

## Gastrointestinal Disorders

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### Introduction

The gastrointestinal tract may be thought of as a tube that processes and absorbs nutrients. The function of the gastrointestinal tract may be disrupted by disease, injury, drugs like chemotherapy or antibiotics, parasites, environmental toxins, or bacterial overgrowth, and result in alterations in nutritional requirements. Many nutrients are absorbed throughout the intestinal tract, whereas others are absorbed only at specific sites. Absorption of the latter class of nutrients is particularly vulnerable to disease or surgical resection. **Figure 12-1** graphically portrays the principal sites of absorption of macro- and micronutrients, vitamins, and minerals.

Symptoms of gastrointestinal disease can arise from disorders located in a specific region of the bowel, the entire bowel, or distant sites (for example, vomiting can occur due to pyloric stenosis, gastroenteritis, or a brain tumor). Common pediatric disorders are listed in **Table 12-1** and common diagnostic tests are given in **Table 12-2**. Many tests are available to evaluate gastrointestinal function as well as the presence or absence of disease.

Common gastrointestinal problems will be discussed in the first section of this chapter. These include acute diarrhea, chronic diarrhea, constipation, gastroesophageal reflux, and lactose intolerance. Discussions of celiac disease, inflammatory bowel disease, pancreatitis, cholestatic liver disease, liver transplant, short bowel syndrome, and intestinal transplant follow.

### Acute Diarrhea

Diarrhea has been defined as passage of three or more loose, watery stools per day or as 10 mL/kg liquid stool per day.<sup>1,2</sup> A child having diarrhea for 3–7 days is among the most common reasons for seeking the assistance of a pediatrician and is estimated to cost at least \$1.5 billion for evaluation and treatment.<sup>3,4</sup> The American Academy of Pediatrics (AAP) and the Centers for Disease Control and Prevention (CDC) have issued practice parameters and

guidelines delineating treatment depending on the presence of dehydration.<sup>3,5,6</sup> “Gut rest,” in which food is restricted, is an outdated concept and may result in malnutrition. General principles of diarrhea management are replacement of fluid and electrolyte losses and nutritional therapy with early age-appropriate feeding.<sup>1</sup> The composition of commonly used oral maintenance and rehydration solutions is presented in **Table 12-3**.

### Nutrition Management

Nutrition management varies with the degree of dehydration. The AAP has distinguished stages of dehydration using the following physical signs:

- **Mild:** Slightly dry mucous membranes, increased thirst
- **Moderate:** Sunken eyes, sunken fontanelle, loss of skin turgor, dry mucous membranes
- **Severe:** Signs of moderate dehydration plus one or more of the following: rapid thready (scarcely perceptible) pulse, cyanosis, rapid breathing, delayed capillary refill time, lethargy, coma<sup>3</sup>

### Mild Diarrhea with No Dehydration

The AAP encourages continuing a normal diet throughout the acute illness, including breastfeeding or full strength infant formula and a regular diet, excluding beverages high in sugar (resulting in high osmolality) such as juices and sodas. Increased fluid intake is necessary to compensate for losses. Infants and children who are not dehydrated can be kept hydrated using frequent breastfeeding, usual infant formula, and milk. The use of lactose-free formula is no longer recommended in management of acute diarrhea.<sup>3,7</sup> Using a regular diet as treatment for mild diarrhea does not change the volume of diarrhea and requires education of parents concerning treatment goals of maintaining a regular diet and hydration.<sup>3</sup> Most infants and children demonstrate hunger and thirst during mild, acute diarrheal illness, and parents

