

# Complications of Enteral Nutrition

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**E**NTERAL nutrition is the preferred route for providing nutrition support when the gastrointestinal (GI) tract is functional. Compared with conventional central venous feeding, enteral feeding is associated with fewer serious complications, is more nutritionally complete, is more effective in maintaining or restoring host immune response, and takes advantage of normal physiologic and metabolic processes. In addition, delivery of nutrients by way of the GI tract allows maintenance of physical and immune-mediated barriers; decreases risk of sepsis; reduces the risk of cholestasis; and stimulates dozens of gut peptides, which affect far more than the GI tract.<sup>1-5</sup> The cost of feeding tube placement, administration, equipment, and formula is also considerably less than parenteral nutrition.

Most of the complications associated with enteral feeding are minor, but some can be quite serious. The incidence and severity of complications, however, can be reduced by assessment of the patient's clinical status and nutritional needs, careful placement of the feeding tube, monitoring the feeding process, and proper selection and advancement of the formula. In this chapter, the more common complications of enteral nutrition are discussed along with guidelines for their prevention and treatment. Complications can be categorized in several ways, but we have grouped them under three main headings: (1) problems encountered during the placement of feeding tubes and delivery of enteral formulas (2) clinical and metabolic problems, and (3) nutritional problems.

## Complications with Initial Placement of Feeding Tubes

### Nasogastric and Nasoenteric Tubes

Complications that can occur during the placement of nasogastric or nasoenteric tubes include nasopharyngeal irritation and pain; misplacement of the tube; and in patients who are confused or upset, further agitation and combativeness. The smaller, softer, and more flexible types of feeding tubes used today can easily coil or kink during placement. Patients who are alert can swallow small amounts of water to facilitate tube passage.<sup>6-8</sup> Lidocaine or other topical anesthetic is sometimes used to reduce patient discomfort.<sup>9</sup> When the patient cannot participate in tube placement, a stylet can be used to stiffen the tube or the small tube can be attached to or passed inside a larger one to be withdrawn after placement. Perforation of the lung, esophagus, stomach, or small intestine can result from using stylets, rigid tubes, or endoscopes to place, clear, or advance the feeding tubes.<sup>7,8</sup> Intracranial entry has been

reported in cranial trauma and nontrauma patients.<sup>7,10</sup> Fortunately, perforation rarely occurs and can be prevented by enlisting the patient's cooperation, using a lubricated tube to facilitate passage, and stopping advancement of the tube if resistance is encountered. Newer tubes are now available that prevent the stylet from exiting the distal end of the feeding tube.

When tubes are inadvertently placed into the lung, patients usually demonstrate some form of respiratory distress (coughing, shortness of breath, inability to speak), but some patients never exhibit symptoms. In some cases patients may not be able to communicate or may not exhibit a normal reaction to respiratory insults. Initial position of nasogastric/nasoenteric tubes is verified automatically when placed by endoscope, fluoroscopy, sonography, or electromyograms. These methods are also considered the best ways to verify feeding tube position after traditional placement, but they may not be available or practical for frequent use at the bedside or home setting. Several "bedside" methods are used to verify tube placement, but because no single method is foolproof, at least two techniques are usually recommended: (1) asking the patient to speak, (2) auscultation (listening at the abdomen for "gurgling" while air is introduced into the tube) or (3) withdrawing fluid to check for volume, appearance, acid pH, or the presence of bilirubin or digestive enzymes<sup>11,12</sup> Another technique being evaluated is the use of a colorimetric sensor for the presence of carbon dioxide, which would indicate that the tube is in the lung.<sup>13</sup>

Recommendations for frequency of checking the position of enteral tubes vary, depending on institutional protocol. Because feeding tubes may become displaced, coiled, or kinked, some institutions recommend daily verification of placement when continuous feedings are used and before starting bolus or intermittent feeding. Common nursing practice is to color tube feedings with blue food coloring to differentiate the presence of the feeding from other fluids and secretions. Another technique used to determine aspiration of tube feeding includes use of glucose-oxidase strips to detect presence of sugars in the tube feeding.<sup>14</sup> The sensitivity and specificity of both techniques in proving presence of tube feeding in lung aspirates appears to be marginal, and the blue dye used may not always be safe. Clinical features, such as presence of fever, purulent aspirates, or radiographic evidence of pulmonary infiltrates, can be used to determine aspiration.<sup>15</sup>

Placement of feeding tubes into the duodenum or jejunum has been recommended in persons at increased risk of reflux and aspiration and in patients who may have impaired gastric

emptying or upper GI obstruction. Although not all investigators agree that transpyloric placement is superior in preventing aspiration,<sup>6,15</sup> the consensus appears to be that jejunal placement may decrease the frequency of aspiration in at least high-risk patients. Patients considered at increased risk for reflux, aspiration, or aspiration pneumonia include those with delayed gastric emptying, dysphagia, altered mental status, inadequate cough and swallowing reflexes, and lower esophageal sphincter dysfunction.<sup>6,8,16</sup> Use of large diameter tubes may also allow more reflux of feeding.<sup>17</sup>

Feeding tubes can be passed beyond the stomach and into duodenum or jejunum by allowing the tube to migrate through the pylorus by natural peristalsis. However, the process may take several days even with the aid of prokinetic medications, and success is marginal. Nasoenteric placement may also be performed intraoperatively, laparoscopically, endoscopically, or aided by use of magnets.<sup>11</sup> When feeding into the jejunum, more attention should be paid to feeding rate, caloric density, and osmolarity because several digestive, absorptive, and coordinating functions of the stomach and proximal small bowel are bypassed (Box 17-1).

### Complications with Placement of Gastrostomy and Jejunostomy Tubes

Nasogastric tubes are not usually considered acceptable for prolonged use (> 4 weeks), not only because of esthetic concerns, but also because of potential problems with rhinitis, tissue erosions, tube deterioration, and increased risk of reflux and aspiration. Alternatives include surgically placed or endoscopically placed gastrostomy and jejunostomy tubes. Each has its indications and limitations.

### Surgically Placed Gastrostomy and Jejunostomy (Open and Laparoscopic Gastrostomy and Jejunostomy)

Surgically placed gastrostomy or jejunostomy tubes are usually now reserved for persons with pharyngeal, esophageal, or gastric obstructions; upper GI tumors or when abdominal surgery is already being performed for other purposes. Surgical placement of gastrostomy tubes is relatively expensive; requires the use of a sterile setting; and may include

several complications related to the surgical procedure, anesthesia, the type of tubes employed, or establishing and maintaining the insertion site. Published complication rates vary widely, from 2% to greater than 50%, with an overall complication rate of approximately 15%.<sup>7,18,19</sup> The most common complications associated with open gastrostomy feeding tube placement include local wound infection, catheter leakage, and tube dislodgment. Wound dehiscence, peritonitis, aspiration, bleeding, and GI obstruction are more serious but less frequent complications.<sup>7,18</sup>

Laparoscopic placement of gastrostomy and jejunostomy may result in many of the same complications as surgical gastrostomy tube placement. Laparoscopic gastrostomies and jejunostomies are usually less invasive and result in less tissue trauma and scarring. Jejunal placement of a large intraluminal balloon, “bumper,” or T-tube in some cases can result in a higher incidence of obstruction because the lumen of the jejunum is considerably smaller than the stomach. If the loop of jejunum is not immobilized during the procedure, risk of volvulus may also be increased. Feeding into the jejunum also requires more caution in the rate and concentration of enteral formulas, and tube placement too far into the jejunum may also increase risk of GI distress.

