestine and may be accompanied by fever, vomiting, and abdominal pain or tenderness.

Diarrhea that persists for at least 14 days usually is caused by a parasitic infection, whereas diarrhea with neurologic changes typically is caused by toxins. Diarrhea accompanied by symptoms of a systemic illness, such as jaundice, weakness, arthritis, or fever, can have

bacterial or viral origins.<sup>5,9</sup> Table 1 includes the pathogens associated with acute gastroenteritis in children.<sup>5</sup>

**History and Physical Examination**

The objectives of the history and physical examination are to assess whether the child is dehydrated and to determine the etiology of the acute gastroenteritis, if possible. The history should include the following: how often the child is urinating and having bowel movements, whether vomiting is interfering with the child's ability to keep down fluids and solid food, the duration of illness, the nature of the stools (e.g., whether blood or mucus is present), the type of emesis (e.g., whether bile is present), the presence of fever, the child's mental status, any accompanying medical conditions, recent exposure to a potentially untreated or compromised water supply (e.g., travel), availability of a caregiver to provide oral rehydration therapy, and whether oral rehydration therapy has been attempted with any success.<sup>1,5,6,10</sup> Specific questions should be asked to rule out other potential illnesses that can cause diarrhea. Caregivers can be interviewed by telephone about the child's symptoms. Red flags that should prompt urgent evaluation by a physician are listed in Table 2.<sup>10</sup>

The child's weight during the illness versus posttreatment is often used to assess the degree of dehydration retrospectively.<sup>11</sup> Dehydration scales from multiple medical organizations use various signs and symptoms to predict levels of clinical dehydration. Although the diagnosis is imprecise, general categories of dehydration are described as none (less than 3 to 5 percent loss of body

**Table 3. Signs and Symptoms in Children Suggesting Different Degrees of Dehydration**

Evaluation	<i>Signs and symptoms of dehydration</i>		
	<i>Minimal/none (&lt; 3 percent loss of body weight)</i>	<i>Mild to moderate (3 to 9 percent loss of body weight)</i>	<i>Severe (&gt; 9 percent loss of body weight)</i>
Breathing	Normal	Normal, fast	Deep
Capillary refill time	Normal	Prolonged	Prolonged, minimal
Extremities	Warm	Cool	Cold, mottled, cyanotic
Eyes	Normal	Slightly sunken	Deeply sunken
Heart rate	Normal	Normal to increased	Tachycardia, with decreased heart rate in most severe cases
Mental status	Well, alert	Normal, fatigued or restless, irritable	Apathetic, lethargic, unconscious
Mouth and tongue	Moist	Dry	Parched
Quality of pulses	Normal	Normal to decreased	Weak, thready, or impalpable
Skin turgor	Instant recoil	Recoil in less than two seconds	Recoil in greater than two seconds
Tears	Present	Decreased	Absent
Thirst	Drinks normally; might refuse fluids	Thirsty, eager to drink	Drinks poorly, unable to drink
Urine output	Normal to decreased	Decreased	Minimal

NOTE: Absence of specific signs has a high predictive value for no dehydration: absence of abnormally low urine output (LR = 0.27), absence of dry mucous membranes (LR = 0.41), absence of sunken eyes (LR = 0.49), absence of tears (LR = 0.54), prolonged capillary refill time (LR = 0.57).<sup>12</sup>

LR = likelihood ratio.

Adapted from King CK, Glass R, Bresee JS, Duggan C; Centers for Disease Control and Prevention. Managing acute gastroenteritis among children: oral rehydration, maintenance, and nutritional therapy. MMWR Recomm Rep. 2003;52(RR-16):13, with additional information from reference 12.

weight), mild to moderate (greater than 3 to 10 percent), and severe (greater than 10 percent).

