10

Overview of Enteral Nutrition

Jennifer Doley, MBA, RD, CNSC, FAND, and Wendy Phillips, MS, RD, CNSC, CLE, FAND

CONTENTS

Hydration

Glycemic Control

Adequacy

Conclusion

References

Acknowledgments: Susan L. Brantley, MS, RD, LDN, CNSC, and Mary E. (Beth) Mills, MS, RD, LDN, CNSC, were the authors of this chapter for the second edition.

Objectives

Identify indications and contraindications for enteral nutrition (EN) in specific patient populations.

Describe factors to consider when developing appropriate EN feeding regimens.

Identify and describe methods used to assess the tolerance, efficacy, and safety of EN delivery.

Test Your Knowledge Questions

1. Which of the following is a benefit of EN compared with parenteral nutrition (PN) or no nutrition?

A. Maintenance of normal gallbladder function
B. Reduced gastrointestinal (GI) bacterial translocation
C. More efficient nutrient metabolism
D. All of the above

2. High-protein hypocaloric EN feeding providing 65% to 70% of energy needs, as determined by indirect calorimetry (IC), is recommended for intensive care unit (ICU) patients with which of the following conditions?

A. Malnutrition
B. Obesity
C. Liver failure

D. Acute respiratory distress syndrome (ARDS)

3. Risk factors for aspiration include all of the following except:
A. Malnutrition
B. Use of naso-/oro-feeding tube
C. Bolus EN feeding
D. Supine position

Test Your Knowledge Answers

1) The correct answer is D. EN provides nutrients to the small intestine, stimulating the release of cholecystokinin, which helps maintain normal gallbladder function and reduce the risk of cholecystitis. Luminal nutrients provide GI structural support and help maintain the gut-associated and mucosa-associated lymphoid tissues vital to immune function. Immunoglobulin A (IgA), which is secreted within the GI tract in response to intraluminal nutrients, can prevent bacterial adherence and translocation. Nutrients from EN more closely mimic normal oral feeding, and undergo first-pass metabolism, promoting more efficient nutrient utilization.1
2) The correct answer is B. Patients with malnutrition should receive more than 80% of their estimated nutrient needs within 48 to 72 hours of intubation. Delays in initiating and advancing EN result in greater energy and protein deficits, which may contribute to higher infection and mortality rates. Studies indicate obese patients benefit from low-calorie, high-protein feedings to minimize the metabolic complications of feeding, preserve lean body mass (LBM), and mobilize fat stores. In patients with ARDS, studies indicate no difference in outcomes between those receiving eucaloric feedings and those receiving trophic feedings.2
3) The correct answer is A. Although malnutrition may result in generalized weakness and contribute to swallow dysfunction, malnutrition by itself is not recognized as a risk factor for aspiration. Conditions that manipulate or affect the function of the lower esophageal sphincter, such as the presence of a feeding tube in the esophagus, increase the risk of reflux and thus aspiration. Bolus feedings, which increase the volume of contents in the stomach, and the supine position also increase the risk of reflux.

Introduction

Enteral nutrition is defined as “nutrition provided through the gastrointestinal tract via a tube, catheter, or stoma that delivers nutrients distal to the oral cavity.”3 The history of EN, including the first rectal feedings;4 the early “formula” mixtures of wine, eggs, milk, and other food substances;5 and the growth and use of EN as a routine intervention in modern-day critical care units can be found elsewhere.5,6 Common indications for EN include stroke and other neurologic disorders that impair swallowing ability, oral intubation for mechanical ventilation preventing oral nutrition intake, or the need to feed the gut distal to an obstruction or high-output fistula.7 A functional GI tract, with sufficient length and

absorptive capacity, is necessary for effective nutrient delivery using EN.1,8 EN can be tailored to the care setting, such as critical care and acute care units, long-term care facilities, or the home.

Enteral formulas are composed of a variety of sources of macronutrients, micronutrients, and water in different quantities to meet the individual goals of nutrition therapy. Because the formula itself may not be sufficient to meet the need for specific nutrients, additional amino acids, probiotics, vitamins, trace minerals, and fiber components may be added to EN regimens to provide specific therapeutic benefits.

The safety and efficacy of EN use has been demonstrated in several patient populations, including those with head injuries, trauma, burns, major surgery, and pancreatitis.2

Before initiating EN, clinicians should consider ethical issues, including the patient and/or family's wishes, quality of life, goals of care, and risks and benefits of nutrition therapy in the context of the patient's diagnosis, prognosis, and long-term care goals.9 See Chapter 39 for more information on ethical issues.