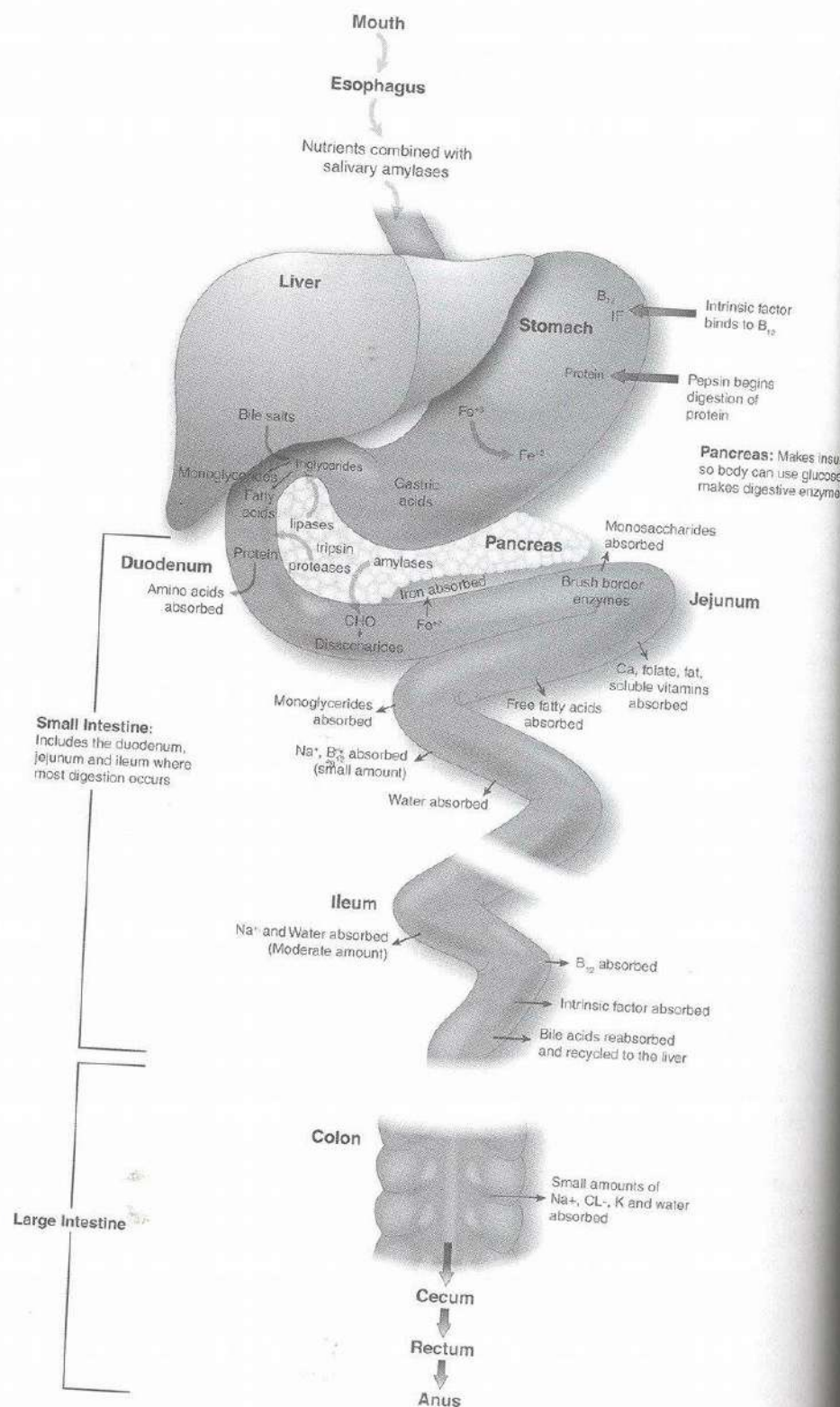


FIGURE 12-1 Normal Digestion and Absorption in the GI Tract



TABLE 12-1 Common Pediatric Gastrointestinal Disorders

Presenting Symptom	Differential Diagnosis	Treatment
<i>Stomach and Esophagus</i>		
Vomiting/regurgitation	Congenital anomaly of the gastrointestinal tract Gastroesophageal reflux  Eosinophilic esophagitis Eosinophilic gastritis Peptic disease  <i>H. pylori</i> Gastroparesis	Surgery  Infants: positioning, medications such as antacids, H2 blockers, and proton pump inhibitors (PPI). If preceding fails, consider surgical treatment. All ages: medications, antacids, H2 blockers, PPI, avoid caffeine-containing foods and other personal triggers Elimination diet, swallowed steroids Steroids, immunosuppressive medication Medications such as antacids, H2 blockers, and PPI; avoid caffeine-containing foods and other personal triggers Antibiotics, PPI Prokinetics, diet changes such as multiple small low-fat meals per day, or postpyloric feeds
Dysphagia (choking after eating), odynophagia (pain with swallowing)	Congenital anomalies, strictures, webs Eosinophilic esophagitis Esophageal spasms/dysmotility  Peptic strictures	Surgery Elimination diet, swallowed steroids Calcium channel blockers and nitrates; avoid extreme temperatures in foods Medications such as antacids, H2 blockers, and PPI; dilation
<i>Liver and Pancreas</i>		
Jaundice	Extrahepatic biliary tract obstruction, such as biliary atresia  Autoimmune hepatitis	Surgical correction; diet/formula with medium chain triglycerides (MCT), fat-soluble vitamin supplementation, choleretic agents such as ursodeoxycholate Steroids, evaluation for fat malabsorption, fat-soluble vitamin supplementation, protein restriction only if encephalopathic
Jaundice with recurrent abdominal pain	Gallstones Choledochal cyst	Surgery Surgery
Nausea, vomiting, abdominal pain	Pancreatitis  Pancreatic pseudocyst	NPO; if severe or prolonged course expected then postpyloric tube feeds or parenteral nutrition; pain control, H2 blockers; when clinically able, resume low-fat oral diet Monitor cyst size; if cyst increases with enteral nutrition, may require parenteral nutrition
Chronic diarrhea, failure to thrive	Pancreatic insufficiency, such as cystic fibrosis Cholestatic disease	Enzyme replacement therapy, fat-soluble vitamin supplementation, high calorie balanced diet Diet/formula with MCT, fat-soluble vitamin supplementation
<i>Small Bowel and Colon</i>		
Anemia, gastrointestinal bleeding	Congenital malformations, such as Meckel's diverticulum, duplication cysts	Surgery