One scale commonly used to assess dehydration is from the Centers for Disease Control and Prevention (Table 3).<sup>10,12</sup> In another commonly used assessment scale, the presence of two of four abnormal factors (abnormal overall appearance, capillary refill time of greater than two seconds, absence of tears, dry mucous membranes) has a likelihood ratio of 6.1 (95% confidence interval [CI], 3.8 to 9.8) when determining whether a child has at least 5 percent dehydration.<sup>11</sup> The presence of three of the abnormal factors indicates 5 to 10 percent dehydration, and the presence of four factors indicates at least 10 percent dehydration.<sup>11,13</sup> Prolonged capillary refill time alone has the highest predictive value, with a likelihood ratio of 4.1.<sup>11</sup>

A meta-analysis of 13 studies showed that the three best examination signs for determining dehydration in children are an abnormal respiratory pattern, abnormal skin turgor, and prolonged capillary refill time.<sup>12</sup> In a child who is potentially dehydrated, the respiratory rate should be obtained to evaluate for hyperpnea (rapid, deep breathing without accompanying signs of respiratory distress), which suggests possible acidosis.<sup>10</sup> Abnormal skin turgor is often described as “inelastic skin” or “tenting.” Assessment of skin turgor involves pinching a small fold of skin at the umbilical level and lateral abdominal wall, then promptly releasing it and measuring how long it takes for the skin to return to its normal form (e.g., prolonged, slightly

delayed, immediate).<sup>13</sup> Capillary refill time is assessed by compressing a superficial capillary bed and counting how many seconds it takes for normal color to return after the pressure is released. Capillary refill time can vary with the site of pressure application, ambient temperature, medication use, lighting, and autonomic changes.<sup>12</sup> It is not affected by fever and should be less than one and one-half to two seconds.<sup>11</sup> Capillary refill time should be measured on the sternum in infants and on the palmar surface of a finger held at heart level in older children.<sup>14</sup>

Parental report of the child’s symptoms also can aid in assessing for dehydration. A recent study demonstrated that parental reporting of decreased fluid intake, decreased urine output, diarrhea, and emesis during a child’s illness is sensitive for identifying clinically important dehydration. A child who has normal tearing as reported by the parents is less likely to have dehydration of 5 percent or greater (negative likelihood ratio = 0.4) or significant acidosis (negative likelihood ratio = 0.1).<sup>15</sup>

### Laboratory Testing

Serum electrolyte measurement is usually unnecessary in children with mild to moderate dehydration. Urine specific gravity and blood urea nitrogen measurements have poor sensitivities and specificities for diagnosing dehydration in children.<sup>16</sup> However, a normal serum bicarbonate level (more than 15 to 17 mEq per L [15 to 17 mmol per L]) somewhat reduces the chances of dehydration,

**SORT: KEY RECOMMENDATIONS FOR PRACTICE**

Clinical recommendation	Evidence rating	References
A dehydration level of at least 5 percent can be determined if two or more of the following signs are present in a child: overall ill appearance, capillary refill time of greater than two seconds, absence of tears, and dry mucous membranes.	C	11
The three best examination signs for determining dehydration in children are an abnormal respiratory pattern, abnormal skin turgor, and prolonged capillary refill time.	C	12
Laboratory tests are recommended only in cases of suspected severe dehydration (greater than 10 percent) for which intravenous fluids and electrolytes are needed.	C	5, 10
Stool cultures are recommended only for persistent diarrhea (at least 14 days) or if an outbreak of a diarrheal disease needs to be diagnosed (e.g., rotavirus infection).	C	5, 10

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>.

with a likelihood ratio between 0.18 (95% CI, 0.08 to 0.37) and 0.22 (95% CI, 0.12 to 0.43).<sup>12</sup> A serum bicarbonate level of less than 13 mEq per L (13 mmol per L) increases the chances that outpatient oral rehydration therapy will be ineffective.<sup>17</sup> Laboratory values may be helpful in evaluating severe dehydration, for which intravenous fluids and electrolyte supplementation (especially potassium, bicarbonate, and sodium) are needed. Although it is not necessary to routinely obtain stool cultures and send stool for ova and parasite testing, they should be collected in cases of persistent diarrhea (at least 14 days) or if an outbreak of a diarrheal disease needs to be diagnosed (e.g., rotavirus infection).<sup>5,10</sup>

**Data Sources:** Essential Evidence Plus, PubMed, the Cochrane database, the Agency for Healthcare Research and Quality evidence reports, and the National Guideline Clearinghouse were searched using the key terms of pediatric gastroenteritis, pediatric dehydration, rotavirus vaccines, oral rehydration therapy, oral rehydration solutions, and probiotics. The search included meta-analyses, randomized controlled trials, clinical trials, and reviews. Search date: February 2011; PubMed was searched again on June 20, 2011.