Benefits

When comparing alternative feeding methods for patients who cannot ingest food and fluids by mouth, EN is preferred over PN.2 Using the GI tract as much as possible for digestion and absorption of nutrients helps maintain the functional integrity of the gut. Nutrients provided via the enteral route undergo first-pass metabolism, promoting efficient nutrient utilization. The presence of nutrients in the small intestine maintains normal gallbladder function by stimulating the release of cholecystokinin, reducing the risk of cholecystitis that may occur if patients are kept nil per os (NPO [nothing by mouth]) or fed solely with PN.1

In addition to the benefit of maintaining normal digestive and absorptive capabilities, luminal nutrients provide GI structural support and help maintain the gut-associated and mucosa-associated lymphoid tissues vital to immune function. IgA, which is secreted within the GI tract in response to intraluminal nutrients, can prevent bacterial adherence and translocation. Additionally, in several prospective randomized clinical trials, EN has been shown to reduce infectious complications associated with pneumonia, sepsis, intravenous (IV) line sepsis, and intra-abdominal abscess. Finally, the provision of EN is, overall, less expensive than PN.1,10,11 Therefore, whenever feasible, EN is a superior choice to PN.

Contraindications

While EN remains the preferred route of nutrition support when feasible, there are times when use of the GI tract is contraindicated. Patients with the conditions listed in Table 10-1 may require PN instead of EN.1,8,12

TABLE 10-1 Contraindications for Enteral Nutrition

- Severe short bowel syndrome (<100–150 cm remaining small bowel in the absence of the colon or 50–70 cm remaining small bowel in the presence of the colon)
- Other severe malabsorptive conditions
- Severe GI bleed
- Distal high-output GI fistula
- Paralytic ileus
- Intractable vomiting and/or diarrhea that does not improve with medical management
- Inoperable mechanical obstruction
- When the GI tract cannot be accessed—for example, when upper GI obstructions prevent feeding tube placement

GI, gastrointestinal.

Source: Data are from references 1, 8, and 12.

Assessment

After determining whether the patient is an appropriate candidate for EN, several factors need to be assessed to make necessary decisions regarding EN initiation. Expected duration of EN therapy, feeding modality, aspiration and refeeding risk, primary diagnosis, and comorbidities will all drive decisions regarding feeding tubes, formulas and administration schedules.

Access

When choosing a feeding tube, several factors should be considered, including—but not limited to—expected duration of therapy, desired feeding location (such as stomach or small intestine), administration mode (such as continuous or bolus), and the expertise of clinicians available for feeding tube placement.

Options for short-term EN therapy include tubes inserted through the nose or mouth into the stomach, past the pylorus into the duodenum, or distal to the ligament of Treitz into the jejunum. Long-term options include gastrostomy, jejunostomy, and gastrojejunostomy tubes for patients who will require nutrition therapy for longer than 4 to 6 weeks. These tubes can be placed using percutaneous endoscopic methods; radiological methods using fluoroscopy, ultrasound, or computed tomography (CT) are also available. When possible, the least-invasive placement method should be used; however, open or laparoscopic surgical placement may be necessary or convenient if another abdominal surgery is already being performed.

Clinical factors may influence the choice of feeding tube. Patients who are awake and alert often prefer small-bore, flexible tubes to limit discomfort. These tubes may reduce the risk of upper GI bleeding and therefore may be appropriate for patients who are overly anticoagulated or have esophageal varices.13 Patients with significant ascites, unusual GI anatomy, or hiatal hernias may require surgically placed tubes if the gastroenterologist determines that endoscopic placement is not possible or may cause complications. See Chapter 12 for more information about enteral access and devices.

Formula Selection

Several commercially prepared enteral formulas are available to meet the needs of a variety of patients, and these products are generally categorized as standard or disease-specific. Standard formulas provide macronutrients and micronutrients in sufficient proportions to meet normal requirements for most patients. They have an energy density of 1 to 2 kcal/mL, and some contain fiber while others do not.14 Most formulas, whether standard or disease-specific, do not provide sufficient fluid to meet hydration needs, thus necessitating the provision of additional water.