### Needle Catheter Jejunostomy

Needle catheter jejunostomy is a placement technique used during abdominal surgery.<sup>19,20</sup> A small catheter is placed into the jejunum over a wire placed via needle puncture through the abdominal wall. Because the catheter is small, placement results in less trauma, and consequently is less likely to cause fistula, bowel obstruction, or volvulus than other jejunostomy techniques. It may also be removed more easily than most feeding devices. Because of the small tube size (5 to 6 Fr), clogging is more common, unless lower viscosity feedings are used and tubes are irrigated appropriately. Replacement of dislodged tubes may also be more difficult.

### Complications Associated with Percutaneous Endoscopic Gastrostomy, Gastrojejunostomy, and Direct Endoscopic Jejunostomy

Percutaneous endoscopic gastrostomy (PEG) is a type of tube placement performed with the aid of an endoscope. The tube is placed by one of several “push” techniques (abdominal wall punctured from outside the stomach) or “pull” techniques (wall of the stomach and abdomen punctured from inside the stomach). The tube is normally secured on the inside of the stomach/jejunum by a balloon, collar, or T-tube and on the outside by a flange, button, or collar to prevent movement and leakage of the tube. Newer techniques and equipment have allowed endoscopic placement of tubes orally or nasoenterically into the stomach or the jejunum (PEG/J), or direct placement into the jejunum.<sup>18,19,21-25</sup> Placement and use of PEG/J tubes are associated with complication rates ranging from less than 10% to greater than 30%, depending on the type of apparatus, the patient’s clinical status, and the experience of the clinicians who place the tube and care for the patient. Endoscopically placed gastrostomies, and PEG/J tubes in general, appear to be superior to surgically placed gastrostomies and jejunostomies in terms of overall morbidity and

#### BOX 17-1

### Preventing Problems During Nasogastric and Nasojejunal Tube Placement

- Explain the procedure to the patient.
- Check for clear nasal passages; position patient correctly.
- Have the patient participate to the degree possible, swallow to aid passage, and so on.
- Use lubricated feeding tube.
- Use silicone-based polyurethane or other tubes that are soft and do not harden.
- Use caution with stiff tubes, stylets, and guidewires.
- Use a tube that will not allow stylet to pass through distal end.
- Stop when resistance is met.
- Use connectors for feeding bags/sets that are incompatible with IV tubing or are labeled “not for IV use.”
- Verify placement initially and at least daily thereafter.
- Use restraints, mitts, or bridles only when necessary and only to limit access to the feeding tube.

mortality and cost. PEG tubes are now considered the route of choice for long-term enteral feeding.<sup>18,19,23</sup>

Complications associated with PEG/PEJ feedings include leakage, irritation or infection around the feeding site; peritonitis; fistulas; dislodgment of the tube, collars, or buttons; GI obstruction from dislodged components of the tube; abdominal pain; and aspiration pneumonia.<sup>18,21-25</sup> Medical conditions that increase the apparent risk of complications for placement of feeding gastrostomies include severe malnutrition, malignancies, significant obesity, ascites, coagulopathies, abdominal trauma, and active inflammatory disease. Newer tubes and placement strategies are being developed to reduce the risk of obstruction, dislodgment, and complications related to anesthesia with surgical and endoscopically placed gastrostomies and jejunostomies.

## Mechanical Problems During Tube Feeding

### Nasogastric and Enteric Tubes

After the feeding tube has been placed, the tube may be displaced by coughing, retching, or vomiting or as a result of the patient or other health care personnel pulling the feeding tube, purposely or inadvertently. Removal is quite common in confused or demented patients or those who are not convinced of the necessity of enteral feedings. Feeding tubes, especially the small silicone or urethane type, can kink or knot, even after placement. When rubber or polyvinyl chloride (PVC) feeding tubes are used for prolonged periods, they may become stiff and brittle, and subsequently crack. Large tubes of any type are more likely to cause mucosal irritation and erosions. PVC or rubber tubes of any size are more likely to stiffen and cause mucosal irritation or erosion. Sometimes a feeding tube or the distal segment of tube that contains the weight becomes enlarged with time. Rarely, portions of the feeding tube break and may result in obstruction of the GI tract. By far, however, clogging, displacement, and removal of nasogastric and nasoenteric tubes are the most common of the mechanical complications.<sup>8,21,26</sup>

**OBSTRUCTION OF FEEDING TUBES.** Obstructed or clogged feeding tubes are one of the most common mechanical problems associated with nasogastric and nasoenteric feeding tubes. Tubes are more likely to become occluded when (1) small diameter tubes are used, (2) powdered or crushed medications are passed through the tubes, (3) acidic or alkaline medications are passed through the tube, (4) tubes are not routinely flushed after feedings are stopped, or (5) blenderized food formulas containing particulate matter are used.<sup>21,27-31</sup> Congealing or clumping of formula in the tube can also result from interaction of the formula with acid and proteolytic enzymes in the stomach. Withdrawal of gastric residuum often results in clumping and obstruction when acid gastric secretions are mixed with formula in the feeding tube. When tube feedings are introduced into the small intestine, the tube is exposed to digestive enzymes and alkaline secretions, but because the overall pH is closer to neutral and the enzymes are more active digestants, clogging is not as likely as with intragastric feeding.<sup>27,28</sup> Microbial growth and colonization of the feeding tube can result in clogging if formula is not rinsed from the tube after the feeding is stopped. The risk of clogging can be

minimized by relatively simple procedures that are sometimes difficult to achieve in practice without monitoring. One of the primary preventive measures is to flush with enough water to keep the tube clear. During continuous feeding, tubes should be routinely flushed with water every 4 hours, whenever the feeding is stopped, and whenever (liquid or powdered) medications must be given through the feeding tube.<sup>29-31</sup> Using liquid forms of medication does not insure that clogging will not occur. Acidic or alkaline medications or viscous elixirs can cause the formula to clump or thicken.<sup>30,31</sup>

In clinical practice, a great deal of credence has been placed in using a variety of fluids to rinse or open feeding tubes. Cola beverages, cranberry juice, and warmed tea have been purported to be useful for unclogging feeding tubes. In truth, the ingredients in these fluids that are commonly believed to be “digestants” are weak and ineffective when compared with more potent pancreatic enzymes, such as pancrelipase (Viokase) and pancreatin, to unclog tubes.<sup>21,27-29</sup> Furthermore, when soft drinks and juices are used as rinsing agents, their dried residues can further narrow the lumen of the tube and contribute to clogging. Warm water is far superior as a solvent and rinsing agent and leaves little or no residue.<sup>21,29</sup>