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# Gastroenteritis in Children: Part II.

## Prevention and Management

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The treatment of gastroenteritis in children focuses on preventing dehydration. A child with minimal or no dehydration should be encouraged to continue his or her usual diet plus drink adequate fluids. Many studies have shown that a child's regular diet reduces the duration of diarrhea. Oral rehydration therapy with a rehydration solution can be used to treat diarrhea in children with mild to moderate dehydration. Ondansetron can decrease vomiting or help avoid the need for intravenous fluid, but it increases episodes of diarrhea. Probiotics can be used to shorten the course of diarrhea. Good handwashing reduces the incidence of acute gastroenteritis, but not rotavirus. The introduction of two rotavirus vaccines in the United States in 2006 significantly reduced the incidence of rotavirus gastroenteritis. The oral, live vaccines have strong safety records, despite a minimal incidence of intussusception. (*Am Fam Physician*. 2012;85(11):1066-1070. Copyright © 2012 American Academy of Family Physicians.)

### ► Patient information:

A handout on gastroenteritis treatment, written by the authors of this article, is available at <http://www.aafp.org/afp/2012/0601/p1066-s1.html>. Access to the handout is free and unrestricted. Let us know what you think about AFP putting handouts online only; e-mail the editors at [afpcomments@aafp.org](mailto:afpcomments@aafp.org).

This is part II of a two-part article on gastroenteritis in children. Part I, "Diagnosis," appears in this issue of *AFP* on page 1059.

Prevention of dehydration is the cornerstone of gastroenteritis treatment in children. A child with minimal or no dehydration should be encouraged to continue his or her usual diet plus drink adequate fluids. Many studies have shown that a child's regular diet reduces the duration of diarrhea.<sup>1,2</sup> The BRAT diet (bananas, rice, applesauce, and toast) is too restrictive, unless the foods are part of the child's regular diet, and is not recommended by the American Academy of Pediatrics.<sup>3</sup> This article, Part II of a two-part series, discusses therapies for gastroenteritis in children. Part I focuses on the evaluation and diagnosis.<sup>4</sup>

Early oral rehydration therapy using an oral rehydration solution (ORS), before the child becomes more severely dehydrated, is important and can be done at home.<sup>5</sup> The best way to accomplish early treatment is to train the physician's office staff to explain how to use an ORS when caregivers call for help at the beginning of the child's illness. Clear liquids, such as water, sodas, chicken broth, and apple juice, should not replace an ORS because they are hyperosmolar and do not adequately replace potassium, bicarbonate, and sodium. These fluids, especially water and apple juice, can cause

hyponatremia. An adult ORS also should not be used. The sodium-to-glucose ratio of the ORS should be equimolar at 1:1.

Using an over-the-counter ORS (e.g., Pedialyte, Infalyte, Rehydrate, Resol, Naturalyte) is recommended so that the child's caregiver can administer it easily. They are available in liter containers, "juice boxes," and popsicles. An ORS is composed of sodium, dextrose, and bicarbonate in a ratio that does not overwhelm the hyperactive bowels with a hyperosmolar solution, but that is strong enough to replace the electrolyte loss.<sup>6,7</sup> Caregivers should be instructed on the appropriate amount of ORS to use, because the label directions generally would not provide adequate replacement fluids in dehydrated children.<sup>8</sup> *Table 1* includes principles of gastroenteritis treatment in children that are endorsed by the Centers for Disease Control and Prevention, the World Health Organization, and the American Academy of Pediatrics.<sup>1,9</sup>

### Mild to Moderate Dehydration

In mild to moderate dehydration, the goal of treatment is to restore the fluid deficit and maintain hydration. The usual ORS composition is 50 mEq per L of sodium, 25 g per L of dextrose, and 30 mEq per L of bicarbonate. Mild to moderate dehydration can be