Disease-specific formulas include those designed for patients with renal or hepatic disease, diabetes, pulmonary disease (chronic obstructive pulmonary disease and ARDS), and immunocompromised patients. For patients with malabsorption, elemental or semi-elemental formulas may be beneficial as they are easily digested and absorbed.15 Evidence supporting the use of disease-specific formulas is limited, and guidelines support the use of standard EN formulas in most patient populations.1,2

Manufacturers frequently develop new products with differing amounts or the addition of specific micronutrients, as well as altered macronutrient components and profiles, based on data from recent controlled studies, clinical practice guidelines, and expert recommendations.6 Although homemade blenderized formulas can be used, they are more susceptible than commercial formulas to microbial contamination and are generally not used in the hospital setting.14

Modular components can be coadministered via the feeding tube to further individualize EN provision to meet specific nutrition goals. Increased energy content can be achieved by the addition of hydrolyzed cornstarch and maltodextrin as a carbohydrate component, and fat content can be increased through the addition of oils such as fish oils, medium-chain triglycerides, and safflower oils. Additionally, protein content can be increased through the addition of powdered calcium caseinates and whey protein concentrates. Individual amino acids such as glutamine and arginine are available and can be added via the enteral route if needed in quantities beyond what the EN formula provides.16–19 Modulars typically are not mixed directly with EN formulas because they may clog the feeding tube. See Chapter 11 for more information on EN formulations.

Refeeding Risk

Although no standard definition or diagnostic criteria for refeeding syndrome exists, it is generally characterized by fluid and electrolyte shifts resulting from sodium and carbohydrate provision to malnourished patients. Although refeeding can occur with oral intake, it is more commonly associated with enteral, and especially parenteral, nutrition. Symptoms are generally seen in adults within 2 to 5 days of starting nutrition.20

Hypophosphatemia is present in almost all cases of refeeding;21 other biochemical abnormalities may include hypokalemia, hypomagnesemia, hypocalcemia, hyperglycemia, and thiamin deficiency. These abnormalities are generally caused by increased use of these nutrients for carbohydrate metabolism. Refeeding can manifest as asymptomatic depletion of serum phosphorus, but, in severe cases, it can

result in cardiopulmonary compromise.20,21 See Table 10-2 for potential signs and symptoms of refeeding syndrome.21

TABLE 10-2 Potential Signs and Symptoms of Refeeding

- Electrolyte abnormalities

– Hypophosphatemia

– Hypokalemia

– Hypomagnesemia

– Hypocalcemia

– Hyponatremia

- Cardiovascular conditions

– Arrhythmias

– Hypotension

– Heart failure

– Cardiac arrest

- Thiamin deficiency
- Fluid retention
- Hyperglycemia
- Neurologic conditions

– Weakness

– Numbness

– Paresthesia

– Myalgia

– Vertigo

- Respiratory conditions

– Shortness of breath

– Pulmonary edema

– Respiratory failure

Source: Data are from reference 21.

Ideally, refeeding should be prevented; therefore, it is important to recognize risk factors, which include severe malnutrition, prolonged NPO status, and GI or renal conditions resulting in electrolyte losses (see Practice Scenario 10-1).20,21 The use of medications that can result in electrolyte depletion, such as diuretics, is also a risk factor. Before starting nutrition support in at-risk patients, serum electrolytes should be checked and repleted if needed. Although EN formulas generally provide more than 100% of the Recommended Dietary Allowance for thiamin, additional thiamin supplementation may be beneficial, especially for patients at risk for deficiency, such as those with malnutrition or alcohol dependency.20 The typical dose for repletion is 100 mg of thiamin daily for 5 to 7 days.

Practice Scenario 10-1

Questions: How do you assess the risk for refeeding in a patient requiring enteral nutrition (EN) therapy? How can you reduce the risk for refeeding in the enterally fed patient?

Scenario: A 62-year-old homeless man with alcohol dependency is admitted to the intensive care unit (ICU) with altered mental status. He is unable to provide a medical, diet, or weight history; however, medical records indicate the patient has cirrhosis and has been admitted frequently for delirium tremens. The patient is underweight, with a body mass index of 17 and significant fat and muscle wasting. He is nil per os (NPO) on admission. On hospital Day 2, the patient is intubated to protect his airway due to worsening confusion and agitation. Serum laboratory results from the day of admission indicate potassium level of 3.1 mmol/L, phosphorus level of 2.2 mmol/L, and magnesium level of 1.6 mmol/L. Medications include multivitamin, thiamin, and folate administered via intravenous infusion. Enteral nutrition (EN) is started within 24 hours of intubation. On the morning following EN initiation, serum laboratory results indicate potassium level of 2.9 mmol/L, phosphorus level of 1.4 mmol/L and magnesium level of 1.5 mmol/L.

