Invited Review

Enteral Nutrition for Adults in the Hospital Setting

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Abstract

In patients unable to tolerate oral intake, multiple options of nutrient delivery are available to the clinician. Administration of enteral nutrition (EN) has long been considered the standard of care for nutrition support among patients unable to meet energy and protein requirements orally. Healthcare practitioners must make careful decisions related to ordering, administering, and monitoring EN therapy. In the hospital setting, the registered dietitian is a key resource in enteral formula selection and method of administration, monitoring for and troubleshooting EN-related complications, and transitioning to oral feeding. The hospital setting also presents many unique challenges in providing optimal nutrition to the enterally fed patient. (Nutr Clin Pract. 2015;30:634-651)

Keywords
enteral nutrition; adults; nutrition therapy; nutritional support; hospitalization; nutrition assessment; malnutrition

Introduction

Enteral nutrition (EN) is defined as nutrition provided through the gastrointestinal (GI) tract via a tube, catheter, or stoma that delivers nutrients distal to the oral cavity.¹ Enteral access allows the short- and long-term delivery of nutrients to the digestive tract of patients who cannot maintain their requirements orally. Administration of EN has long been considered the standard of care among patients unable to meet energy and protein requirements orally. As such, many hospitalized patients in the United States receive EN. According to the latest available statistics from the National Center for Health Statistics, patients received EN during approximately 251,000 hospital stays in 2012, 78% of which were adults.²

The provision of EN not only provides micronutrients and macronutrients but also supports the functional and structural integrity of the largest immune organ in the body—the gut. Some of the physiologic changes induced by the delivery of EN include stimulating blood flow to maintain adequate perfusion, stimulating intestinal motility/contractility, maintaining villous height, promoting insulin sensitivity, supporting commensal bacteria, and attenuating oxidative stress and the systemic inflammatory response to illness, among other things³⁻⁷ (Figure 1). These physiologic changes help maintain intestinal barrier function and therefore prevent increases in gut permeability and decrease the virulence of pathogenic organisms (eg, bacterial translocation) often seen in patients with host immune deficiencies, immunosuppression, stress, hypoperfusion, and disturbances in normal gut flora due to lack of enteral stimulation.⁸

The prevalence of malnutrition in hospitalized patients has been estimated at 30%-60%, with up to 69% of patients experiencing a decline in their nutrition status during hospitalization,⁹ and published reports consistently describe incomplete delivery of EN.¹⁰⁻¹² To prevent the downstream complications that can result from inadequate nutrient intake in the hospital setting, including increased morbidity and mortality related to iatrogenic malnutrition, longer lengths of hospital stay, and increased hospital costs, healthcare providers must pay close attention to the adequacy of EN intake and adjust therapies on a frequent basis. The purpose of this article is to provide a basic review of EN in the adult hospitalized patient to guide clinicians in the management of EN. An interdisciplinary team approach is required for the successful navigation of nutrition assessment, patient and enteral access device selection, enteral formula selection and method of administration, monitoring for and troubleshooting EN-related complications, and transitioning to oral feeding.

Nutrition Assessment

A complete nutrition assessment includes a review of the patient’s medical, surgical, social, and diet history, anthropometric measurements, and laboratory data, as well as a verbal discussion with the patient and/or caregiver and completion of a nutrition-focused physical assessment. The intent of the nutrition assessment is to document baseline nutrition parameters, identify risk factors for malnutrition and specific nutrient deficits, establish individual nutrition needs, and identify any factors that may influence the provision of nutrition support therapy.¹³

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Currently, there is no single laboratory test or panel that can accurately or consistently diagnose malnutrition. Despite their widespread use as nutrition markers, serum proteins such as albumin, prealbumin, and transferrin are now well established as negative acute phase reactants that are sensitive to acute and chronic inflammation. Severe, sustained, or repeated bouts of inflammation correlate with adverse outcomes. Since serum proteins correlate with the patient’s overall severity of illness and level of inflammation, they can be useful predictors of morbidity and mortality in hospitalized patients.

In 2012, a standardized, etiology-based approach to diagnosing malnutrition in the adult hospitalized patient was developed. This approach recognizes the effects of acute and chronic disease-related inflammation and includes the assessment of 6 characteristics, and their respective thresholds, for both moderate and severe malnutrition. Identification of 2 of 6 malnutrition characteristics (weight loss, insufficient energy intake, depletion of subcutaneous fat, depletion of muscle mass, decline in handgrip strength, and fluid accumulation) is needed to diagnosis protein-energy malnutrition. It is important to note that malnutrition can occur at any body mass index (BMI) and that hepatic proteins can be within normal ranges in patients with pure starvation-associated (noninflammatory) malnutrition.

### Energy Needs

Energy needs in the hospitalized adult patient are generally based on age, sex, BMI, body composition, and clinical status. A.S.P.E.N. consensus guidelines suggest that most adults require a range of 20–35 kilocalories per kilogram (kcal/kg). Indirect calorimetry (IC), which measures whole body oxygen consumption and carbon dioxide gas exchange to yield resting metabolic rate, is considered the gold standard for determining energy needs in the acute care setting. However, IC is often unavailable due to its high cost and the specialized training required. Therefore, a number of predictive equations have been developed to estimate energy needs in various patient populations, although results do not always correlate with IC across all patient populations and can vary with obesity, age, and severity of illness. If used, equations must be applied in patients similar to the reference population from which the equation was derived.
derived, with the understanding that clinical judgment is still required. Regardless of the method used to determine energy needs, it is essential to adjust energy provision based on the patient's clinical status and response to nutrition therapy.

**Protein Needs**

Protein is essential for the structure, maintenance, and growth of cells, tissues, enzymes, hormones, antibodies, and transport carriers. Daily protein requirements are based on a patient’s age, weight, nutrition status, and the degree of stress imposed by disease or injury. The Dietary Reference Intake (DRI) for protein for healthy adults is 0.8 g/kg. Hospitalized patients often experience accelerated muscle catabolism and net negative nitrogen balance due to acute or chronic illness(es). Metabolically stressed adult patients generally require 1.2–2.0 g/kg of protein. The goal of protein provision in metabolically stressed patients is to achieve positive nitrogen balance, or a state in which protein synthesis exceeds protein breakdown. Nitrogen balance studies can be useful in assessing the adequacy of protein intake, although these studies may be difficult to conduct in the hospital setting due to the need for complete and accurate measurements of intake (via oral, enteral, and/or parenteral routes) as well as output (including urine, stool, fistula, wound, and ostomy losses).

**Fluid Needs**

Water is the most abundant substance in the body, accounting for 50%–60% of body weight. Total body water does vary with age, weight, sex, and adiposity. The goal of fluid management is to maintain adequate hydration, tissue perfusion, and electrolyte balance. Healthy adults usually require 30–40 mL/kg daily to achieve fluid balance. Assessing fluid status in hospitalized patients requires physical examination and the assessment of intakes and outputs, weights, laboratory values, and vital signs. Most fluid is lost from the GI tract and kidneys, although a significant amount of fluid can also be lost through the lungs and skin. Metabolic changes, such as fever and hyperthyroidism, and medical therapy, such as diuretics or the lungs and skin. Metabolic changes, such as fever and hyperthyroidism, and medical therapy, such as diuretics or

**Micronutrient Needs**

Micronutrients are required for effective metabolism and biochemical processes. A patient’s specific vitamin and mineral requirements vary depending on the patient’s nutrition and clinical status. A multivitamin/mineral supplement is warranted when the nutrition support regimen does not provide sufficient amounts and no other form of nutrition is provided.