**SORT: KEY RECOMMENDATIONS FOR PRACTICE**

<i>Clinical recommendation</i>	<i>Evidence rating</i>	<i>References</i>
A child's regular diet should be continued during an episode of gastroenteritis.	C	1, 2
When rehydrating a child with gastroenteritis using an oral rehydration solution, an average of 10 mL per kg should be added for every loose stool or episode of vomiting.	C	8
When used with an oral rehydration solution, probiotics can help reduce the duration of diarrhea in children with gastroenteritis.	A	20

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>.

managed by replacing the fluid loss as 50 mL per kg. This can be accomplished at home by competent caregivers using a syringe to administer approximately 1 mL of ORS per kg of body weight every five minutes over three to four hours.<sup>3</sup> If vomiting occurs, the ORS should be restarted after 10 minutes to one hour. An average of 10 mL per kg should be added for every loose stool or episode of vomiting.<sup>8</sup> A syringe or calibrated measuring device is highly recommended for more accurate measurement.<sup>10</sup>

### Moderate to Severe Dehydration

Moderate to severe dehydration usually requires hospitalization, although oral rehydration therapy can be attempted in the emergency department using a syringe or a nasogastric tube if the infant or child refuses to drink. Criteria for hospital admission include caregivers who are unable to adequately administer an ORS at home, intractable vomiting, poor ORS intake by mouth or nasogastric tube, profuse diarrhea, unusual irritability or drowsiness, or no symptom improvement after 24 hours of ORS administration at home.<sup>5</sup> The child's regular diet should be continued during oral rehydration therapy, if possible, but may have to wait until after intravenous fluids are administered when the child is hospitalized.

An accelerated method of oral rehydration therapy for infants and children with severe diarrhea and/or vomiting entails administering 30 mL per hour of an ORS for infants, 60 mL per hour for toddlers, and 90 mL per hour for older children.<sup>7</sup> An average of 10 mL per kg should be added for every loose stool or episode of vomiting.<sup>8</sup> Ondansetron (Zofran), a 5-hydroxytryptamine-3 serotonin antagonist, can be used in the

emergency department if vomiting is hindering oral rehydration therapy.<sup>11</sup> A meta-analysis showed that ondansetron (0.15 or 0.3 mg per kg intravenously, or 1.6 to 4 mg per kg orally, depending on age) significantly decreased vomiting in children with acute gastroenteritis soon after administration of the drug (number needed to treat = 5). The risk of requiring rehydration with intravenous fluids was significantly reduced (relative risk = 0.4; 95% confidence interval, 0.3 to 0.7). Patients taking ondansetron also had a significantly reduced risk of hospital admission (7.5 versus 14.6 percent; relative risk = 0.52; 95% confidence interval, 0.27 to 0.95). Ondansetron was well tolerated, except for increased episodes of diarrhea for up to 48 hours after use.<sup>12</sup> Another meta-analysis showed that ondansetron decreased

persistent vomiting, need for intravenous fluids, and hospital admissions in children with gastroenteritis. Other antiemetics should not be used because of potential adverse effects.<sup>11</sup>

Administration of intravenous fluids requires at least four to six hours in the emergency department or an overnight stay in the hospital. Rehydration with intravenous fluids replaces the sodium and water deficit, as well as the ongoing fluid deficit. Depending on the severity of dehydration, a child might need two intravenous lines or an intraosseous line. A rapid fluid bolus is given at a rate of 20 mL per kg of body weight. A bolus of 10 mL per kg

### Table 1. Principles of Treating Children with Gastroenteritis and Dehydration

- Rehydration should be administered orally with an over-the-counter oral rehydration solution
- Children should receive rapid oral rehydration (within three to four hours of symptom onset)
- In infants who are breastfed, breastfeeding should continue
- In infants who are formula-fed, diluting the formula is not recommended, and special formulas usually are not needed
- As soon as the dehydration is corrected, a regular diet should resume
- Ongoing diarrhea losses should be replaced with additional doses of an oral rehydration solution
- Medications and unnecessary laboratory tests should be avoided

Information from references 1 and 9.