Vomiting	Food allergies Infectious enteropathies	Hydrolysate formula, elimination diet Oral rehydration solutions, followed by lactose and/or sucrose restrictions
Diarrhea in neonatal period	Congenital disorders of carbohydrate absorption and transport	Restriction of the problematic carbohydrate, balanced nutrition, vitamin/mineral supplementation, enzyme replacement
Diarrhea, perioral and perianal rash	Zinc deficiency	Zinc supplementation

(continued)

**TABLE 12-1** (Continued)

Presenting Symptom	Differential Diagnosis	Treatment
Diarrhea	Food allergies	Elemental formula and/or elimination diet
	Infectious enteropathies	Intravenous fluids, oral rehydration solutions, followed by lactose and/or sucrose restrictions if clinically indicated
	Crohn's disease	Enteral feeds for therapy and/or malnutrition, replete iron, fat-soluble vitamins, and zinc as necessary; monitor vitamin B <sub>12</sub> if severe ileal disease or resection
	Ulcerative colitis	Enteral feeds for weight gain, replete iron as necessary, low-residue diet if strictures
	Celiac disease	Gluten-free diet
	Short bowel syndrome	Parenteral nutrition progressing to enteral nutrition to oral feeds; vitamin and mineral supplements specific to patient's condition
	Fructose intolerance	Dietary restrictions of fructose-containing foods
	Lactose intolerance	Dietary restrictions of lactose-containing foods
Diarrhea, normal growth pattern	Irritable bowel syndrome, chronic nonspecific diarrhea, toddler's diarrhea	Normal diet for age, increased soluble fiber intake, decreased intake of sorbitol-containing beverages (apple and pear juice) and other personal triggers
Abdominal distention/pain	Celiac disease	Gluten-free diet
	Short bowel syndrome	Total parenteral nutrition progressing to MCT-predominate hydrolysate formula; vitamin and mineral supplements
	Functional constipation	Complete bowel clean-out using saline enemas, mineral oil, Miralax; high-fiber diet and adequate fluids; bowel habit training
	Congenital disorders of carbohydrate absorption and transport	Restriction of the problematic carbohydrate, balanced nutrition, vitamin/mineral supplementation, enzyme replacement
	Fructose intolerance	Dietary restrictions of fructose-containing foods
	Lactose intolerance	Dietary restrictions of lactose-containing foods
Constipation	Hirschsprung's disease; post-NEC strictures	Surgery
	Functional constipation	Complete bowel clean-out using saline enemas, mineral oil, Miralax; high-fiber diet and adequate fluids; bowel habit training