Once the tube is clogged, the options are to remove the tube or attempt to clear the obstruction. Several methods have been recommended, and the success rates probably depend on the cause of the obstruction, the amount of tube occluded, and how long the tube has been clogged. Irrigating the tube with a syringe filled with warm water can be attempted, but with only gentle pressure. Excessive pressure can rupture or break the feeding tube. Small, hollow tubes can be passed inside the feeding tubes to deliver warm water to more distal sites. A mixture of pancreatic enzyme and sodium bicarbonate can be used to dissolve clots, using a smaller tube to deliver the mixture to the obstruction.<sup>21,27</sup> Generally, use of water or digestive enzyme solutions have been superior to commonly used cranberry juice and cola beverages in clearing feeding tubes.<sup>21,27-29</sup> In an earlier study, routine irrigation with 30 ml of water proved far superior in maintaining patency to irrigation compared with cranberry juice. Eleven of 15 tubes became occluded when routinely flushed with cranberry juice, while none of 15 irrigated with water became clogged.<sup>29</sup> Stylets used with tube placement, newer corkscrew stylets, endoscopy brushes, and endoscopic retrograde cholangio pancreatography (ERCP) tubes have been used to physically break up the obstructions.<sup>21,26,32</sup> In the past, stiff wires were sometimes used to open feeding tubes, but perforation of the tube and mucosal surfaces have been reported.<sup>26</sup> Caution must be used to prevent perforation of the GI mucosa using any stylet, and wires should not be used. When kinked or knotted tubing is the cause of obstruction, the tube must either be repositioned or removed (Box 17-2).

### Feeding Sets and Pumps

In most cases, when continuous feeding is desired the formula is poured into a feeding bag or rigid bottle or the formula may be prepackaged in feeding containers. The feeding bag is hung on a pole or stand similar to those used for intravenous solutions. The feeding bag is typically connected to a pump to control flow rate. In the past, gravity drip was the primary

## BOX 17-2

## Preventing Obstruction of Feeding Tubes

- With continuous feeding, routinely flush feeding tubes every 4 hours.
- Flush feeding tubes with water whenever feedings are stopped.
- Flush feeding tubes before and after gastrointestinal contents are withdrawn.
- Avoid giving powdered, crushed, highly acidic, or alkaline medications through the feeding tube whenever possible.
- If medications must be given through the tube, flush it with water before and after.
- Prevent contamination of enteral feeding.
- Avoid passing viscous foods and fiber supplements through small tubes.
- If blended foods are used, be sure foods are finely divided, and use larger tubes.

mode of delivery for continuous feeding and clips or screws attached to the tubing from the reservoir were used to regulate flow rates. Establishing and maintaining a consistent flow rate was difficult, and the tubing often became permanently crimped at the site of the regulator. Most of the tubing used currently with feeding bags and pumps is too narrow to allow gravity drip at acceptable rates with most standard enteral formulas. Gravity drip is now primarily used when bolus or intermittent feedings are used without a pump. Larger tubes or using a disposable syringe barrel is used as the reservoir. Rapid administration becomes more of a concern when bolus feedings are given.

Commercial feeding bags and tubing “sets” currently used in combination with enteral pumps rarely cause problems, but a few complications can still occur. The outlet ports from feeding bags and connecting tubes can become occluded if the tubing lines become kinked; if medications, viscous foods, or fibrous materials are added to the bags; or if bacterial growth is significant (at least  $10^7$  organisms per milliliter).<sup>33</sup>

Other problems with feeding sets include difficulty opening and closing the reservoirs, bursting open if dropped, leaking from the fill site or connectors, and incompatibility with feeding pumps. “Generic” feeding sets are available, but sometimes only the sets sold with the pump fit properly. In some facilities with a large volume of enteral feeding, feedings are poured into the containers and frozen for later use. Some types of containers, however, may crack or leak after being frozen. Fewer complications appear to occur with prefilled, ready-to-hang feeding bags or bottles. The prefilled, ready-to-feed formulas are economical, can be stored for long periods of time at room temperature, reduce the chance for delivery of excessively concentrated or dilute formula, discourage the addition of other fluids and medications to the reservoir, and reduce (but not eliminate) the chance of contamination and longer “hang time.”<sup>34-36</sup> Disadvantages include the inability to modify the feeding solutions and limited variety of the products available in ready-to-feed form.

Institutions or purchasing groups can establish criteria for selecting desired tube feeding reservoirs and sets, such as (1) a rigid neck that allows filling without requiring manipulation with the operator’s fingers to open the reservoir, (2) filled reservoirs that do not leak after freezing or during storage and transport, (3) filled reservoirs that are sturdy enough to be dropped from a reasonable height without breaking or opening, and (4) filled reservoirs that are compatible with feeding pumps and feeding method.

Connection of distal ends of feeding sets to intravenous lines is a rare but obviously serious complication. It could potentially occur in a critical care setting when a number of intravenous lines are being used.<sup>37,38</sup> The problem can be prevented by requiring that tubing connectors be incompatible with intravenous sets or that the manufacturer attach a tag to the distal end of the feeding set labeled “*not for IV use.*”

Mechanical problems that may occur with feeding pumps include electrical failures (motor, switches, alarms, sensors, battery), breakage after being dropped, or becoming inoperable after becoming wet. Feeding tubes can break or kink, and the flexible section of the tubing that is stretched around cam-driven models can be pulled apart. Excessively high or low pressures can be generated within the tubing, especially with distal feeding tube obstructions. Flow rates can be inaccurate when changes occur in the viscosity of the feeding or when the tubing becomes bent or twisted as the patient moves about. Most pumps are fairly reliable, and accuracy is generally within 10% of stated rates, but flow rates should be evaluated at different settings, with different formulas, and under various conditions.<sup>39,40</sup>

## Clinical Problems Related to Tube Feeding

### Diarrhea—Incidence and Definition

In the acute care setting, the reported incidence of diarrhea in tube-fed patients ranges from less than 5% to greater than 60%.<sup>41-43</sup> The higher figures are more likely to be reported in the intensive care unit (ICU) setting. In these settings, diarrhea occurs with such frequency that it is assumed to be a natural consequence of enteral feeding. On the other hand, in the long-term or home care settings, constipation or impaction may be problematic with use of the same enteral feeding formulas—even when similar or less stringent protocols for advancement, rate, and concentration of feedings are used. Coexisting physiologic stressors, medications, and treatments in acute care settings likely contribute to the higher incidence of diarrhea. The incidence of diarrhea can also vary depending on the definition of diarrhea and conditions under which enteral feedings are used. Diarrhea can simply be a descriptor of stool volume and texture or a life-threatening medical problem. Significant diarrhea is more likely related to factors other than the use or composition of the enteral feeding.<sup>42-45</sup>