## Gastroenteritis: Part 2

should be used for a frail child. The intravenous fluid of choice is normal saline 0.9%, although a lactated Ringer solution also may be used. The choice of intravenous fluid depends on the level of serum sodium. Urinary output and serum electrolyte, blood urea nitrogen, creatinine, and serum glucose levels should be checked often. Maintenance fluids should be given at a daily rate of 100 mL per kg for the first 10 kg, 50 mL per kg for the next 10 kg, and 20 mL per kg for the next 10 kg.<sup>13,14</sup> As soon as adequate rehydration has been achieved, oral rehydration therapy can begin along with a regular diet, and the patient should be weaned from intravenous fluids. Patients at high risk of aspiration due to obtundation from electrolyte imbalances can be given an ORS via nasogastric tube.<sup>15</sup> Complications of rehydration with intravenous fluids include hyponatremia, hypernatremia, and hypoglycemia; serum electrolyte levels should be monitored closely.<sup>16</sup>

**In general, antidiarrheal medications should not be used in children with acute gastroenteritis.**

tion therapy can begin along with a regular diet, and the patient should be weaned from intravenous fluids. Patients at high risk of aspiration due to obtundation from electrolyte imbalances can be given an ORS via nasogastric tube.<sup>15</sup> Complications of rehydration with intravenous fluids include hyponatremia, hypernatremia, and hypoglycemia; serum electrolyte levels should be monitored closely.<sup>16</sup>

### Probiotics

Probiotics are beneficial in modulating the immune response against foreign antigens in children with gastroenteritis.<sup>17</sup> Probiotics do not colonize the gastrointestinal tract and are eliminated within one to two hours after ingestion. Probiotics degrade and modify dietary antigens and balance the anti-inflammatory response of cytokines. There is no known interaction between probiotics and medications.<sup>18</sup> Probiotics are widely used in countries outside the United States because they are available over the counter, can be given orally at home, and are commonly recommended by physicians to limit the duration of diarrhea when it occurs.<sup>19</sup> Their use is much less common in the United States.

A Cochrane review of 63 studies concluded that probiotics reduce the duration of diarrhea by approximately one day when used in conjunction with an ORS, but the review did not specify if one type of probiotic is superior.<sup>20</sup> A meta-analysis of *Lactobacillus* therapy for acute gastroenteritis in inpatients showed that the therapy reduced the duration of diarrhea by 0.7 days and reduced the frequency of diarrhea by 1.6 stools on day 2 of therapy.<sup>21</sup> A meta-analysis of the *Lactobacillus* GG strain showed that the therapy significantly reduced the duration of diarrhea by 1.1 days and of rotavirus-related diarrhea by 2.1 days.<sup>19</sup>

Studies of *Saccharomyces boulardii* in children who

presented to the emergency department with acute gastroenteritis revealed significantly decreased stool frequency after 48 hours, a nearly one-day decrease in duration of diarrhea, and a one-day decrease in duration of hospitalization. There was no significant decrease in the number of children requiring intravenous fluids.<sup>22</sup> In a randomized controlled trial of outpatients, *S. boulardii* therapy decreased duration of diarrhea by 1.5 days, accelerated recovery to less than seven days, and decreased the risk of prolonged diarrhea (greater than seven days). *S. boulardii* therapy worked best if given within 48 hours of diarrhea onset.<sup>23</sup>

In a randomized controlled trial of five different probiotics given for five days in an outpatient setting, the median duration of diarrhea and the number of stools were significantly reduced after the first 24 hours in children who took *Lactobacillus* GG or a mix of four bacterial strains (i.e., *Lactobacillus delbrueckii var bulgaricus*, *Streptococcus thermophilus*, *Lactobacillus acidophilus*, and *Bifidobacterium bifidum*). There was no effect on the number of children admitted to the hospital, on fever or its duration, or on vomiting or its duration. Of note, those who took *S. boulardii* showed no improvement.<sup>24</sup>