**Patient Selection**

Hospitalized patients with a functional GI tract, who are unable to meet energy and protein requirements orally, are generally candidates for EN therapy. When oral intake is deemed unsafe, insufficient, or impossible, the clinician must consider the risks and benefits of EN therapy in the context of the patient’s diagnosis, clinical status, and prognosis and determine whether EN is consistent with the patient and/or family’s wishes. Some examples of conditions that merit consideration for EN therapy include endotracheal intubation, swallowing difficulty due to dysphagia, altered mental status or delirium, luminal obstruction in the head and neck area, the esophagus, or the stomach from malignancy, or poor oral intake resulting in weight loss and/or malnutrition. Patients with hypermetabolic and hypercatabolic states such as trauma, burns, and malignancy may also benefit from EN therapy, as it may be difficult for them to meet the needs with oral intake alone.

**Contraindications** to enteral feeding may include patients with intractable vomiting or diarrhea, severe GI malabsorption, paralytic ileus, GI ischemia, severe short bowel syndrome, or high-output enterocutaneous fistula. Relative contraindications include intestinal obstruction, diffuse peritonitis, or when nutrition intervention is not warranted or desired by the patient or proxy.

**Timing of Enteral Nutrition**

Initiation of EN should always follow a complete evaluation of the patient’s disease state, medical condition, and the relative risks and benefits. The timing, however, may depend on the indication for EN as well as the patient’s nutrition state. For most hospitalized patients, initiation of EN is recommended when oral intake is absent or likely to be absent for a period of 5–7 days. However, earlier initiation may be warranted in the moderately or severely malnourished patient to support metabolic demands and prevent functional decline. This concept is also reflected in recommendations for the postsurgical patient population, which state that EN should be considered within 7 days of surgery in the normally or overnourished, within 3–5 days of surgery in the moderately malnourished, and within 1–2 days of surgery in the severely malnourished. In the critically ill population, it is recommended that EN should be started early within the first 24–48 hours following admission to the intensive care unit (ICU) due to the beneficial effects on intestinal physiology and immunity discussed previously.

**Enteral Access**

The selection of an enteral access device should depend on the patient’s disease state, GI anatomy, function and accessibility, and expected duration of therapy. Short-term access options include placement through the nose or mouth with the tip of the feeding tube terminating within the stomach, past the pylorus, or distal to the ligament of Trietz. For EN therapy lasting > 4 weeks, more permanent access options include gastrostomy, jejunostomy, and gastrojejunostomy tubes. For all patients who require an enteral access device, close monitoring is required.
to maintain patient safety and prevent events such as inadvertent tube displacement.

Enteral access devices vary with respect to tubing material and size, which is measured using the French (Fr) scale. The French size is a measure of the external diameter of a catheter. One French unit is equal to 0.33 millimeters, so the larger the French size, the larger the catheter. The most common tube sizes used in the adult population range from 8–24 Fr.24,25 (Figure 2). Large-bore (≥14 Fr) short-term access tubes are made of a stiff polyvinyl material, are less likely to clog, and are easier and more reliable when aspirating gastric contents. Small-bore (8–12 Fr) tubes are made of silicone, polyurethane, or a mixture and are softer and more comfortable for the patient but are more prone to clogging and more difficult to use for aspiration of gastric contents.26

Oro/Nasoenteric

Oroenteric and nasoenteric feeding tubes may be used as short-term access (<4 weeks’ duration) until more definitive measures are implemented. They can also provide opportunities to assess patient tolerance of EN prior to placement of permanent feeding tubes. Oroenteric (ie, orogastric) tubes are limited by patient discomfort and are better tolerated in intubated and sedated or chemically paralyzed patients. Large-bore nasoenteric tubes, when used, should be replaced with a more pliable tube of smaller diameter within 5–7 days to potentially reduce morbidity and improve patient discomfort.25

Oroenteric and nasoenteric feeding tubes can be placed at the bedside or using endoscopic or fluoroscopic techniques. Complications that may arise from oroenteric or nasoenteric tube placement include epistaxis, sinusitis, esophageal perforation, and unintentional placement into the bronchopulmonary tree. Bedside placement of nasoenteric (gastric or small bowel) feeding tubes can be achieved without the use of technology, however, use of an electromagnetic tube placement device has demonstrated success rates as high as 90%.27-29 Achieving placement within the jejunum is most reliably achieved with endoscopic or fluoroscopic techniques. As a rule, confirmation of the feeding tube tip position should be obtained prior to the initiation of enteral support.18,25

Contraindications to short-term enteral access include certain patterns of facial fracture, obstruction of the GI tract distal to the site of access, esophageal varices or diverticula for risk of bleeding, head and neck cancers, and upper GI tract strictures so narrow that a tube cannot be passed through it. Disease-related or medication-induced coagulopathies should trigger heightened awareness for complication but generally do not preclude placement.25,26

Enterostomy

For long-term enteral access (>4 weeks’ duration), percutaneous feeding tubes can be placed using surgical, endoscopic, fluoroscopic, and radiologic techniques. These tubes are typically made of silicone or polyurethane with a diameter of 14–28 Fr, with the exception of percutaneous endoscopic jejunostomies, which are 8–12 Fr.24 Anatomic alterations, presence of ostomy sites or drain tubes, or surgical scars may alter the location for tube insertion. Once placed, percutaneous endoscopic gastrostomy tubes may be used for feedings within 2 hours in the adult population.26 Contraindications to placement include presence of ascites, neutropenia, peritonitis, and neoplastic, inflammatory, or infiltrative disease of the gastric/abdominal wall.31

Complications from surgically placed tubes may include bleeding, peristomal leakage, skin and soft tissue infection, incisional hernia, injury to intra-abdominal viscera, and complications associated with general anesthesia. Delayed complications may include buried bumper syndrome, gastric ulcers, fistulas, and tumor tract seeding.26 Most bumper-type tubes will need to be replaced every 1–2 years, or earlier if breakage, occlusion, or dislodgement occurs. Balloon-type tubes, which are filled with 5–10 mL of sterile water, are often used after the removal of a bumper-type tube. To prevent balloon deflation due to water leakage, the balloon water volume should be checked every week. Due to degradation of the balloons, this type of tube requires replacement every 3–4 months.26

Gastric vs Small Bowel Access

Gastric access is appropriate in most cases, as it allows for more normal nutrient digestion and absorption and more versatility in feeding regimen. Feeding into the stomach stimulates the gastric phase of digestion and does not bypass any potential sites for nutrient absorption. Small bowel feeding access may

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**Figure 2.** Common French sizes of adult enteral access devices.
be achieved by passing a feeding tube past the pylorus (duodenal placement) or past the Ligament of Treitz (jejunal placement) and is most appropriate for patients with gastric outlet obstruction, gastroparesis, gastric fistula, pancreatitis, and known reflux and aspiration of gastric contents. Although several studies have demonstrated no difference in aspiration risk between intragastric and small bowel feeding, small bowel feeding has been promoted as a means to avoid aspiration.