Intervention: Electrolyte replacement protocols are followed to replenish potassium, phosphorus, and magnesium levels on the day of admission. Electrolytes are rechecked prior to the initiation of EN and are within normal ranges. A standard EN formula is started at a rate of 20 mL/h and advanced slowly, by 10 mL every 12 hours, to a goal rate of 60 mL/h, which provides 25 kcal/kg. Electrolyte replacement protocols are again used to replete electrolyte levels, and the levels are rechecked per protocol until they are within normal range. The patient is monitored closely for other signs of refeeding, including cardiac arrhythmia.

Answer: Risk factors for refeeding include malnutrition, poor nutrition intake, and increased GI losses from ileostomies, diarrhea, or fistulas. The dietitian diagnoses the patient with severe malnutrition. Although the patient cannot provide a diet history, one can presume that, because of current alcohol dependency, homelessness, and altered mental status, the patient's nutrition intake prior to admission was limited. In recognition of these factors, EN was initiated at a low rate and advanced slowly to reduce the risk for refeeding. Depleted electrolyte levels were replaced prior to the start of EN, and again after EN initiation, and were rechecked frequently until normal levels were achieved. Thiamin was also provided as part of the standard regimen for treatment of active alcohol dependency; if not already

provided, thiamin supplementation should have been initiated because of the risk for deficiency and refeeding.

Rationale: Biochemical abnormalities of refeeding syndrome may include hypophosphatemia, hypokalemia, hypomagnesemia, hypocalcemia, hyperglycemia, and thiamin deficiency, which are generally caused by increased use of these nutrients for carbohydrate metabolism. Severe cases of refeeding can result in cardiopulmonary compromise.20,21

Slowly advancing EN to goal rate in high-risk patients is recommended. Bankhead and colleagues8 suggest initiating EN at 25% of goal rate and advancing to goal over 3 to 5 days. However, nutrition support providers should use clinical judgment to develop an individualized plan for advancement, considering the presence and severity of malnutrition, electrolyte levels prior to the start of EN, and assessment of refeeding risks compared with the benefits of early EN feeding.8 In some cases, if electrolytes—especially phosphorus and potassium—are severely depleted, it is prudent to delay advancement of EN to the goal rate.

Rapid identification of the signs and symptoms of refeeding is important to minimize complications; for this reason, serum electrolytes should be monitored daily once nutrition is initiated. Once electrolytes are repleted and electrolyte levels are stabilized, daily laboratory monitoring may no longer be required. Treatment of refeeding syndrome depends on the symptoms, but, in most cases, it can generally be managed by electrolyte replacement.20 Electrolyte replacement protocols or guidelines may be beneficial.22 See Chapter 13 for more information on EN complications.

Aspiration Risk

Aspiration, or the inhalation of GI or oropharyngeal contents into the lungs, can result in pneumonia and its consequences, including death. Dysfunctional swallowing can lead to aspiration of oral secretions and orally ingested foods and beverages, whereas regurgitation or reflux results in aspiration of stomach contents, the latter being relevant to EN administration. It should also be noted that aspiration of gastric contents is less likely to result in bacterial colonization of the respiratory tract than oral secretions.23 As with refeeding, prevention is ideal, and risk factors should therefore be assessed when choosing a feeding tube and developing an EN regimen. See Table 10-3.24

TABLE 10-3 Risk Factors for Aspiration

- Inability to protect the airway related to

– Reduced level of consciousness

– Neurologic deficit

- Delayed gastric emptying related to

– Gastroparesis

– Medications (eg, opiods)

– Hyperglycemia

– Electrolyte abnormalities

- Presence of naso- or oroenteric feeding tube
- Gastroesophageal reflux disease
- Supine position
- Vomiting
- Bolus enteral feedings
- Mechanical ventilation
- Age >70 years
- Transport outside the intensive care unit
- Inadequate nurse-to-patient ratio
- Poor oral care

Source: Data are from reference 24.

Traditionally, a key strategy to decrease the incidence of aspiration in patients receiving EN has been postpyloric feeding tube placement, which reduces the volume of stomach contents. In a 2015 Cochrane review, the authors concluded that there was moderate-quality evidence to suggest that postpyloric feeding resulted in a 30% lower rate of aspiration than gastric feeding.25

Although experts have concluded that postpyloric feeding reduces aspiration, evidence that it reduces risk of pneumonia is less clear; some studies have concluded that small bowel feeding did reduce incidence of pneumonia,26,27 but other studies have not.28,29 Most research suggests that although the incidence of pneumonia may be higher in gastric feeding, there is no difference in length of stay or mortality in gastric vs small bowel feeding; therefore, gastric feeding is considered safe for most patients.2 Gastric feeding is preferable if waiting for migration of a feeding tube tip past the pylorus will delay the early initiation of EN; evidence indicates that gastric feeding increases nutrient provision.30,31 However, postpyloric feeding is still recommended for patients at high risk for aspiration.2 See Chapter 13 for more information on EN complications.