Diarrhea is usually defined by at least two of three descriptors. Typically it is characterized by stool weight greater than 250 to 300 g, watery consistency, and/or more than three stools per day.<sup>41-45</sup> Sometimes the term *diarrhea* is used by patients or caretakers to describe watery or frequent stools but the 24-hour stool weight may actually be less than 200 g. Frequent small stools may still be a clinical problem, but their occurrence and resolution may not be related to tube feeding. Diarrhea may result from osmotic, secretory and or infectious etiologies.<sup>42-45</sup>

The stools resulting from patients receiving enteral formulas, specifically from defined formula diets, tend to be “mushy” and may be mistaken for diarrhea. Diarrhea definitely occurs more frequently in tube-fed, acute care patients than in a normal population, but, in evaluating reports of diarrhea, descriptors such as *consistency*, *frequency*, and *volume* of stools should be included.<sup>43</sup>

**DIARRHEA—ASSOCIATED CAUSES AND RISK FACTORS.** The long list of causes and contributors to diarrhea includes medications, rate of delivery of the tube feeding, composition of the feeding formula, malnutrition (involving both micronutrients and macronutrients), aggressive refeeding, patient's concomitant clinical problems, and opportunistic infection. In hospitalized patients, most cases of diarrhea can probably be attributed, directly or indirectly, to medications and the severity of the patient's illness (Box 17-3).<sup>41-46</sup>

Medications, specifically antibiotics, may contribute to diarrhea in several ways. Antibiotics can reduce the usual "salvage" by colon bacteria of small amounts of malabsorbed foodstuffs. Antibiotics such as penicillins, cephalosporins, and gentamycin can alter colonic flora or drastically reduce the numbers of colonic bacteria that normally convert osmotically active molecules (e.g., carbohydrate and amino acids) to gases and short-chain fatty acids (SCFAs). The SCFAs are normally absorbed rapidly and efficiently from the lumen of the colon as long as the amount produced is close to normal.<sup>43-46</sup> Absorption of the SCFAs also aids absorption of electrolytes and water from the colon. Eradication of the bacteria from the colon results in accumulation of osmotically active molecules and reduced absorption of electrolytes and water. If more substrates than usual are malabsorbed, as often occurs in hospitalized patients, the resulting accumulation of osmols can result in considerable fluid loss.<sup>47</sup>

Antibiotics can also have direct effects on GI function. Erythromycin, for example, increases the migrating motor complex activity of the proximal gut, resulting in more rapid gastric emptying and movement of proximal small bowel contents. Erythromycin is also poorly absorbed and like clarithromycin and others, is considered an enteric irritant.<sup>46</sup> Clindamycin increases biliary secretion and is considered a GI mucosal irritant.<sup>48</sup> Finally, some antibiotics may effect opportunistic proliferation of pathogenic organisms normally suppressed by competitive organisms in the GI tract. The organisms or the toxins produced can result in large fluid losses by decreasing absorption and increasing secretion of fluid and

electrolytes.<sup>46,49</sup> *Clostridium difficile* is most commonly associated with antibiotic-related diarrhea and accounts for 10% to 25% of cases, but *Clostridium perfringens*, *Salmonella*, *Shigella*, *Campylobacter*, *Yersinia enterocolitica*, and *Escherichia coli* organisms have also been implicated.<sup>46,49,50</sup> The specific cause of *Clostridium difficile* infection cannot always be isolated, but it is associated with the number of antibiotics used, the duration of exposure to antibiotics, the number of days in the hospital, and specific types of antibiotics. Clindamycin, penicillins, and cephalosporins are implicated most often, but tetracycline, erythromycin, chloramphenicol, sulfonamides, quinolones, and trimethoprim have also been associated with the occurrence of *C. difficile*.<sup>46-50</sup> Increased risk of *C. difficile* infection is also associated with use of antineoplastic agents, especially methotrexate, doxorubicin, and cyclophosphamide.<sup>51,52</sup> Patients with human immunodeficiency virus (HIV) and immune deficiencies may have several contributors to the etiology of the diarrhea, including toxic effects of medications, proliferation of opportunistic organisms, and GI manifestations of the disease itself.<sup>53,54</sup>

Antacids, (especially magnesium salts), histamine H<sub>2</sub>-receptor blockers,<sup>42,43,45,55</sup> and proton pump inhibitors<sup>56-57</sup> have been implicated in cases of diarrhea. At least in theory, reducing gastric acid can allow proliferation and colonization of microbes in the stomach and small intestine normally held in check by acid. Although use of acid-suppressing medications may not always be a direct cause, their use has been associated with diarrhea individually or in combination with other medications.<sup>42,56,57</sup>

Hyperosmolar medications and sorbitol elixirs can also contribute to diarrhea.<sup>31,42</sup> Liquid forms of medications such as acetaminophen, cimetidine, dextromethorphan, ferrous sulfate, multivitamins, potassium chloride, and theophylline may be hypertonic, with osmolarities in the range of 800 to more than 6000 mOsm/L. The liquid medications may also contain significant amounts of sorbitol, a sugar with a "cool," sweet taste that is poorly absorbed.<sup>31,42</sup> Only 5 to 20 g of sorbitol is sufficient to cause diarrhea in children and adults.<sup>58</sup> Antacids and other medications that contain significant amounts of magnesium can also contribute to diarrhea. "Standing" orders for laxatives, stool softeners, and acid-suppressing medications sometimes are not discontinued, and occasionally a patient may take laxatives covertly.

Impaction, which most often occurs in immobilized, chronic-care patients, can be manifested by symptoms of diarrhea. Passage or secretion of fluid around the impaction may be responsible for the loose stool. The volume of stool usually is not great, and the patient may intermittently pass small volumes of liquid stool and experience abdominal distention and cramping.

Malnutrition can contribute to diarrhea in several ways.<sup>59-61</sup> It can result in reduced gastric acid secretion; decreased secretion of enzymes from the stomach, pancreas, and brush border; and decreased proliferation, height, and maturity of intestinal villi. The net effect is reduced efficiency and effectiveness of digestion and absorption. Malnutrition can compromise overall host immunity, decrease levels of secretory immunoglobulin A (IgA) in the GI tract, and may increase the potential for microbial proliferation and entry of microbes across the mucosal

### BOX 17-3

#### Potential Causes of Diarrhea

- Medications: Antibiotics; H<sub>2</sub>-receptor antagonists, antacids; medications containing significant amounts of sorbitol, magnesium; hypertonic medications; antineoplastic agents
- GI disorders or dysfunction, including gastric or small bowel resection, inflammatory bowel disease, pancreatic insufficiency, radiation enteritis, sprue, protein-losing gastroenteropathies
- Malnutrition, including hypoproteinemia and micronutrient deficiencies.
- Excessive rate of feeding, concentration, volume, or osmolality, especially in malnourished patients and patients whose GI tract has not been used for several days
- Opportunistic GI infection: Immunosuppression from disease or medications, hypochlorhydria; infusion of significant amounts of contaminated feeding formula; altered GI flora
- Physiologic stress
- Bowel impaction
- Intolerance or allergy to feeding formula
- Diabetes
- Hyperthyroidism

barrier. In a severely compromised host, transfer of microbes from the GI tract is considered a significant source for septic complications. Significant hypoalbuminemia is associated with decreased tolerance to enteral feedings, which theoretically is due to gut edema or decreased oncotic gradient across the bowel wall. Hypoalbuminemia may also reflect significant malnutrition or physiologic stress, either of which could decrease tolerance to enteral feeding. Low serum albumin does not contraindicate tube feeding but may require that rate, osmolality, and volume of feedings must be increased cautiously.