**Maintaining Patient Safety**

Patient safety should always be considered when providing medical therapies, including the provision of EN. Two unique issues that clinicians encounter in the hospital setting are patient-initiated device removal and the high potential for enteral misconnections. It is important for all members of the healthcare team to be aware of the risk factors for both and to employ prevention strategies to avoid patient harm.

The frequency of nasogastric tube removal has been reported to be 28.9%, the highest rate among all removed devices. Patient characteristics found to be closely associated with tube removal include disorientation, restlessness, agitation, and anxiety. Premature discontinuation of therapeutic devices, including nasoenteric and percutaneous enterostomy devices, may result in patient harm or injury. Of particular concern is if inadvertent removal occurs before stoma tract maturation, which usually occurs within 7–10 days. If the stoma tract is not mature, the replacement tube cannot be reintroduced through the same tract but, rather, near the original site to maintain apposition of the stomach to the abdominal wall. In addition to the harm that can be caused by tube displacement itself, lack of enteral access can contribute significantly to feeding delays, preventing the patient from receiving adequate nutrition delivery. Several strategies have been proposed to prevent self-initiated device removal including taping nasoenteric tubes to the patient’s face, inserting nasal bridles to secure nasoenteric tubes, and using hand mittens or restraints. For combative patients with enterostomies, abdominal binders can be useful adjuncts following placement to prevent them access to their tube. Some institutions employ constant observers to watch patients to maintain patient safety.

An enteral misconnection is “an inadvertent connection between an enteral feeding system and a non-ental system such as an intravascular line, peritoneal dialysis catheter, tracheostomy, medical gas tubing, etc.” More than 116 cases of enteral misconnections were reported between 1972 and 2010, and they continue to occur. Inadvertently delivering EN through an intravenous system is a very serious event that can result in patient death from embolus or sepsis. Both human factors and physical and design factors have been identified as contributors to enteral misconnections. Human factors include time constraints, fatigue, inadequate training, less than optimal room lighting, and patient transfers. Physical and design factors include the use of universal connectors (ie, Luer connectors), which allow connection between many types of therapeutic devices, as well as inadvertent disconnection. In 2006, the Joint Commission issued a sentinel event alert regarding tubing misconnections and urged product manufacturers to implement “incompatibility by design” features for small-bore connectors. Since then, a new standard for small-bore connectors has been developed, and changes to the EN delivery system have already been set in motion. On the nutrition end, a cross-spike unique to EN (“nutrition source connector”) has been developed and in use since 2012. On the patient end, a new ENFit connector (“patient access connector”) has been developed for enteral administration sets, enteral syringes, and enteral feeding tubes. To improve patient safety, the ENFit connector will not allow connectivity with any other therapeutic devices, will provide a locking feature to prevent disconnections, and will have a female connector that will fit only into a new male patient-access feeding tube port.

**Enteral Formula Selection**

Commercially prepared enteral formula emerged in the late 1960s and has undergone many changes in formulation since its inception. Today, more than 100 enteral formulas are available for use in the United States and vary greatly with respect to concentration, macronutrient and micronutrient composition, fiber content, and the addition of pharmacologically active substances intended to modulate the immune response. A detailed review of enteral formula components and considerations for use was recently published; a summary is provided in Table 1. Efficacy studies are not required before enteral products can be manufactured and used in patient care because they cannot be promoted as medications to treat specific diseases. To maintain patient safety and prevent complications of bacterial contamination, proper use of administration sets and formula storage should also be taken into consideration when selecting an enteral formula.

**Nutrient Composition of Enteral Formulas**

The concentrations of enteral formulas range from 1–2 kcal/mL. Formulas with the lowest concentration are approximately 85% water and have an osmolality closer to that of the body’s intracellular and extracellular fluids (285–290 mOsm/kg). These formulas may be useful in patients with diarrhea to prevent osmotic-induced dumping. Formulas with the highest concentrations are approximately 70% water and may be used in patients requiring a fluid restriction secondary to conditions such as congestive heart failure, renal failure, liver failure, syndrome of inappropriate antidiuretic hormone, or hypervolemic hyponatremia.

Carbohydrates represent the primary macronutrient in most enteral formulas and are usually provided in the form of corn syrup solids, hydrolyzed corn starch, and maltodextrin. Some
formulas may contain sucrose or fructose as well. Most enteral formulas do not contain lactose and are gluten free.

Protein can be provided in various forms including intact or hydrolyzed proteins from soy, casein, and whey, or as crystalline amino acids. Formulas containing hydrolyzed proteins and amino acids are often termed semi-elemental and elemental, respectively. Although they are marketed as being more easily digested and better tolerated, the superiority of elemental vs polymeric formulas has not been clearly demonstrated as there is limited research in this area. However, hydrolyzed protein formulas may be considered in patients with persistent diarrhea, pancreatic disease, or other malabsorptive conditions.22

Fat is provided in enteral formulations as long-chain fatty acids (LCFAs) obtained from corn, soybean, sunflower, and safflower oils, as medium-chain triglycerides (MCTs) from palm kernel and coconut oil, or as structured lipids that combine LCFAs and MCTs on the same molecule. Some formulas also contain eicosapentaenoic acid and docosahexaenoic acid from fish oil. It is important to note that although MCTs do not require bile salts or pancreatic enzymes for digestion and are metabolized at the cellular level without the assistance of carnitine, they do not provide a source of essential fatty acids and must be used in combination with LCFAs.

Most enteral formulas have been designed to meet the DRI for vitamins and minerals in a volume of 1–1.5 liters per day. If the minimum volume required to meet the DRI is not consistently being provided, supplemental vitamins and minerals may be required. On the other hand, some formulas contain increased amounts of certain vitamins or minerals. It is important that the clinician pays particular attention to the amount of vitamins and minerals being provided by all sources to avoid the consequences of inadequate or excess intake.

Whereas some enteral formulas are fiber free, many contain fiber in differing types and amounts to promote the health of the GI tract and maintain regular bowel function. Insoluble fiber acts as a bulking agent, increasing the speed at which stool moves through the intestines, whereas soluble fiber keeps the stool soft by absorbing water.48 Common sources of fiber include soy fiber and guar gum. Many also contain prebiotics