**TABLE 12-2** Common Diagnostic Tests for Pediatric Gastrointestinal Disorders

Test	Description	Useful to Help Diagnose
Barium enema	Barium sulfate administered by enema; colonic lumen and mucosa visualized by fluoroscopy.	<ul style="list-style-type: none"> <li>Colonic strictures and obstructions</li> <li>Hirschsprung's disease</li> <li>Polyps</li> </ul>
Barium swallow	Barium sulfate administered orally; upper gastrointestinal tract is visualized by fluoroscopy.	<ul style="list-style-type: none"> <li>Aspiration</li> <li>Dysmotility disorders</li> <li>Hiatal hernias</li> <li>Strictures</li> <li>Varices</li> </ul>
Breath hydrogen test	Oral administration of sugar and expiratory collection of hydrogen as an indirect measure of bacterial fermentation of unabsorbed carbohydrate.	<ul style="list-style-type: none"> <li>Fructose malabsorption</li> <li>Lactose malabsorption</li> <li>Bacterial overgrowth</li> </ul>
DXA (dual energy X-ray absorptiometry)	Measures bone density in the spine, hip, or forearm.	<ul style="list-style-type: none"> <li>Osteomalacia</li> <li>Osteopenia</li> <li>Osteoporosis</li> </ul>



TABLE 12-2 (Continued)

Test	Description	Useful to Help Diagnose
Colonoscopy	Insertion of flexible fiber optic tube via anus into large bowel; visual examination of colonic lining, biopsies obtained.	<ul style="list-style-type: none"> <li>• Colitis</li> <li>• Polyps</li> </ul>
CT (computed tomography scan) of abdomen	Multiple radiographs of abdomen with or without intraluminal and/or intravenous contrast; computer reconstructs multiple images to generate "slices" through the abdomen.	<ul style="list-style-type: none"> <li>• Areas of inflammation (e.g., abscess)</li> <li>• Blood vessel anatomy and obstructions</li> <li>• Organ size and consistency</li> <li>• Tumors</li> </ul>
EGD (esophagogastroduodenoscopy)	Fiber optic tube is inserted into upper gastrointestinal tract allowing mucosal lining of upper GI tract to be visualized and biopsies to be taken.	<ul style="list-style-type: none"> <li>• Celiac disease</li> <li>• Duodenitis</li> <li>• Esophagitis, including eosinophilic esophagitis (EE)</li> <li>• Gastritis</li> <li>• Peptic ulcer disease</li> </ul>
Fecal fat test	Concurrent 3-day diet record of fat intake and stool collection; comparison as percentage of total fat in 24 hours excreted in stool. Malabsorption indicated in children if greater than 7% of fat is excreted; for infants less than 6 months of age if greater than 15% of fat is excreted.	<ul style="list-style-type: none"> <li>• Fat malabsorption</li> <li>• Pancreatic insufficiency</li> </ul>
pH probe	Tube with pH sensor is inserted into esophagus for 24 hours with feeding at regulated intervals.	<ul style="list-style-type: none"> <li>• Gold standard for gastroesophageal reflux</li> </ul>
Scintigraphy ("milk scan")	Barium ingested with X-rays capturing movement through upper GI tract	<ul style="list-style-type: none"> <li>• Delayed gastric emptying</li> <li>• Pulmonary aspiration</li> </ul>
Ultrasound	Can be of all abdominal organs or individual organs such as the stomach, intestines, gallbladder, liver, spleen, pancreas, kidney, and bladder	<ul style="list-style-type: none"> <li>• Anatomical abnormalities</li> <li>• Cysts</li> <li>• Obstructions</li> <li>• Stones</li> <li>• Tumors</li> </ul>
Upper GI/upper GI with small bowel follow-through:	Barium ingested with X-ray monitoring of path in GI tract to duodenum or to ileum if small bowel follow through.	<ul style="list-style-type: none"> <li>• Anatomical abnormalities</li> <li>• Inflammation</li> <li>• Tumors</li> </ul>
X-ray of abdomen		<ul style="list-style-type: none"> <li>• Bowel dilatation or obstruction</li> <li>• Calcified gall bladder stones</li> <li>• Gas patterns and free air</li> <li>• Presence of stool in GI tract</li> <li>• Pneumatosis</li> <li>• Toxic megacolon</li> </ul>