**MANAGEMENT OF DIARRHEA.** The first steps in resolving diarrhea are to evaluate the severity, duration, and pattern of occurrence and then to investigate possible causes including secretory, osmotic, or infectious sources. Where possible and as appropriate, the physician should withdraw or substitute the offending medications (e.g., magnesium-based antacids can sometimes be replaced with calcium or aluminum salts). Hypertonic elixirs or sorbitol-containing medications can often be diluted or replaced. With malnourished patients or patients with jejunal feedings or compromised GI function, feeding rate or concentration can be reduced or continuous feedings can be used instead of bolus. If specific offending ingredients are causal (e.g., lactose or allergens), the enteral formula may be changed. After preventable causes of diarrhea have been addressed, medications such as opiates, loperamide, or paregoric may reduce or resolve many cases of mild to moderate diarrhea. In cases of diarrhea caused by stasis and bacterial overgrowth, however, drugs that slow motility may worsen the situation.<sup>45,46</sup>

Diarrhea has also been associated with proliferation of microbes in enteral feeding solutions. Safe, clean handling of feeding formula, tubes, and reservoirs; addition of stabilizers; and acidification of the formula all may help prevent contamination and growth of microbes in the formula.<sup>62</sup>

Severe diarrhea (generally considered more than 1 L of stool per day) usually indicates significant malabsorption, maldigestion, or secretory or infectious causes. Maldigestion or malabsorption, for example, might respond to decreasing the concentration, osmolality, or rate of the formula, or changing the composition of the formula, (e.g., using medium-chain triglycerides or pancreatic enzymes) or changing to a chemically defined diet to enhance absorption. Secretory diarrhea may result from infectious agents such as *C. difficile* or other agents, viral gastroenteritis, inflammatory states, and/or as a result of malabsorbed bile acids. Osmotic diarrheas are typically more rectified by dietary modification than secretory and other forms of diarrhea, although diet may help attenuate other forms.

Infectious diarrhea, as in *C. difficile* infection or the patient with acquired immunodeficiency syndrome (AIDS) who may be suffering from several opportunistic infections such as giardiasis, cryptosporidiosis, amebiasis, salmonellosis, or shigellosis, may require specific antimicrobial therapy.<sup>53,54</sup> In HIV, the disease, medications used to treat the GI infection, and malnutrition may contribute to the diarrhea.

Various forms of foodstuffs or prebiotic and probiotic supplements have been used to prevent or treat diarrhea with varying degrees of success. Prebiotic supplements or foods that contain oligosaccharides, fibers, or resistant starches have a

role in “stabilizing or normalizing” GI flora and function.<sup>41,62-66</sup> The prebiotic materials tend to soften stools in cases of constipation and firm stools during diarrhea. Continuous supplies of some prebiotics alter fecal flora, increase water absorption, help maintain the unstirred water layer along the mucosa, and are fermented by colonic microbes to SCFAs. SCFAs serve as a primary fuel for colonocytes, are trophic to enterocytes, and enhance colonic absorption of water and sodium. The more acid milieu favors the proliferation of “beneficial” bifidobacteria and lactobacilli that prevent adherence or colonization of organisms such as *C. difficile* and, in underdeveloped countries, cholera. Pectin, fructose oligosaccharides, inulin, psyllium, soy fibers, and banana flakes all have been claimed to be helpful in firming stools and preventing or treating diarrhea, but additional study in humans and specifically enteral applications are warranted.<sup>41,63-66</sup> Addition of prebiotics may be relatively ineffective in treating more severe cases of infectious, secretory, or osmotic diarrheas. Whenever possible, enteral products should probably contain dietary fiber or prebiotic materials for normal health maintenance.

Supplementation of formulas with probiotics (nonpathogenic organisms that exert positive effects on health) also holds promise for prevention and treatment of diarrhea and other GI and systemic problems. Applications in enteral nutrition are limited, but ingestion of several strains of probiotic organisms has been at least partially effective in the prevention of antibiotic- and rotavirus-associated diarrhea and gastroenteritis. *Lactobacillus rhamnosus* GG, *Lactobacillus acidophilus*, and *Saccharomyces boulardii* are examples of probiotics that have been used in controlled human trials with some success.<sup>68,69</sup>

### Aspiration

Aspiration is one of the most serious and potentially life-threatening complications of tube feeding.<sup>2</sup> This is especially true in the patient compromised by disease, trauma, neurologic disorders, immune deficits, or malnutrition.<sup>21,43,70</sup> The term *aspiration*, in this context, refers to entry of tube feeding or GI secretions into the lungs. The incidence of aspiration ranges greatly from less than 4% to greater than 70%, depending on the criteria used to define aspiration, the population studied, and the method(s) employed to verify the complication. Consequences range from coughing and wheezing to infection, tissue necrosis, and respiratory failure. The consequences of aspiration depend on the volume, pH, particle size, composition, and microbial content of the aspirated material and the prior health of the patient. Some minor degree of pharyngeal aspiration of gastric secretions occurs in normal, healthy individuals with little consequence. With tube feedings, however, the likelihood for significant aspiration and adverse sequelae is greater.

Factors that increase the risk of clinically significant aspiration include the supine position of the patient, delayed gastric emptying, reflux, use of large diameter feeding tubes, tracheal intubation, age of the patient, neuromuscular disorders, decreased consciousness, increased concentration of microbes in the aspirate, aspiration of gastric contents (acid and digestive enzymes), and decreased intensity of nursing care.<sup>15-17,21,70</sup> Ileus, GI obstruction, and a host of other medical and surgical problems can also cause vomiting, which, especially in a

compromised patient, further increases the risk of aspiration. Use of bolus feedings or rapid infusion of enteral feedings, especially those of higher osmolality or caloric concentration, can increase the risk of reflux, vomiting, and aspiration, even when infused transpylorically or by gastrostomy tube.

As mentioned earlier, aspiration can also occur as a result of misplacement or dislocation of the feeding tube. Typically, if the feeding tube enters the airway while it is being placed, the patient coughs and expresses discomfort; however, patients who are sedated or obtunded may not be able to respond normally.