### Table 1. Categories of Commercially Prepared Enteral Formulas and Modular Products.

<table>
<thead>
<tr>
<th>Formula Type</th>
<th>Characteristics and Variations</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymeric</td>
<td>Contains whole protein as the nitrogen source. Content can vary greatly in terms of caloric density, macronutrient distribution, amount and type of fiber added, and vitamin, mineral, and electrolyte composition.</td>
<td>Suitable for patients with normal or near normal functioning bowel (ie, no significant malabsorptive disorders).</td>
</tr>
<tr>
<td>Hydrolyzed or “predigested”</td>
<td>Proteins are hydrolyzed to peptides (peptide based), amino acids (elemental), or a combination of both (semi-elemental).</td>
<td>Suitable for patients with extensive impairment of gastrointestinal function (ie, significant malabsorptive disorders such as persistent diarrhea, pancreatic disease, or significant gastrointestinal resection). Not intended for routine use.</td>
</tr>
<tr>
<td>Disease specific</td>
<td>Content can vary greatly in terms of caloric density, macronutrient distribution, amount and type of fiber added, and vitamin, mineral, and electrolyte composition.</td>
<td>Use of some disease-specific formulas (pulmonary, diabetic, and hepatic) is not currently supported by strong research. Efforts should be made to avoid overfeeding.</td>
</tr>
<tr>
<td>Immune modulating</td>
<td>Contain any combination of pharmacologically active substances such as arginine, glutamine, ω-3 fatty acids, γ-linolenic acid, nucleotides, or antioxidants. Can be polymeric or hydrolyzed. Content can vary greatly in terms of caloric density, macronutrient distribution, amount and type of fiber added, and vitamin, mineral, and electrolyte composition.</td>
<td>Intended to modulate immune function. Designed with appropriate physiologic rationale for specific patient populations, but due to conflicting outcomes data, use should be determined on a case-by-case basis.</td>
</tr>
<tr>
<td>Modular products</td>
<td>Contain predominantly 1 nutrient.</td>
<td>Consider the size of the enteral access device as some modular products may increase risk of tube occlusion. Ensure adequate flushing before and after administration of modular products.</td>
</tr>
</tbody>
</table>
in the form of fructooligosaccharides, oligofructose, or inulin. Manufacturers have also developed unique blends of fiber with the theoretical intention of improving gut flora. The overall fiber content of most enteral formulas is well below the recommended 14 g/1000 kcal to achieve daily intakes of 25–38 g/day. It has been recommended to avoid the use of fiber-containing products in hypotensive patients at high risk for developing ischemic bowel and patients with severe dysmotility.22

**Enteral Additives and Modular Products**

Enteral formula can only be provided “as is.” Although there are many different products on the market, it is not possible for institutions to maintain a supply of them all. Therefore, a clinician’s ability to meet the needs of all patients using the institution’s formulary may be limited. For some patients, their “ideal” formula may not even exist. In these situations, the use of modular products, which are administered separately from the enteral formula, can be helpful. More than 20 modular products are available in the United States. The largest component of each modular product is usually a single nutrient. Protein modulars are used most frequently, compared with fat or carbohydrate modulars, to help meet the protein needs of hypermetabolic or hypercatabolic patients or those with excessive losses through wound exudate, fistula effluent, or therapies such as continuous renal replacement therapy. Fiber additives are also commonly used to help manage stool frequency and consistency in the hospital setting.

**Regulatory Standards**

It is important to note that enteral formulas are considered medical foods by the U.S. Food and Drug Administration (FDA), defined as “a food which is formulated to be consumed or administered enterally under the supervision of a physician and which is intended for the specific dietary management of a disease or condition for which distinctive nutritional requirements, based on recognized scientific principles, are established by medical evaluation.”49 Although medical foods must comply with all applicable FDA requirements for foods, they are exempt from the labeling requirements for health claims and nutrient content claims. Because the research of disease-specific formulas with regard to improved clinical outcomes is limited, it is important for the clinician to avoid using the patient’s medical condition alone to guide enteral formula selection.

**Food Allergies, Sensitivities, and Strict Dietary Practices**

It is important for the clinician to keep in mind each patient’s food allergies, sensitivities, and dietary practices when choosing an enteral formula. As mentioned previously, most enteral formulas do not contain gluten or lactose due to the commonality of gluten and lactose intolerance in the adult population. For patients with food allergies such as egg, corn, casein, whey, and soy, the clinician should refer to the most recent product label, as ingredient lists may change due to product reformulation and/or different suppliers providing ingredients for the products. Most manufacturers will include on the product label whether it is suitable for halal or kosher practices. For vegan patients, attention should be paid to the list of ingredients to ensure that the source of protein is derived from soy rather than whey or casein.

**Administration Sets and Hang Time**

According to manufacturer guidelines, the hang time for sterile formula in a closed system (eg, ready-to-hang bottles or bags of formula) is 24–48 hours, whereas the hang time for a sterile formula in an open system (eg, formula poured into an administration set) is 8 hours for hospitalized patients and 12 hours for patients in the home setting.30 Any nonsterile formula (eg, powder formula) that needs to be reconstituted by mixing with sterile water should hang for no more than 4 hours; if not used immediately, reconstituted formula can be refrigerated for up to 24 hours after preparation.30 Open-system enteral administration sets should be changed every 24 hours in the hospital setting to prevent unacceptably high levels of bacteria from accumulating in the tubing.50,51 Due to the increased nursing time required to change enteral formula systems more frequently and the reduced risk of contamination, many institutions prefer to use closed-system enteral formulas as much as possible. Additions to closed-system containers are to be avoided.22

**Initiation and Advancement**

EN may be administered in a variety of ways, and the method of administration can strongly affect the success of EN therapy. To determine the most appropriate method of administration, the clinician should consider the patient’s age, preexisting and current medical condition(s), nutrition status and requirements, the location of the feeding tube tip, and the patient’s expected tolerance.

A study by Desachy et al52 compared the initial efficacy and tolerability of early EN with immediate vs gradual introduction of optimal flow rate among 100 shock-free intubated and mechanically ventilated patients. In the immediate optimal flow group, EN was initiated at the rate corresponding to 25 kcal/kg/day (average 75 mL/hour). In the gradual introduction group, EN was initiated at a flow rate of 25 mL/hour and increased in increments of 25 mL/hour every 24 hours until the rate corresponding to 25 kcal/kg/day was reached (average of 76.5 mL/hour). Patients in the immediate group received a significantly higher amount of calories compared with those in the gradual group, with no differences in the rates of diarrhea or suspected aspiration pneumonia. The authors concluded that
EN can be introduced at the optimal dose regimen in select patients. Patients who may benefit from more conservative initiation and advancement of EN include patients who have not been fed for an extended period of time; have not received enteral nutrients in a long time; are hemodynamically unstable, requiring vasopressors or inotropic agents; are chemically paralyzed; have recently undergone a significant bowel resection, temporary abdominal closure, or multiple abdominal re-explorations; or who have bowel wall edema.26

**Delivery Methods**

Continuous feeding is commonly used for the adult hospitalized patient requiring EN therapy and is achieved via pump assist. The goal infusion rate is determined by dividing the desired formula volume by the number of hours of administration. Because of the frequency with which enteral feeds are interrupted in the hospital setting, resulting in delivery of only 50%-60% of prescribed EN volume on a daily basis, some institutions have implemented a volume-based feeding protocol to ensure that the volume of EN prescribed to their patients is actually provided.53,54 To allow for time away from feeding, intermittent or bolus feedings may be used. Bolus feedings are defined as formula delivered by gravity-assist or syringe over approximately 15 minutes, whereas intermittent feedings are usually delivered over 30–45 minutes via gravity assist or pump assist.55 These feeding methods are usually reserved for medically stable patients with feeding tubes terminating in the stomach. Volumes typically range from 240–720 mL per feeding, depending on individual tolerance, with a frequency from 2–6 times daily. Hospitalized patients may transition from 1 delivery method to another as their clinical status changes. Sample calculations are provided in Figure 3.