ources: Corkins MR, Scolapino J. Diarrhea. In: Merritt R, ed. *The ASPEN Nutrition Support Practice Manual*, 2nd ed. Silver Spring, MD: ASPEN; 2005:207–210; Graham-Maar French HM, Piccoli DA. Gastroenterology. In: Frank G, Shah SS, Catallozzi M, Zaoutis LB, eds. *The Philadelphia Guide to Inpatient Pediatrics*. Philadelphia, PA: Lippincott, Williams, and Wilkins; 2003:100–115; and Leonberg BL. *ADA Pocket Guide to Pediatric Nutrition Assessment*. Chicago: American Dietetic Association; 2008:106.

respond to these cues. The BRAT(T) diet (bananas, rice, applesauce, tea, and toast) should be avoided because it is low in calories and is not a balanced source of nutrition. However, foods that are high in carbohydrates, such as rice, bread, peas, and potatoes, may slow diarrheal output.

#### Diarrhea with Mild to Moderate Dehydration

Increased fluid intake is necessary to compensate for losses and may require the use of oral rehydration solutions (ORS) in addition to the regular diet.<sup>3</sup> The use of ORS helps to replace fluid and electrolyte losses from diarrhea. Dehydration

TABLE 12-3 Oral Rehydrating Solutions (ORS)

Solution	Glucose/ CHO (g/L)	Sodium (mEq/L)	Potassium (mEq/L)	Osmolality (mmol/L)	CHO/Sodium
Pedialyte (Abbott, Columbus, Ohio)	25	45	20	250	3.1
Pediatric Electrolyte (PendoPharm, Montreal, Quebec)	25	45	30	250	3.1
Kaoelectrolyte (Pfizer, New York, New York)	20	48	20	240	2.4
Rehydralyte (Abbott, Columbus, Ohio)	25	75	20	310	1.9
WHO, ORS, 2002 (reduced osmolality)	75	75	30	224	1
WHO, ORS, 1975 (original formulation)	111	90	20	311	1.2
Cola*	126	2	0.1	750	1944
Apple juice*	125	3	32	730	1278
Gatorade* (Gatorade, Chicago, Illinois)	45	20	3	330	62.5
Whole cow's milk	12 (lactose)	40	1226	285	Not available

\*Cola, juice, and Gatorade are shown for comparison only; they are not recommended for use.

Abbreviations: CHO, carbohydrate; WHO, World Health Organization.

Sources: Adapted from Oral therapy for acute diarrhea. In: Kleinman RE, ed. *Pediatric Nutrition Handbook*, 6th ed. Elk Grove Village, IL: American Academy of Pediatrics; 2009:651–659; and Roberts J, Shilkofski N. *The Harriet Lane Handbook*, 17th ed. Elsevier Mosby; 2005:559, Table 20–14a.

can be treated at home by giving an ORS solution by syringe at the rate of 1 teaspoon (5 mL) per minute over 4 hours for a child less than 15 kg or 2 teaspoons (5–10 mL) for children 15–20 kg. This method of fluid administration is adequate to replace the fluid deficit within a 4-hour period. After 1–2 hours of this treatment, the infant or child may begin voluntarily accepting the rehydration liquid. If the child or infant is unable to cooperate, a nasogastric (NG) tube may be used at home or in the hospital. After correction of dehydration, age-appropriate feeding should be initiated as described above.<sup>3</sup>

#### Diarrhea with Severe Dehydration

Severe dehydration in infants and children is a medical emergency and requires immediate hospitalization. Once rehydration is complete, age-appropriate feeding can be initiated.