Several measures have been advocated to prevent aspiration, but each has limitations. To further prevent aspiration in tube-fed patients, elevating the head of the bed to at least 30 degrees, checking residual gastric volume, and use of prokinetic agents such as metoclopramide and erythromycin to enhance gastric emptying have been recommended, especially in patients at high risk.<sup>6,7,15,70</sup> In general, aspiration is less of a risk with continuous than with bolus or intermittent feedings.<sup>6,15,70</sup> Placing tubes transpylorically, especially at or beyond the ligament of Treitz, may reduce (but not eliminate) the risk of aspiration. Whether and the degree to which enteric placement of feeding tubes prevents aspiration have been controversial but may depend on the placement and feeding protocols and the risk of the population studied.<sup>15,21,23,70</sup>

The volume of fluid remaining in the stomach or small intestine depends on the rate at which the tube feeding is administered, amount of fluids secreted from the GI tract, rate of GI transit, and GI absorptive rate. Each factor must be considered when deciding to start and advance enteral feedings. In most settings, protocols for routine checks of gastric residuum are used, especially for high-risk patients or when increasing rate and concentration of bolus feedings. Use of a cutpoint for volume of gastric or intestinal residuum as a decision tool to limit subsequent feedings is a common and logical clinical practice. However, the association between gastric or enteric volume and aspiration has not been well documented and the cutpoints are not well correlated with gastric emptying. Recommendations range from 150 to 250 ml for intragastric feedings and approximately 100 ml for gastrostomies placed on the anterior wall,<sup>15,38,43,71</sup> but even these recommendations might vary depending on the degrees of patient risk. The higher the flow rate, volume, caloric concentration, osmolality, and viscosity of the feeding, the greater the potential for increased gastric residuals.

### Contamination of Feeding Solutions

Ready-to-feed commercial enteral products, unlike modular or tube feedings prepared from regular foods, are essentially sterile until opened (Box 17-4). Contamination of enteral formulas decanted into feeding bags, however, is common in the hospital setting. Contamination and proliferation of microbes in the formula may simply result in altered color, consistency, or clumping of the feeding, but in some cases, contamination may be manifested in colonization of the GI tract and diarrhea.<sup>33,71-73</sup> The typical hospitalized, tube-fed patient is at greater risk than a free-living, healthy person for adverse consequences of contaminated foods. The patient may be immunologically compromised as a result of malnutrition, disease, or

#### BOX 17-4

#### Reducing Risk of Microbial Contamination

- Use prefilled, ready-to-feed enteral feeding when possible.
- Wash hands before handling enteral feeding products.
- Check for out-of-date, swollen, or leaking enteral formula containers.
- When filling enteral formulas into feeding bags, avoid touching fluid path, openings, and spikes.
- Discard unused portions of feedings or refrigerate unused portions immediately after decanting; label unused portion with time, date, and patient's identification.
- Watch for change in color and consistency in enteral formulas during delivery.
- Avoid unnecessary opening/additions to tube feeding.
- If not using prefilled enteral feeding, discard remainder of formula after 8 to 12 hours hang time; rinse feeding bag and all tubing with water; refill with fresh product.
- In hospital, discard feeding bag or set every 24 hours.
- If reuse of feeding bag cannot be avoided, use bag that does not have crevices or corners that cannot be cleaned. Insufficient data are available regarding safety of reusing enteral feeding bags.
- If blended food formula is used, employ safe handling practices from start to finish; avoid using for immunosuppressed patients.

medications. In a patient fed directly into the small bowel, the bacteriostatic effects of gastric acid and digestive enzymes are bypassed, further increasing the risks associated with contaminated formula. If the patient is receiving medications to block or neutralize gastric acid secretions, the chances for gastric and intestinal colonization may also be increased.

When commercially prepared enteral products are found to contain significant concentrations of microbes during administration to the patient, the primary source is typically the hands of persons who open, fill, and connect the feeding reservoirs.<sup>62,71-75</sup> Microbes are typically transferred from nursing staff who perform routine patient care activities and then fill the feeding bags. The types of microbes found in enteral feedings in the clinical setting are not those typically associated with food-borne illness, but rather are nosocomial organisms normally found in hospital units.

Most enteral feedings provide excellent media for microbial growth but hyperosmolar tube feedings, those that have a more acidic pH and those that contain microbial inhibitors, are less likely to support microbial growth than typical isotonic formulas.<sup>33,72-76</sup> Potassium sorbate, methylparaben, and sodium benzoate, all common food additives, have been used by one enteral formula company to inhibit growth of at least some organisms, but effectiveness data are not available.

Because normal enteral feedings bags may be relatively expensive, they are sometimes reused in clinical and home settings. The safety and cost effectiveness of reusing enteral feeding bags, however, has probably not been adequately evaluated. Few studies have been published regarding rinsing and cleaning procedures, degree of contamination, and patient outcomes. Published reports are limited, conflicting, and far from complete.<sup>76-77</sup> Some enteral feeding reservoirs are difficult to clean completely, and the same concerns that face food service managers regarding clean equipment, safe food preparation, and storage apply to reuse of enteral feeding products.<sup>33,35,62,78-80</sup> Additional study is required regarding which types of enteral formulas and bags can be rinsed and reused and with what procedures and for what duration. Guidelines for one institution

may not apply for all formulas, feeding apparatus, patients, or situations.

Contamination is less likely to occur with commercial enteral feeding formulas, which are prefilled into feeding bags.<sup>34,35,80-83</sup> Because the prefilled products come in a limited number of concentrations and nutrient mixtures, they may not be used in acute care as often as they might in extended care facilities or the home setting after the patient is more stable. The bags are normally 1 to 2 L in volume and, if handled with reasonable care, can be hung by the bedside for 24 to 36 hours. Contamination can still occur in prefilled containers when (1) spikes are inserted to connect the tubing; (2) when medications or other additives are introduced; or (3) theoretically, from retrograde seeding of microbes in bags that do not have drip chambers that separate tubing and fresh enteral product in the feeding bag.<sup>80-84</sup>

A primary reason that enteral formulas are rarely made from regular foods is the significant risk of contamination during preparation. Although commercial products are now used almost exclusively, patients or their caretakers sometimes insist on using tube feedings made from regular foods. In addition to organisms found naturally on or in foods, employees or patient caregivers in the home must practice sanitation and safety measures at each step from purchase of the individual ingredients to preparation and storage.<sup>62,75,76,78-80,82</sup> Each piece of equipment used for measuring, mixing, and storing the products must be clean. Ensuring a safe, blenderized tube feeding delivered to the patient's bedside is an institutional food service nightmare. Because commercial products are less likely to become contaminated if rather simple guidelines are followed, they are the preferred choice when safety and sanitation are concerns.