**Refeeding Syndrome**

The term refeeding syndrome is generally reserved to describe the metabolic alterations that occur during nutrition repletion of severely malnourished or starved individuals in amounts greater than a weakened cardiopulmonary system can accommodate.87,88 Hypophosphatemia is considered the hallmark of refeeding syndrome, although other clinical manifestations include hypokalemia, hypomagnesemia, thiamin deficiency, and sodium retention/fluid overload. Clinicians should always consider the patient’s nutrition status when initiating EN, as this can help determine the patient’s risk of developing metabolic alterations that could potentially lead to multiorgan system dysfunction and even death.39 Patients most at risk for refeeding syndrome include those with minimal intake for > 7 days with evidence of metabolic stress; significant weight loss; undernutrition as a result of chronic disease(s); anorexia nervosa; persistent nausea, vomiting, or diarrhea; malabsorptive conditions; or history of excessive alcohol intake.56,87,90 Although clinicians could be inclined to believe that refeeding is unlikely among an increasing percentage of overweight and obese patients, coupled with modern practices of conservative energy provision, the prevalence of acute and chronic disease-related malnutrition renders refeeding syndrome a very real
Table 2. Complications in Enterally Fed Patients and Prevention/Treatment Strategies.

<table>
<thead>
<tr>
<th>Complication</th>
<th>Cause</th>
<th>Prevention/Treatment</th>
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| Refeeding syndrome      | • Rapid reintroduction of carbohydrates during nutrition repletion in severely malnourished or starved individuals | • Correct electrolyte abnormalities prior to initiation and during delivery of nutrition  
|                         |                                                                       | • Start and increase calorie provision conservatively over the course of 5–7 days       
|                         |                                                                       | • Minimal initial fluid and sodium provided                                           
|                         |                                                                       | • Supplement with 50–100 mg intravenous/oral thiamin for 5–7 days                      |
| Nausea/vomiting         | • Motion sickness                                                     | • Provide an anti-emetic regimen                                                      |
|                         | • Emotional stress                                                    | • Use prokinetic agents to increase gastric motility                                  |
|                         | • Headaches or migraines                                             | • Reduce, replace, or discontinue medications that delay gastric emptying             |
|                         | • Indigestion                                                        | • Consider a low fat, isotonic, or more calorically dense formula                     |
|                         | • Delayed gastric emptying                                           | • Ensure enteral formula and water flushes are delivered at room temperature          |
|                         |                                                                       | • Temporarily reduce the enteral infusion rate by 20–25 mL/hour or extend the infusion time of cycled or intermittent feeds |
| Aspiration pneumonia    | • Contaminated oropharyngeal secretions                              | • Obtain postpyloric enteral access                                                  |
|                         |                                                                       | • Elevate head of bed 30–45 degrees, especially while providing enteral nutrition      |
|                         |                                                                       | • Provide subglottic suctioning, drain condensate from ventilator circuits, and provide chlorohexidine oral rinse as appropriate |
|                         |                                                                       | • Achieve adequate glucose control                                                  |
|                         |                                                                       | • Avoid unnecessary antibiotics                                                     |
| Diarrhea                | • Medications                                                        | • Discontinue or reduce dose of offending medication, or replace with alternative non-diarrhea-causing medication |
|                         | • Infections, illness severity, and disease states                   | • Change from liquid solution to tablet form or dilute hypertonic medications         |
|                         | • Bacterial contamination                                            | • Identify and treat underlying medical/surgical issues and infections                |
|                         | • Enteral formula                                                    | • Consider adjusting the type of formula depending on disease state to prevent malabsorption |
|                         |                                                                       | • Use a clean, aseptic technique when handling the feeding system                    |
|                         |                                                                       | • Use sterile, liquid formula formulations over powder, reconstituted formulas when possible |
|                         |                                                                       | • Limit formula hang time, especially when using an open system                     |
|                         |                                                                       | • Provide education and training on policies, procedures, and practices associated with preparing, storing, and administering enteral formula |
|                         |                                                                       | • Adjust fiber type and/or amount provided; consider decreasing insoluble fiber or increasing soluble fiber |
|                         |                                                                       | • Consider an isotonic formula or slower infusion rate                              |
|                         |                                                                       | • Try a peptide-based formula or one with a higher percentage of fat from medium chain triglycerides or structured lipids |
|                         |                                                                       | • Ensure that the formula, modulators, and water flushes are room temperature        |
| Constipation            | • Medications                                                        | • Adjust medications that decrease gastrointestinal motility                          |
|                         | • Laxative abuse                                                     | • Add or adjust bowel regimen                                                        |
|                         | • Inadequate fluid or fiber intake                                   | • Use fiber-containing enteral formulas if no contraindication exists                 |
|                         | • Neuromuscular, hypothyroid, and gastrointestinal disorders         | • Increase amount of free water provided                                              |
|                         | • Lack of physical activity                                         | • Promote ambulation as able                                                        |

(continued)
Table 2. (continued)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Cause</th>
<th>Prevention/Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ileus <em>22,76-81</em></td>
<td>• Electrolyte imbalances</td>
<td>• Correct electrolyte abnormalities</td>
</tr>
<tr>
<td></td>
<td>• Major lower gastrointestinal surgeries</td>
<td>• Consider initiating early enteral nutrition in setting of a mild to moderate ileus</td>
</tr>
<tr>
<td></td>
<td>• Delayed enteral nutrition</td>
<td>• Limit sedatives and paralytic agents as much as possible</td>
</tr>
<tr>
<td></td>
<td>• Inflammation</td>
<td>• Flush enteral devices with 20–30 mL of warm water every 4 hours during continuous feeds and before and after intermittent feedings and medications</td>
</tr>
<tr>
<td></td>
<td>• Medications</td>
<td>• Avoid flushing enteral access devices with carbonated beverages and juices</td>
</tr>
<tr>
<td>Clogged feeding tube <em>18,82-86</em></td>
<td>• Suboptimal flushing techniques</td>
<td>• Minimize contact of liquid medications with enteral formula or crush tablets into a fine powder before mixing with water</td>
</tr>
<tr>
<td></td>
<td>• Improper medication administration</td>
<td>• Avoid frequent checking of gastric residual volumes</td>
</tr>
<tr>
<td></td>
<td>• Precipitation of enteral formulas by gastric acid</td>
<td>• Reference manufacturer recommendations to ensure the enteral formula being used is compatible with the patient’s enteral access device</td>
</tr>
<tr>
<td></td>
<td>• Small-bore feeding tubes</td>
<td>• Treat clogged tubes with a warm water flush with moderate pressure, activated enzyme solutions, or an approved declogging device</td>
</tr>
<tr>
<td></td>
<td>• Formula composition</td>
<td>• Replace enteral access device</td>
</tr>
</tbody>
</table>

possibility. Based on case reports, refeeding syndrome can manifest itself up to 5 days after the initiation of feedings.88

A variety of strategies have been suggested to prevent the deleterious effects of refeeding syndrome. Any serum electrolyte abnormalities should be corrected prior to initiation of nutrition. Calorie provision should be started and increased conservatively, although recommendations vary. Common recommendations include starting energy intake at 15–20 kcal/kg/day, 1000 kcal/day, or 50% of estimated needs and gradually increasing to goal amounts over 5–7 days, keeping in mind that the minimum carbohydrate requirement to suppress gluconeogenesis, spare proteins, and supply fuel to the central nervous system is approximately 100–150 g/day.58 The amount of fluid and sodium initially supplied should be minimized because of the expansion of the extracellular water compartments and the propensity to retain these during initial refeeding. Serum values of sodium, potassium, magnesium, and calcium should be monitored daily during the first week and replaced as indicated. Last, because thiamin is an essential cofactor in the metabolism of carbohydrate, supplementation in the range of 50–100 mg/day intravenously or 100 mg orally for 5–7 days is recommended for patients at risk for refeeding.87