#### Lactose-Containing Products

Lactose-containing products, especially when given with complex carbohydrates, are no longer thought to increase diarrheal output or prolong the illness unless stool output clearly increases on a lactose-containing diet.<sup>8</sup>

#### Fiber

Infant formulas with added soy fiber have been reported to reduce liquid stools with no change in overall stool output in acute diarrhea and to reduce the length of antibiotic-associated diarrhea.<sup>5,9,10</sup> Use of soy formula with added fiber is not a standard of care because continuation of breast

feeding or usual formula works to correct dehydration in most cases. Fiber has been used as part of a food-based regimen in several studies in underdeveloped countries for chronic diarrhea. The World Health Organization has developed an algorithm for the treatment of persistent diarrhea using locally available foods and simple clinical guidelines for use in underdeveloped countries.<sup>11</sup> Kolacek and colleagues compared a modular diet using food with a semi-elemental infant formula in the treatment of chronic diarrhea. The modular diet was found to decrease the duration of diarrhea and the time to nutritional recovery.<sup>12,13</sup> The modular diet included boiled minced chicken meat, sunflower oil emulsion, sucrose, corn flour, and a full range of vitamins and minerals. The success with this diet demonstrates the importance of returning to age-appropriate feeding as soon as rehydration is accomplished.

#### Prebiotics and Probiotics

Use of probiotics and prebiotics in infant and enteral formulas and in foods has been proposed as beneficial in the treatment of acute and chronic diarrhea of infancy and childhood. *Probiotics* are live microorganisms, historically available in fermented foods such as yogurt, that promote health by improving the balance of healthy organisms in the intestinal tract.<sup>5</sup> Additional proposed mechanisms are preventing adhesion of microbes to the gut mucosa, down regulation of inflammatory responses, and stimulation of immunoglobulin A production.<sup>14,15</sup> Technology has allowed beneficial bacteria to be freeze-dried, added to formula or foods, and be reactivated in the gut when consumed.<sup>16</sup>



Prebiotics are complex carbohydrates, not microorganisms, that promote the growth of healthy microorganisms in the intestinal tract.<sup>5</sup> Human milk contains oligosaccharides (a type of prebiotic) that promote the growth of *Lactobacilli* and *Bifidobacteria* in the colon of breastfed infants.<sup>5,17</sup> Higher intake of breast milk has been associated with a lowered incidence of acute diarrhea.<sup>18</sup>

Questions about consuming live probiotic bacteria and prebiotics include whether long-term consumption is safe and whether consumption has positive health effects. A randomized controlled trial has reported that healthy infants consuming a formula supplemented with prebiotic mixtures achieved normal growth and had stools more similar to breastfed infants when compared to infants fed an unsupplemented formula. The prebiotic mixtures included polydextrose and galactooligosaccharides in one group and polydextrose, galactooligosaccharides, and lactulose in the second group.<sup>19</sup> A double-blind randomized placebo-controlled trial evaluated the tolerance and safety of long-term consumption of different levels of cow's milk formula not supplemented and supplemented with different levels of *Bifidobacterium lactis* and *Streptococcus thermophilus* in infants 3–18 months of age. Healthy infants consuming the probiotic-supplemented formula reported a lower frequency of colic or irritability, and reduced severity of antibiotic-induced acute diarrhea.<sup>20</sup> Another study reported safe consumption by healthy infants of a formula containing *Bifidobacterium lactis* and *Streptococcus thermophilus*.<sup>21</sup> It has also been reported in a multicenter randomized double-blind trial that infants and children with mild diarrhea for longer than 3 days had a slightly decreased duration of acute diarrhea when treated with killed *Lactobacillus*.<sup>22</sup> Another double-blind, placebo-controlled, randomized trial reported that infants in child care centers fed a standard cow's milk formula supplemented with *L. reuteri* or *B. lactis* had fewer and shorter episodes of diarrhea compared to infants fed the same formula without added probiotics.<sup>23</sup> There is still no consensus concerning the types and amounts of probiotics that are beneficial. More research is needed.

Infant formulas with prebiotics and probiotics include Nutramigen with Enflora LGG (probiotic, *Lactobacillus rhamnosus* GG) by Mead Johnson, Similac Advance EarlyShield (galactooligosaccharide) by Abbott, and Enfamil PREMIUM with Triple Health Guard (galactooligosaccharide) by Mead Johnson.