Intervention

Administration

After assessment of the patient has helped establish the route of feeding and formula to be used, decisions regarding EN initiation need to be made, including timing, modality, administration regimen, and energy, protein, and fluid goals.

Timing

In the hospital setting, the ideal time to start EN can vary depending on degree of illness and nutrition status on admission. Little has been published regarding the initiation of EN for noncritically ill patients; however, the American Society for Parenteral and Enteral Nutrition (ASPEN) Enteral Nutrition Handbook

suggests that EN does not need to be initiated for a well-nourished patient until no or inadequate intake reaches 7 to 14 days.1 Other sources suggest initiating EN within 5 to 7 days for well-nourished patients, and even sooner in malnourished patients.32

Early EN initiation is recommended in high-risk critically ill patients. Although definitions vary by study or protocol, “early” is usually defined as EN that is initiated within 24 to 48 hours of the initial insult, such as surgery, mechanical ventilation, or neurologic injury. Early initiation has been shown to significantly reduce mortality and infectious morbidity; for this reason, it is recommended that EN begin within 24 to 48 hours in this population.2

Early EN is recommended for specific subsets of the critically ill population, including patients with moderate to severe acute pancreatitis. Comparing early EN to late EN, and early EN to no nutrition provision, research has demonstrated positive outcomes, such as reduced infection rates, with early EN.33–35 (See Chapter 28 for information on pancreatitis.) Similar research on post–liver transplant patients has also found significant improvements in infection rates, length of stay and survival.36–38 (See Chapter 27 for information on liver disease and Chapter 31 for a discussion of solid organ transplantation.) Other critically ill populations, including trauma, traumatic brain injury, open abdomen in the absence of bowel injury, burns, and sepsis all seem to benefit when EN is initiated within 48 hours, if the patient is hemodynamically stable.2 Burn patients in particular may benefit from even earlier EN initiation, within 4 to 6 hours of injury, if possible.2,39,40 (See Chapter 23 for more information on critical care and sepsis and Chapter 24 for coverage of trauma, surgery, and burns).

Modality

Enteral feeding may be administered by a continuous, intermittent drip, or bolus method. Factors such as the patient’s preexisting and current medical conditions, location of the feeding tube tip, and the patient’s expected tolerance to EN should be considered when selecting the delivery method.41 The choice of feeding modality is also affected by the level of care, and the modality may change as the patient transitions across the continuum of care, from the ICU, to a lower acuity hospital unit, to a long-term care facility or the home. Patients may be fed with one method, or a combination of methods may be used to improve EN tolerance and quality of life. Some patients transition from one method of feeding administration to another as their clinical status evolves.

Continuous Feeding

Pump-assisted continuous drip infusions are the preferred method for feeding patients who are critically ill, are mechanically ventilated using an oro-tracheal method, are at risk for refeeding syndrome, have poor glycemic control, are being fed via jejunostomy tube, or have demonstrated intolerance to intermittent gravity drip or bolus feedings.41 A variety of enteral feeding pumps are available on the market, ranging from lightweight portable pumps for home use to more durable pumps for use at home and in healthcare facilities.

The gravity drip method (without the use of a pump) may be used to provide continuous drip feedings to the noncritically ill patient living at home or outside the hospital setting. To determine the EN infusion

rate, divide the total daily formula volume desired by the number of hours per day the formula will be administered. Table 10-4 shows a sample calculation of a continuous EN prescription. It is helpful to describe the volume of feeding in terms with which the patient and family are familiar, such as 60 mL/h equals ¼ cup (or 4 tablespoons) of formula infused over an entire hour, or 1 mL per minute.42

TABLE 10-4 Sample Calculations for a Continuous Feeding Regimen

1) Calculate daily nutrient needs:
- 1900 kcal
- 80 g protein
- 2100 mL water

2) Choose EN formula:
- Standard formula
- 1.2 kcal/mL, 55 g protein per liter, 810 mL free water per liter

3) Calculate total volume of formula needed:
- 1900 kcal ÷ 1.2 kcal/mL = 1583 mL/d