Nausea/Vomiting

There are many causes of nausea and vomiting, which are often quite similar. Common causes include motion sickness, emotional stress (fear), headaches or migraines, indigestion, food poisoning, various viruses, and certain smells or odors. The most common cause of nausea and vomiting, especially in critically ill patients, appears to be delayed gastric emptying.59

Risk factors for delayed gastric emptying include hyperglycemia, illness severity, low Glasgow Coma Score, elevated intracranial pressure, traumatic brain injury, recent anesthesia or surgery, surgical vagotomy, use of certain medications (eg, opiates, analgesics, anticholinergics), rapid infusion of formula, and the use of a high fat formula.59,62,91

Nausea and vomiting have been reported in up to 26% of patients receiving EN therapy.63 Usually, these symptoms can be successfully managed without needing to initiate parenteral nutrition. Anti-emetic medications can help manage nausea quite effectively if scheduled on a regular basis. Prokinetic agents such as metoclopramide and erythromycin can increase gastric motility and are especially effective when used in combination.92 If delayed gastric emptying is suspected, other interventions may include reducing, replacing, or discontinuing opiates, analgesics, and anticholinergics. Adjustments to the EN formula or regimen should also be considered, if possible. Strategies may include changing the enteral formula to one that is low in fat, isotonic, or more calorically dense, ensuring that enteral formula and water flushes are being administered at room temperature, temporarily reducing the rate of enteral infusion by 20–25 mL/hour, extending the infusion time of cycled or intermittent feeds, and obtaining postpyloric enteral access.59,60,63,91

Gastric Residual Volume and Aspiration Pneumonia

Historically, gastric residual volumes (GRV) have been used to assess tolerance to EN and determine one’s risk for aspiration/aspiration pneumonia. This practice remains controversial as neither the practice nor the method of checking GRV itself is
validated. Limitations to accurate measurement include the position of the patient, type and size of the syringe used, and the size, material, and position of the tip of the feeding tube. In addition, the quality (color, consistency) and composition of gastric volumes are rarely differentiated and may include recently administered medications and water flushes rather than undigested formula alone.

Pneumonia and bacterial contamination of the respiratory tract are often caused by aspiration of contaminated oropharyngeal secretions originating from the upper airway, teeth, artificial airway, ventilator-circuit condensate, or nasal sinuses. Additional data suggest the relative importance of oropharyngeal colonization over gastric colonization in the development of ventilator-associated pneumonia. Nonnutrition prevention strategies, therefore, include (but are not limited to) adequate handwashing and hand disinfection; head of bed elevation of 30–45 degrees especially while receiving EN; scheduled drainage of condensate from ventilator circuits (if applicable); subglottic suctioning; chlorhexidine oral rinse in selected patients; avoidance of unnecessary antibiotics; and insulin therapy to maintain serum glucose levels within the desired range.

Regarding GRV, the results of several studies have demonstrated that a lower GRV cutoff value of 50–150 mL compared with a higher cutoff of 250–500 mL does not decrease the risk of regurgitation, aspiration, or pneumonia but instead increases the unnecessary withholding of EN. It has been recommended that interruption of EN should be avoided for GRV < 500 mL in the absence of other signs and symptoms of intolerance (nausea, vomiting, bloating, abdominal discomfort or distention) but that close monitoring is warranted in patients with gastric residuals between 200 and 500 mL, ensuring that all measures to reduce aspiration risk are initiated. Recently, results from a large randomized controlled trial suggest no beneficial effect of monitoring GRV at all; however, these results represent primarily a medical population with a low incidence of GI disorders. Although GRV may not be useful in determining aspiration risk, it remains a simple and insightful tool to help clinicians detect early signs of GI dysfunction, thereby allowing for timely intervention. Figure 4 provides an example of an algorithm designed to manage GRV and optimize patient tolerance to EN.

**Diarrhea**

Diarrhea is a serious condition and can cause electrolyte abnormalities, dehydration, loss of nutrients, fecal incontinence leading to skin breakdown, malabsorption from increased transit time, and inadequate nutrient intake from pausing or stopping EN. The incidence of diarrhea in the hospital setting is difficult to determine given the lack of a standardized definition and wide range of

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**Figure 4.** Sample algorithm for managing gastric residual volumes. EN, enteral nutrition; GRV, gastric residual volume; HOB, head of bed.
It has been reported that diarrhea occurs in 30% of patients on medical and surgical floors and > 80% of patients in intensive care units. In tube-fed patients alone, the incidence of diarrhea ranges from 11.3%–66.1%, depending on the definition used. Definitions of diarrhea often include frequency of bowel movements of 3 or more watery or loose bowel movements in a 24-hour period, or stool weight of > 200 g/day. Descriptive terms such as passage of loose, unformed stool or the presence of both abnormal stool frequency and liquid consistency are also used. Although diarrhea is a commonly reported side effect of EN, it can also be caused by many other factors in the hospitalized patient. Traditionally, diarrhea is categorized as motility-related, malabsorptive, inflammatory/exudative, secretory, or osmotic (Table 3). Therefore, managing diarrhea in the enterally fed patient requires a systematic approach prior to making changes to the enteral feeding regimen. Understanding the type of diarrhea can help establish a differential diagnosis and guide treatment strategies.

Infectious etiologies and medical conditions should always be considered, evaluated, and treated appropriately if identified. Clostridium difficile infection is the most frequently identified cause of nosocomial diarrhea. The incidence and

### Table 3. Categories of Diarrhea

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Characteristics</th>
<th>Common Causes</th>
</tr>
</thead>
</table>
| Dysmotility           | Altered gastric, small bowel, or colonic motility causing rapid transit time or increased intestinal motility | • Alternating between constipation and diarrhea  
• Improvement overnight or when fasting  
• Intermittent, nonlocalizing abdominal pain  
• Sensation of incomplete evacuation after bowel movement | • Diabetic neuropathy  
• Hyperthyroidism  
• Irritable bowel syndrome  
• Postsurgical (gastrectomy, vagotomy) |
| Inflammatory or exudative | Impaired water and electrolyte absorption due to intestinal inflammation | • Elevated white blood count  
• Presence of mucus, blood, and/or plasma proteins in stool | • Intestinal lumen damaged (graft-vs-host disease, radiation enteritis)  
• Small bowel disorders (Crohn’s disease, ulcerative colitis) |
| Malabsorptive         | Damage to or loss of absorptive ability causing malabsorption of nutrients   | • Bloating  
• Excess gas  
• Steatorrhea  
• Weight loss | • Gastric bypass surgery  
• Pancreatic insufficiency or disease  
• Short bowel syndrome  
• Small bowel bacterial overgrowth  
• Small bowel mucosal diseases (celiac sprue) |
| Osmotic               | The bowel is unable to reabsorb fluid as it passes through the intestinal lumen due to the presence of nonabsorbable, osmotically active solutes | • Decreased stool with fasting or withholding the poorly absorbed substrate  
• Fecal osmotic gap > 50 mOsm/kg  
• Stool volume of < 1 liter daily (usually proportionate to the offending substrate) | • Bowel resection or villi and brush border atrophy  
• Incomplete breakdown or malabsorption of nutrients in small intestine (lactose, hyperosmolar substances, sugar alcohols, fat)  
• Medication induced (osmotic laxatives and antacids [magnesium, phosphate, sulfate], sugar alcohol containing [mannitol, sorbitol, xylitol]) |
| Secretory             | An increase in the amount of fluid drawn into the intestinal lumen at a rate exceeding the absorptive capacity of the bowel | • Low or absent fecal osmotic gap (< 50 mOsm/kg)  
• Stool volume of > 1 liter daily  
• Unrelated with food intake or no change in stool with fasting | • Alcohol abuse  
• Bile acid malabsorption  
• Endocrine disorders (hypothyroidism)  
• Hormones secreted by neuroendocrine tumors  
• Infectious agents (Escherichia coli, Salmonella, Clostridium difficile)  
• Medication induced (antiarrhythmics, antibiotics, antineoplastics, biguanides, calcitonin, cardiac glycosides, colchicine, nonsteroidal anti-inflammatory drugs, prostaglandins, ticlopidine)  
• Postsurgical (cholecystectomy, intestinal resection) |
duration of diarrhea has also been associated with severity of illness, hypermetabolic stress, serum albumin level, decreased immunity, glucose control, white blood cell count, and peripheral oxygen saturation.106,110