An example of an enteral formula for children over 1 year of age supplemented with probiotics is Boost Kids Essentials 0 and 1.5 (*L. reuteri* inserted in optional straw to use for drinking) by Nestlé. Examples of products using prebiotics include Pediasure enteral formula with fiber (NutraFlora and cFOS) by Abbott; Vital Jr (NutraFlora and scFOS), also from Abbott; and Peptamen Jr with fiber (contains insoluble fiber

and Prebio, a blend of FOS and inulin) and Peptamen Jr with Prebio (no insoluble fiber) by Nestlé.

### Chronic Diarrhea

Diarrheal illnesses in children follow a continuum from acute to chronic or persistent diarrhea. In 1982, the World Health Organization defined persistent or chronic diarrhea as "diarrhea episodes of presumed infectious etiology that begin acutely but last at least 14 days."<sup>24</sup> Persistent diarrhea has also been defined as "the passage of  $\geq 3$  watery stools per day for  $> 2$  weeks in a child who either fails to gain or loses weight."<sup>11</sup> Persistent diarrhea has many triggers, including acute diarrhea caused by an enteric infection, and more recently HIV infection and AIDS.<sup>11</sup>

In a discussion of chronic diarrheal disease, the AAP distinguishes four kinds:

- Osmotic
- Secretory
- Dysmotility
- Inflammatory

*Osmotic diarrhea* may result from congenital or acquired disease and is often associated with failure to absorb a specific carbohydrate such as lactose or with excessive carbohydrate intake, such as excessive juice intake in toddlers or dietary fructose intolerance.<sup>25</sup> Diarrhea stops when the dietary cause is removed. *Secretory diarrhea* does not respond to cessation of oral intake. Disorders include congenital chloridorrhea and neural crest tumors.<sup>25</sup> *Diarrhea from dysmotility* may be associated with rapid transit or irritable bowel syndrome.

*Inflammatory diarrhea* may result from enteric infection, inflammation secondary to celiac disease, or inflammatory bowel disease. Chronic or persistent diarrhea (also called intractable diarrhea of infancy) has been thought of as a nutritional disorder, and certainly requires nutritional treatment for recovery.<sup>26–30</sup>

Malnutrition is considered the most important epidemiologic risk factor for persistent diarrhea worldwide when no specific congenital, inherited, or acquired disorders are identified. Other associated risk factors are:

- Age less than 6 months
- Acute diarrheal episodes within the past 2 months
- Zinc deficiency
- Lack of breastfeeding
- Male sex
- Infection with enteropathogenic or enteroaggregative *Escherichia coli* or *Cryptosporidium*
- A history of intrauterine growth retardation<sup>11</sup>

If infection as a cause is excluded, other etiologies must be considered. These include food allergy, dietary protein intolerances, celiac disease, lactose or other disaccharide



intolerances, cystic fibrosis and other causes of pancreatic insufficiency, and inflammatory bowel disease.<sup>13</sup> Lactose intolerance, celiac disease, and inflammatory bowel disease are discussed later in this chapter. Food allergy and dietary protein intolerances are discussed in Chapter 7, and cystic fibrosis is discussed in Chapter 11.

As with all diarrheal illnesses in infants, chronic diarrhea is dangerous if not treated promptly and appropriately, because it can result in dehydration and severe malnutrition.<sup>28</sup> Recent reports indicate that the incidence of chronic diarrhea has declined in the United States over the past two decades due to better treatment of acute diarrheal episodes.<sup>35</sup>