### Underfeeding

**ENERGY AND PROTEIN INTAKE.** Tube-fed patients often receive less than the prescribed or desired amount of feeding.<sup>8,15,43</sup> Errors can be made in the original estimate of nutrient needs, the product can be diluted or improperly mixed, or the initial feeding rate and volume may not have been increased. The most common reason for underfeeding, however, is interruptions in the feeding schedule. Feedings are stopped for various reasons—diagnostic and therapeutic procedures, ambulation, infusion of medications, clogged or misplaced tubes, occurrence of diarrhea, excess residual volume or other complications, personal care and hygiene, or when visitors come. The patient or caretakers may purposely or accidentally change the rate, time, or volume or replace the formula with liquids of lower nutrient density. Patients or caretakers may be concerned about the cost of the product or excessive weight gain or may simply be confused about the intent or composition of feeding. If patients are underfed for long periods or have high nutritional needs, the resulting undernutrition, including macronutrients and micronutrients, may be significant.

**MICRONUTRIENT DEFICIENCIES.** Deficiencies of vitamins, minerals, and electrolytes as a result of enteral feedings are now relatively rare, as a result of the widespread use of commercial products, which usually provide adequate levels of most nutrients. Some patients, however, may be at increased risk because of poor intake before starting enteral feedings, malabsorption,

increased requirements, or drug-nutrient interactions. Some patients may need therapeutic levels of micronutrients in addition to standard feedings.

Blenderized, modular, and standard tube feedings that are diluted or modified can also be deficient in vitamins or minerals. A patient who has unusually low energy requirements (e.g., <1500 kcal) or receives fewer calories than are needed might also receive too few micronutrients. Some of the more serious deficiencies are discussed next.

**HYPONATREMIA.** Hyponatremia typically is not a result of too little sodium in the diet; usually it reflects a hypervolemic state such as congestive heart failure, cirrhosis, or nephrotic syndrome; it may also reflect a euvolemic state as seen with excess antidiuretic hormone, thiazide diuretics, cortisol deficiency, or hypothyroidism. Because our diet is typically excessive in sodium, hyponatremia related to excess loss of sodium in relation to water is relatively uncommon, but may occur with GI suctioning, vomiting, malabsorption syndromes (including short-bowel syndrome), excessive renal losses, or long-term use of dilute or very low-sodium tube feedings or thiazide diuretics. Caretakers using infant formulas or making home-prepared formulas from unsalted foods for enteral feeding may unknowingly create very low-sodium formulas. Diet and medical history, urinary sodium, and serum osmolality help determine the etiology. Prevention and treatment of hyponatremia typically involves identification of the potential causes and, when appropriate, fluid restriction for dilutional hyponatremia or provision of supplemental sodium for true sodium depletion.<sup>85-87</sup>

**HYPOKALEMIA AND HYPOPHOSPHATEMIA.** Hypokalemia and hypophosphatemia often go hand-in-hand because they typically occur with combinations of prolonged nutrition depletion, catabolic stress, alcoholism, rapid refeeding, or and/or insulin therapy.<sup>43,85,87-92</sup> A potassium-wasting diuretic or long-term diarrhea increases the risk of hypokalemia. Treatment of mild hypokalemia includes increased dietary potassium (e.g., 20 to 40 mEq of potassium chloride) and correction of factors that might have contributed to the hypokalemia. More severe cases of hypokalemia require careful intravenous replacement.

Medications associated with increased phosphorus losses include aluminum hydroxide, theophylline, sucralfate, and foscarnet.<sup>85,87-90</sup> Treatment of hypophosphatemia includes therapeutic replacement of phosphorus and withdrawal or substitution of agents that contribute to hypophosphatemia. With milder hypophosphatemia, 20 to 40 mmol of phosphorus can be provided in the form of 5 to 10 ml of Fleets phosphosoda in 500 to 1000 ml of formula.<sup>88</sup> If hypophosphatemia is significant (e.g., serum phosphorus < 1.6 mg/dl), intravenous phosphorus should be provided.

### Overfeeding

Unlike overfeeding with parenteral nutrition, providing excessive calories or carbohydrate by way of enteral feeding is somewhat limited by decreasing GI tolerance. Significant overfeeding with standard enteral formulas typically results in increased gastric residuals, abdominal bloating, cramping, diarrhea, or reflux, especially in a malnourished patient or one whose GI function is compromised.<sup>41-43,91,92</sup> Overfeeding may lead to gradual weight gain and hyperglycemia; hyperlipidemia;

and increased fat deposition in long-term, tube-fed patients, especially those who are bedridden. Patients with neuromuscular disease may appear normal weight but may have replaced lost muscle mass with gains in fat mass. Accurate initial assessment of calorie requirements followed by periodic reassessment prevents overfeeding.<sup>90</sup> Use of indirect calorimetry, measures of body composition, and weight histories can be used when height-weight relationships may not be helpful.

Overfeeding results in increased metabolic rate, cardiac demand, respirations, and carbon dioxide production. Increased carbon dioxide production can result from either excessive calorie intake or high-carbohydrate intake. Overfeeding and the potential for increased respiratory demand can be monitored by the respiratory quotient (RQ), the ratio of carbon dioxide produced to oxygen consumed by metabolic processing of energy substrates. This value is measured with a metabolic cart while performing indirect calorimetry.<sup>93</sup> RQ resulting from the oxidation of carbohydrate is approximately 1, whereas the RQ from processing fat is only 0.7. The act of converting excess carbohydrate calories to fat has an RQ of 8, and significant overfeeding can result in net RQs greater than 1.0.<sup>93</sup>

Concern for overfeeding carbohydrate or calories is usually directed toward patients with chronic obstructive pulmonary disease (COPD) or those on ventilators who are retaining carbon dioxide and struggling to breathe with, or be weaned from, respirators. Reducing excessive calorie intake is far more therapeutic than reducing the carbohydrate content of the feeding, but if the calorie level is acceptable, reducing carbohydrate content and increasing lipid calories may be beneficial in reducing carbon dioxide load.

### Hyperglycemia

Compared with its relative frequency in association with central venous feeding, hyperglycemia is relatively rare in patients fed by enteral feedings, especially by continuous drip. The relatively slow rate of formula infusion, combined with the normal GI and endocrine mechanisms for processing the energy substrates, make hyperglycemia less likely. Overfeeding of energy and glucose is also somewhat self-limited by GI tolerance. Most hyperglycemia secondary to enteral feeding is likely the result of combinations of other factors commonly seen in the acute care setting, including diabetes, medications (notably steroids), and physiologic stressors. Treatment of hyperglycemia includes making certain that calories and rate of administration are appropriate, using insulin or oral hypoglycemic agents when necessary, reducing or eliminating (when possible) medications associated with hyperglycemia, and adjusting the timing of enteral “meals” with the onset, peak, and duration of hypoglycemic agents. Specialty products that contain fiber and greater proportions of monounsaturated fatty acids may help control glycemia and lipemia for persons fed long term by tube.<sup>94</sup>

For patients with diabetes who require insulin, use of enteral pumps and intermittent feedings can be used quite effectively to regulate blood sugar and control lipids. The patient or caregiver can adjust insulin doses and enteral feeding rates and schedules to produce acceptable levels of glycemia over a 24-hour period. The frequency and composition of the feedings can be tailored to fit the profile to the hypoglycemic agent.