Medication administration also has the potential to contribute to diarrhea. Liquid medication solutions, for example, can contain a number of poorly absorbed sweeteners (eg, sorbitol) and stabilizers, which increase the osmolality of the medication and, therefore, the potential to cause diarrhea. As little as 10–20 g/day of sorbitol has been shown to produce GI side effects (gas, cramping, bloating, and diarrhea) and doses ≥ 20 g/day can produce osmotic-induced dumping syndrome.70,111,112 A dose of 1.3–3.9 g of acetaminophen provides about 8–24 g sorbitol.67 Other medications known to cause diarrhea include antibiotics, antihypertensives, cholinergics, GI agents, glucose-lowering agents, anti-inflammatory drugs, laxatives, prokinetic agents, selective serotonin reuptake inhibitors, and chemotherapy agents.68,104,113 Discontinuing or reducing the dose of an offending medication or changing the form of the medication can help reduce medication-induced diarrhea. Addition of probiotics may attenuate diarrhea, especially if associated with antibiotic use; however, more research is needed to determine the strains and doses needed to provide benefit.22,71 Antidiarrheal medications can also be considered. After all other causes of diarrhea have been ruled out, an assessment of the EN regimen may be warranted. EN-associated diarrhea has been attributed to microbial contamination, low fiber content, and hyperosmolality of the EN formula.108 As mentioned previously, many hospitals now use closed systems of EN administration to reduce the risk of contamination. Use of soluble fiber-containing enteral formula can help reduce the incidence of diarrhea, as shown in a 2008 meta-analysis.114 Soluble fiber modular products can be used if such enteral formulas are unavailable. Slowing the formula infusion rate or changing to an iso-osmolar formula may also be beneficial,26 although the osmolality of the EN formula is not thought to be a major contributor to diarrhea in enterally fed patients with a functioning GI tract.69 For patients with maldigestion or malabsorption, the addition of a semi-elemental or elemental formula with greater percentage of fat from MCTs or structured lipids may improve tolerance.115

**Constipation**

Constipation is also common among enterally fed patients, especially the elderly and bedridden. In critically ill patients, the incidence of constipation has been reported in the range of 15%–83%.72 Many definitions of constipation exist, although most consistently identify infrequent and difficult defecation as defining characteristics.114 The main causes of constipation among patients receiving EN are medications (benzodiazepines and opioids being the most common), inadequate fluid intake or dehydration, inadequate fiber intake, and lack of physical activity.67,73,112 Other causes of constipation include neuromuscular disorders, hypothyroid disorders, GI motility disorders, and history of laxative abuse.112 Constipation can cause abdominal distension or bloating, vomiting, fecal impaction, and bowel perforation, therefore increasing the need for nursing, medical, and/or pharmaceutical interventions.74 For these reasons, constipation has been associated not only with feeding intolerance and delays in EN therapy but also with difficulty weaning from mechanical ventilation in critically ill patients, longer length of ICU stay, and decreased quality of life.73-75

Management of constipation in the enterally fed patient may include adjustments in fiber, fluid, and/or medications with the goal of restoring normal bowel function and decreasing symptoms related to constipation. Use of fiber-containing enteral formulas can help to normalize bowel function and reduce the need for laxatives.114,116 To minimize constipation associated with increased fiber intake, at least 1 mL/kcal of fluid is required.48 It is worth noting that the use of concentrated enteral formulas will likely require large water flush volumes to meet this fluid requirement. If constipation does not improve with increased fiber intake, or if fluid restriction is warranted due to other medical conditions such as congestive heart failure or renal disease, stool softeners, laxatives, and/or enemas may be required to manage and prevent constipation. Other patients who may require a scheduled bowel regimen include those receiving medications that decrease GI motility (eg, sedatives or opioids)75 or who are unable to ambulate.

**Ileus**

The presence or absence of bowel sounds is often used to determine whether the GI tract is functional and may therefore determine EN initiation or delay.117 However, bowel sounds do not always correlate with normal bowel function. In the setting of ileus, for example, bowel sounds can range from hypoactive to nonexistent, but in the setting of an obstruction, bowel sounds may become louder, high-pitched, or even hyperactive.118 The lack of peristalsis, which characterizes ileus, leads to the accumulation of both gas and fluids within the bowel, causing abdominal distension, nausea, and/or vomiting if gastric decompres- sion is not provided.76,77,118 Ileus occurs in 24%–75% of postoperative patients and 50%–80% of critical care patients.77 Major lower GI surgeries are the most common cause of an ileus, and other risk factors include infection and inflammation, electrolyte imbalances, delayed EN, and the certain use of drugs (sedatives, opioid analgesics, alpha-2 adrenergic receptor agonists, and catecholamine vasopressors).72,76,119,120

After surgery, small bowel, gastric, and colonic motility are regained within 24 hours, 1–2 days, and 3–5 days, respectively.79,119 Nutrition is commonly withheld in this population, or provided parenterally, until return of bowel function due to concern that
the digestive tract will not tolerate feedings following the manipulation experienced during surgery and anesthesia. However, the presence of enteral nutrients initiates intestinal propulsive activity and stimulates the secretion of various intestinal hormones, which have a positive effect on GI motility. An early study showed that EN can be safely initiated immediately postoperatively with ileus resolving within 48 hours. Other studies have shown quicker return of bowel function with early enteral feeding. For these reasons, guidelines support feeding through mild to moderate ileus.

### Clogged Feeding Tubes

All feeding tubes are subject to mechanical complications such as occlusion/clogging, for a variety of reasons. Usual causes include suboptimal flushing techniques, improper medication administration, precipitation of enteral formulas by gastric acid (protein denaturation), and use of small-bore feeding tubes. High-fiber and calorically dense formulas have also been identified as risk factors for tube occlusion.