### Nutrition Management

The first step is appropriate fluid resuscitation. Next, cautious refeeding through a combination of enteral feedings and/or parenteral nutrition is started slowly due to the possibility of metabolic alterations from refeeding syndrome.<sup>31</sup> Refeeding protocols may be required depending upon the degree of malnutrition, with monitoring of potassium, phosphorus, magnesium, calcium, and trace elements. Continued use of breast milk is recommended during infancy.<sup>11</sup> Continuously infused breast milk loses calories through adherence of protein and lipids on the tube walls; this factor should be considered when making calorie determinations.<sup>32,33</sup> Alterations in the continuous infusion-feeding method can be made to maximize nutrient delivery by using the shortest amount of tubing available and slanting the feeding syringe.<sup>34</sup> Another option is to use a formula for the continuous infusion for greater lipid delivery, saving the expressed breast milk for oral feedings.<sup>35</sup> In developed countries, specialized enteral formulas that are lactose-free and/or elemental may be preferred; however, research in developing countries has shown success using more readily available foods and formula.<sup>11</sup> Oral zinc supplementation is also recommended by WHO in developing countries.<sup>36</sup> Both a meta-analysis and Cochrane Review also recommend oral zinc supplementation, especially in those patients with malnutrition or history of multiple episodes of acute or persistent diarrhea.<sup>37,38</sup> Carbohydrate intolerance may or may not exist, and tolerance should be monitored. Adequate normal levels of protein, lipids, and vitamins can be given.<sup>39</sup>

Absorption of many nutrients may be improved by using continuous enteral feedings. A crossover study in infants with protracted diarrhea showed greater absorption of zinc, calcium, copper, fat, and nitrogen during continuous enteral feedings than with bolus enteral feedings.<sup>40</sup> Small bolus oral feedings may be retained for oral motor stimulation. The calories needed for catch-up growth may be in the range of 140–200 kcal/kg.<sup>41</sup> Nutritional support may start at 75 kcal/kg/day and increase over 5–7 days to 130–150 kcal/kg/day. Protein is started at 1–2 g/kg/day, in-

creasing to 3–4 g/kg/day as caloric intake increases.<sup>24</sup> Malnutrition and zinc deficiency may play a role in both acute and chronic diarrhea. Zinc supplementation in developing countries has been associated with a decrease in number of stools per day and decreased number of days with watery diarrhea in acute diarrhea and reduction of the duration of persistent diarrhea.<sup>42</sup> Two pooled analyses of randomized controlled trials in developing countries found oral zinc supplementation benefited children with both acute and persistent diarrhea.<sup>43,44</sup> WHO/UNICEF have issued a statement recommending zinc supplementation: 10 mg/day for 10–14 days for infants < 6 months of age and 20 mg/day for 10–14 days for infants and children > 6 months of age.<sup>36</sup> A randomized double-blind placebo-controlled trial of zinc supplementation in breastfed infants in the United States showed no significant difference in diarrhea frequency in the supplemented and not supplemented groups.<sup>45</sup> Recommendations for use of zinc supplementation in developed countries need further research and evaluation.<sup>45</sup> Cereal and other infant foods should be continued as tolerated; however, juices and sodas should be avoided due to their high osmolality. For infants with malnutrition or who are severely dehydrated, use of a lactose-free formula may lead to quicker recovery.<sup>6</sup> Semi-elemental protein hydrolysate formulas such as Alimentum (Abbott) or Pregestimil (Mead Johnson) may also be used. Elemental formulas are commonly used in many hospitals, although short peptides are absorbed better than an equimolar amount of amino acids.<sup>46,47</sup> A semi-elemental formula may be superior to an elemental amino acid-based formula such as Neocate (SHNA), Elecare (Abbott), or Nutramigen AA (Mead Johnson).

As the infant improves, parenteral nutrition or IV hydration, if needed, is weaned, and enteral nutrition gradually increased in the form of continuous feedings. Gradually larger bolus oral feedings are added as tolerated. If this period of progressing from parenteral to enteral nutrition is prolonged, the transition from continuous feeding to oral bolus feedings can often be accomplished in the home setting.

### Constipation

Constipation is common in childhood. The North American Society for Pediatric Gastroenterology, Hepatology and Nutrition (NASPGHAN) defines constipation as “a delay or difficulty in defecation, present for two or more weeks and sufficient to cause significant stress to the patient.”<sup>48</sup>

Treatment in infants may include juices that contain natural sorbitol such as apple, pear, or prune (0.5 g/100 g, 2.1 g/100 g, and 12.7 g/100 g, respectively), increasing fluids, and verifying that infant formula is mixed correctly.<sup>48</sup> Rice cereal, a common first food for infants, may also cause constipation that resolves when infant oatmeal is used instead. Inadequate fluid intake also can be a cause of constipation.<sup>49</sup> High fiber diets with adequate fluids