### Antidiarrheals

In general, antidiarrheal medications should not be used in children with acute gastroenteritis because they delay the elimination of infectious agents from the intestines. Loperamide (Imodium) inhibits intestinal motility and can affect electrolyte and water movement through the bowel. Although loperamide is commonly used for gastroenteritis in older children, there are limited data to support it. Loperamide is not recommended in children younger than two years, and older children are at risk of constipation, central nervous system depression–like sedation, and nausea.<sup>5,25</sup>

Racecadotril (Acetorphan) is an antisecretory drug commonly used in Europe that inhibits intestinal enkephalinase without slowing intestinal transit or promoting overgrowth of bacteria.<sup>5</sup> The drug reduces stool output and duration of diarrhea in acute gastroenteritis, including that caused by rotavirus. Although it is safe and effective, it is not available in the United States.<sup>26,27</sup>

### Prevention

#### HANDWASHING

A meta-analysis of 30 studies revealed that improved hand hygiene reduced the incidence of gastrointestinal illness by 31 percent (95% confidence interval, 19 to 42). The use of regular soap was most beneficial, and antibacterial soap provided little additional benefit.<sup>28</sup> Another

study found that good hand hygiene reduced the incidence of gastroenteritis in general, but had little effect on the transmission of rotavirus.<sup>29,30</sup>

### ROTAVIRUS VACCINE

The rotavirus vaccine is an oral, live vaccine. The Centers for Disease Control and Prevention's Advisory Committee on Immunization Practices recommends routine vaccination at two, four, and six months of age.<sup>30</sup> There are specific guidelines for premature infants and infants who have missed the initial doses. Contraindications to the vaccine in infants are hypersensitivity to the vaccine, gastrointestinal tract congenital malformation, and severe combined immunodeficiency. The live virus is shed in the stool of 25 percent of infants who receive the vaccine and could be transmitted to an unvaccinated contact.<sup>31</sup>

The first rotavirus vaccine (Rotashield) was removed from the market because it was associated with an increased risk of intussusception, with an incidence of one in 10,000 infants.<sup>32</sup> The current two vaccines are Rotarix (monovalent human vaccine) and Rotateq (pentavalent bovine-human reassortant vaccine). These vaccines have not been associated with an increased risk of intussusception at 30- and 42-day intervals, respectively.<sup>32</sup> A recent study of Rotarix in Mexico and Brazil revealed a small risk of intussusception of one in 51,000 to 68,000 infants. However, in Mexico, vaccination with Rotarix would prevent 11,551 hospitalizations and 663 childhood deaths from rotavirus while causing two additional deaths and 41 additional hospitalizations from intussusception.<sup>32</sup> A recent preliminary study of Rotateq in Australia also showed a similarly small increased risk of intussusception.<sup>33</sup>

Both rotavirus vaccines have strong safety records based on extensive studies, including randomized clinical trials. They prevent rotavirus gastroenteritis and reduce the severity of the disease.<sup>30-33</sup> Among all infants, additional physician visits for gastroenteritis were reduced during the 2007 to 2008 rotavirus season by more than 90 percent in the South, Northeast, and Midwest regions of the United States, and by 53 to 63 percent in the West region after the rotavirus vaccines were introduced in 2006.<sup>34</sup> Rotavirus-coded hospitalizations in the United States decreased by 83 percent in the 2007 to 2008 season and by 66 percent in the 2008 to 2009 season.<sup>35</sup> In 2010, the finding of porcine circovirus (PCV) type 1 DNA in the Rotarix vaccine caused the U.S. Food and Drug Administration to temporarily halt its use. However, subsequent evaluation found no evidence that PCV1 and PCV2 pose a safety risk to humans.<sup>36</sup>

**Data Sources:** Essential Evidence Plus, PubMed, the Cochrane database, the Agency for Healthcare Research and Quality evidence reports, and the National Guideline Clearinghouse were searched using the key terms of pediatric gastroenteritis, pediatric dehydration, rotavirus vaccines, oral rehydration therapy, oral rehydration solutions, and probiotics. The search included meta-analyses, randomized controlled trials, clinical trials, and reviews. Search dates: February 2011; PubMed was searched again on June 20, 2011.

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