Initial monitoring typically includes blood glucose measures every 6 to 8 hours (continuous feeding); daily blood urea nitrogen, electrolytes, creatinine, and a record of energy intake; and weekly serum triglyceride and cholesterol levels.<sup>94,95</sup> When the patient’s condition stabilizes, the frequency can be decreased.

### Refeeding Syndrome

Patients who have a long history of poor caloric intake as a result of anorexia, maldigestion, or malabsorption and are then aggressively refeed are at risk for *refeeding syndrome*.<sup>43,91,92</sup> Long-term undernutrition causes gradual loss of skeletal muscle mass and of functional tissues from organ systems—heart, lungs, liver, and GI tract. In addition, patients lose total body stores of biologic catalysts and electrolytes, including several vitamins, phosphorus, potassium, magnesium, zinc, and trace elements. Overfeeding a malnourished patient adds to the physiologic burden by increasing cardiac output, respirations, substrate interconversions, and synthesis of adenosine triphosphate and protein. When refeeding, levels of anabolic hormones increase and levels of circulating nutrients move to serve intracellular functions. Overfeeding and the hypermetabolic state it produces can severely burden the cardiovascular and respiratory systems of previously depleted patients. Overfeeding substrate without sufficient micronutrients can precipitate serious hypokalemia, hypophosphatemia, hypomagnesemia, and other micronutrient deficiencies. Depleted patients have reduced body cell mass and may have very low calorie requirements. Prevention of refeeding syndrome involves ensuring that feeding begins slowly at calorie levels below maintenance needs and that they are gradually advanced to maintenance needs. Micronutrient requirements (particularly for phosphorus, potassium, and magnesium) should be anticipated, closely monitored, and corrected as needed. Restoration of body cell mass can then be targeted with physical therapy and additional calories as the patient improves.

### Azotemia, Hypernatremia, and Dehydration (Tube Feeding Syndrome)

*Tube feeding syndrome* includes azotemia, hypernatremia, and dehydration that result from use of high-protein tube feedings with a high renal solute load, typically with inadequate amounts of water. Classic cases involved elderly patients given concentrated, high-protein feedings, but the problem has also occurred with misuse of modular products and powdered formulas.<sup>96,97</sup> In some cases, the concentration and osmolality of the tube feeding may have resulted in diarrhea, which increased water losses. Because many of the patients were obtunded or unable to speak, they could not express thirst. The combination of high solute load and negative fluid balance resulted in dehydration and subsequent increases in blood urea nitrogen and hypernatremia. Hypernatremia occurred, not because of excessive sodium intake, but rather as a result of hemoconcentration. Most commercial products have safe renal solute loads, but use of modular protein sources, concentrated powdered enteral feedings, and “homemade” high protein tube feedings can create opportunities for excess solute load. Prevention simply requires the provision of adequate fluid (at least 1 ml/kcal plus any unusual respiratory, renal, or GI losses) and avoiding protein loads greater than 1.5 g/kg of desirable body weight. In

particular, infants, the elderly, and those who cannot communicate or control feedings should be carefully monitored.

### Constipation

The occurrence of constipation is less common in the acute care setting than in long-term care settings, but in one series of 400 tube-fed patients, 15% required intervention for constipation.<sup>41</sup> The more common risk factors for constipation include inadequate hydration, inactivity, immobilization, neuromuscular disorders, hypothyroidism, inadequate fiber intake, hypokalemia, previous misuse of laxatives, and GI motility disorders. Use of medications such as anticholinergics, nonsteroidal antiinflammatory agents, narcotics, bile acid sequestrants, furosemide, nitroglycerine, and antidepressants has been associated with constipation.<sup>98-100</sup> Satisfactory resolution may not always be possible, but encouraging the patient to ambulate as much as possible and providing adequate water and fiber in feedings may help. Pharmacologic interventions—stool softeners, appropriate laxatives, or prokinetic agents—may be required.

### Risk-Benefit Decisions in Enteral Feeding

Generally speaking, when typical indications for tube feeding are met, the benefits of enteral nutrition support outweigh the potential complications (Box 17-5). Frequency and severity of complications related to the placement and use of enteral feedings can be reduced considerably by interdisciplinary quality improvement protocols and guidelines. In some cases, risks of complications are inherently greater than the benefits associated with tube feeding, regardless of the quality of care provided, and these must be anticipated. Patients at increased risk for complications include those with significant malnutrition, GI dysfunction or malignancies, metabolic disease, advanced age, dementia and obtundation, unprotected airway, tracheal intubation, reflux, compromised immune function, persons receiving multiple medications, and patients under the care of persons not trained in placement and delivery of tube feeding.<sup>6,7,15,43</sup> The number of potential problems underscores the need for caution in the placement, delivery, and monitoring of the patients feeding apparatus and formula.

In some cases, complications associated with enteral feedings can be significant. Potential morbidity and mortality associated with enteral feeding complications must be weighed against the realistic expectations for improvements in nutrition,

#### BOX 17-5

#### Increased Risk of Complications with Enteral Feeding

- Gastrointestinal dysfunction
- Prior abdominal surgeries
- Dementia, decreased level of consciousness
- Advanced age
- Tracheal intubation, unprotected airway
- Dysphagia, lower esophageal sphincter dysfunction, reflux
- Compromised immune function
- Significant malnutrition
- Caretakers unfamiliar with enteral placement and delivery

functional status, and quality of life. Caretakers and patients need to be informed about risks, benefits, and costs.<sup>101-103</sup>

### Quality Assurance and Improvement in Enteral Nutrition

The objectives of total quality management programs in health care are to evaluate and improve important aspects of patient care. Emphasis is on outcomes, rather than evaluating processes in patient care. Certainly, enteral nutrition qualifies as an important aspect of patient care. Systematic evaluation of enteral feeding practices can improve documentation of care, decrease morbidity and mortality, improve patient satisfaction and confidence in the health care team, and decrease health care costs. Protocols, standards of care, clinical indicators, and clinical pathways can be used as guides measuring practice.<sup>104-107</sup>

Quality improvement in enteral nutrition is best tailored to the specific setting or patient mix. Examples of aspects to be evaluated in quality improvement programs include significant mechanical, metabolic, and GI complications. Examples of indicators used in evaluating enteral nutrition programs include the adequacy of support, prevalence of aspiration, diarrhea, hyperglycemia, or hypophosphatemia; use of rectal tubes; tube replacements; and documentation of patient instruction regarding placement and use of feedings. The results of quality improvement programs can (1) point out the need for changes in policies, procedures, equipment, communication tools or training; (2) recognize good care; (3) document justified expenditures of resources; and (4) create solutions and innovations in patient care.

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