To prevent clogging, several strategies may be employed. Enteral access devices should be flushed with 20–30 mL of warm water every 4 hours during continuous feeding, before and after intermittent feeding, and before and after medication administration. Although liquids have long been considered the preferred medication formulation selected for administration via enteral feeding tubes, many are acidic. It is therefore important to minimize contact with EN formulas as these acidic fluids have a high potential to contribute to tube occlusion. If no other alternatives are available, tablets should be crushed to a fine powder before mixing with water to avoid accumulation of pill fragments within the tube. Frequent checking of GRVs should be avoided when possible to reduce the likelihood of tube occlusion from precipitation of the enteral formula. In general, most adult enteral formulas are manufactured to allow smooth flow through enteral tube diameters as small as 8–12 Fr, although it is best to reference the manufacturer’s recommendations when choosing an enteral formula to ensure that it is compatible with your patient’s enteral access device.

Once an enteral access device has become occluded, the clinician must either remove and replace the device or remove the clog. Several methods for restoring tube patency have been described. In general, a warm water flush with moderate pressure is recommended as the first-line treatment for clogged feeding tubes. If this is not successful, activated enzyme solutions can be used. Carbonated beverages and juices such as cola and cranberry juice, respectively, are not recommended due to their acidity and the potential to cause subsequent occlusions. Several declogging devices are also available, including the Intro-Reducer (Health Improvement Associates, Freeland, MI, USA), the Clog Zapper (CorPak MedSystems, Buffalo Grove, IL, USA), and the DeClogger (Bionix, Toledo, OH, USA). If all attempts to restore patency to an existing enteral access device fail, the clinician must replace the device.

### Drug-Nutrient Interactions

A drug-nutrient interaction involves alteration of the kinetics (absorption, metabolism, disposition, or elimination) or dynamics (clinical/physiological) of a drug or nutrition element or a compromise in nutrition status as a result of the action or side effect of a drug. There is no universal approach to the management of drug-nutrient interactions in clinical practice, however, several drugs are commonly thought to require cessation of EN for up to 1–2 hours before and after administration of the drug. Among these are levothyroxine, carbidopa/levodopa, fluoroquinolones such as ciprofloxacin, warfarin, and phenytoin. The proposed mechanisms are myriad, including but not limited to protein binding, chelation interaction with divalent cations, specific nutrient content of the enteral formula, positioning of the enteral feeding tube, and adsorption to the enteral tubing. Although it is important for the clinician to be cognizant of potential drug-nutrient interactions, it is also important to consider the quality of evidence on this topic. The literature suffers many limitations including lack of prospective, randomized, controlled trials and therefore lacks strong evidence to support cessation of EN for medication administration. Furthermore, at this time there is no established consensus in determining whether a drug-nutrient interaction is even clinically significant. Holding EN for administration of medications significantly challenges the ability of the clinician to provide adequate nutrition support. Therefore, based on a risk-benefit analysis, the clinician’s approach may include changing the management approach immediately or continuing the current regimen and monitoring for therapeutic effect or signs and symptoms of complications associated with interaction. Future research should focus on determining the effect of different feeding methods and enteral formulations and validating the proposed mechanisms of specific nutrients on drug availability and metabolism.

### Transitioning to Oral Intake

Although EN is often needed during critical and acute illness, it should be discontinued when the patient can consume and tolerate adequate amounts of an oral diet. The length of time needed for this transition may vary considerably, depending on the patient’s underlying illnesses and current medical condition. If the patient was mechanically ventilated for a prolonged period of time, had a tracheostomy placed, or displays cognitive deficits, altered mental status, or signs of difficulty with swallowing, a swallow evaluation should be done prior to initiating an oral diet. Once a diet has been started, adjustments in the enteral feeding schedule can help promote appetite and oral intake while still providing adequate nutrition intake through supplemental EN. Several strategies include nocturnal feeding, intermittent feedings between meals, or stopping EN 1 hour before meals. Prior to discontinuing EN, it is important to assess the adequacy of oral energy and nutrient intake through...
food recall or a formal calorie count. When the patient is consuming 60%-75% of estimated energy and protein needs, the clinician should consider stopping EN and removing the temporary enteral access device. If the patient is unable to demonstrate adequate oral intake for > 4 weeks, a permanent feeding tube should be considered.

Transcitioning to Home or an Alternate Healthcare Setting With EN

For patients who are medically stable to discharge from the hospital but are unable to achieve or maintain adequate nutrition by the oral route, EN should be continued in the home or alternate healthcare setting. Early discharge planning and active communication with all members of the patient care team (eg, physician, dietitian, nurse, social worker, and case manager) are required for a successful transition.

The case manager can determine if the patient has appropriate insurance coverage for home EN formula and supplies. As many insurance companies follow Medicare guidelines, the patient will likely need to meet criteria under the prosthetic device benefit provision, which requires that the patient have “a permanently inoperative internal body organ or function thereof.” Specific criteria include anticipated length of therapy for > 3 months, documentation of pathology to or nonfunction of the structures that normally permit food to reach the digestive tract, or disease of the small bowel impairing digestion and absorption of an oral diet.

Prior to discharge from the hospital, the clinician should be sure that the patient has an appropriate route of administration, is receiving the appropriate enteral formula and nutrient provision, and is using an appropriate delivery method. The formula of choice and its administration should be well tolerated. The clinician should reassess all nutrition needs and verify the indication for a specialized formula, if applicable. Intermittent feedings using gravity bags or bolus feedings with syringes are the preferred method of administration for gastric feedings. If continuous gastric feedings are needed, Medicare and other third party payers require documentation of medical necessity or the failure of intermittent or bolus feedings before covering the cost of a feeding pump.

Patient and caregiver education is important to ensure safe and adequate administration of EN at home and should begin early in the discharge planning process as well. Areas of education from home EN include a comprehensive review of the nutrition prescription (eg, name of the formula and volume required, route of administration, method of administration, feeding schedule, and volume/frequency water flushes), enteral feeding equipment and techniques, and complications associated with EN therapy. The homecare agency can provide additional education once the patient is in the home setting.

Last, and of utmost importance, a primary clinician who will be responsible for ordering and managing home EN should be identified prior to patient discharge from the hospital, and the patient should follow up with this clinician soon after discharge. The patient should be monitored periodically for changes in his or her nutrition status and needs, fluid and electrolyte balance, and tube placement and maintenance.

Summary

EN support has become a routine part of the care of hospitalized patients who have a functional GI tract but are unable to meet their nutrition needs orally. All healthcare practitioners should be familiar with patient selection, timing of EN initiation, enteral access, and EN-related complications. Whereas multidisciplinary management of EN is of utmost importance, the registered dietitian is a key resource in determining individual nutrition needs, selecting the appropriate enteral formula, monitoring the adequacy of nutrient provision, and assisting with EN-related compication management and the transition to oral intake or to the home setting with EN. Due to the prevalence of hospital malnutrition and its myriad consequences including increased morbidity and mortality, longer lengths of hospital stay, and increased hospital costs, it is important to routinely monitor patients at risk for malnutrition and to initiate safe, timely, and adequate EN therapy when indicated.

Statement of Authorship

M. Kozeniecki and R. Fritzshall equally contributed to the concepts and content presented in the manuscript; drafted and/or critically revised the manuscript; and agree to be fully accountable for ensuring the integrity and accuracy of the work. All authors read and approved the final manuscript.

References