4) Divide by desired hours of infusion:
- 1583 mL ÷ 24 hours = 65.9 mL/h

5) Round to nearest 5 mL, and calculate final volume:
- 65 mL/h × 24 hours = 1560 mL/d

6) Calculate protein and water provision:
- Protein: 1.56 liters × 55 g/L = 85.6 g/d
- Water: 1.56 liters × 810 mL/L = 1264 mL/d

7) Determine additional protein and fluid needs:
- Protein: No protein modular necessary
- Water: 2100 mL – 1264 mL = 837 mL/d

8) Calculate water flushes (if not receiving fluid from other sources):
- 837 mL ÷ 4 flushes/d = ~200 mL 4 times per day

9) Final EN regimen provides:
- 1560 mL/d × 1.2 = 1872 kcal
- 1.56 L/d × 55 = 86 g protein
- (1.56 L/d × 810) + (200 mL × 4) = 2063 mL water

Cyclic Feeding

Cyclic feeding provides EN by pump or gravity drip over a time period that is less than 24 hours. Depending on the patient's volume tolerance, infusion times may be decreased from 24 hours per day down to as little as 8 hours.43 As a patient recovers from critical illness, this method may be used to transition from 24-hour continuous feedings to 12-hour or shorter nocturnal feedings; it may increase the patient's volitional intake during the day and increase mobility by providing time in which the patient is free from tubing and pump connections.43

Intermittent Feeding

Intermittent feedings can be delivered by infusion pump or by the gravity drip method. This feeding regimen is usually selected for patients with feeding tubes that terminate in the stomach to accommodate the larger volumes administered in a shorter time period. Volumes can range from 240 to 720 mL (1 to 3 cups), be administered in a time period ranging from 20 to 60 minutes, and be provided anywhere from 4 to 6 times per day depending on the volume of formula required to meet the patient's specific needs.41

Patients receiving EN at home may try to mimic the feeding regimen used in the hospital by setting alarms to awaken and administer feeds every 4 to 6 hours, even during the night. Therefore, the patient and family should be instructed that intermittent feeding can occur entirely during waking hours, which improves quality of life and more closely matches their pre-illness or family meal schedule. This schedule adjustment can be accomplished by increasing the feeding volume, if tolerated, so as to decrease the total number of feeds. (See Chapter 38 for more information on home nutrition support.)

Bolus Feeding

Bolus feedings are accomplished by providing a set volume of formula at specified time intervals over a very short period of time, usually with a feeding syringe. A typical feeding regimen might provide 240 mL of formula over a 4- to 10-minute time-frame, with infusions 3 to 6 times per day and at least 3 hours between feedings.43 Bolus feeds can also be administered using a gravity drip method. The rate of formula infusion using a gravity drip bag is regulated by adjusting a roller clamp. When using a syringe without a plunger as a funnel, the rate of delivery of formula is controlled by raising or lowering a formula-filled syringe or adjusting the rate of pressure applied when using the syringe plunger.43 Bolus feedings mimic normal meals, provide freedom of movement, can be administered in more convenient settings (even outside the home), and are usually the least expensive delivery option.43 (See Practice Scenario 10-2 for further discussion of the use of bolus feedings vs continuous enteral administration and Chapter 12 for more information on enteral access and devices.)

Practice Scenario 10-2

Question: When would a continuous enteral infusion be preferred over a bolus administration schedule?

Scenario: A 76-year-old man suffered a stroke with subsequent dysphagia and had a gastrostomy tube placed 7 days ago. After tolerating continuous enteral nutrition (EN) for 5 days, yesterday he was switched to a trial run of bolus feeds to prepare for discharge. Having been administered the volume of bolus feeds required to meet his nutrition needs using a feeding schedule that would work best for his caregivers, he exhibited nausea and distension, despite regular bowel movements. Gut motility medications were tried, with little improvement. The dietitian was asked to provide an alternative feeding plan to facilitate discharge.

Intervention: Bolus feeds of half the previously ordered volume were tried, and the patient tolerated these well. The dietitian documented intolerance of high-volume bolus feedings and worked with case management staff to obtain a feeding pump to administer continuous feeding during night-time hours to reduce the volume required during the day. Caregivers were instructed on the volume of EN to provide for the 4 boluses received during the day, and to administer them slowly, over 30 to 60 minutes, whenever possible. The patient was given this enteral feeding regimen in the hospital and then discharged home after demonstrating tolerance. The patient was instructed to follow up with a dietitian after discharge, as tolerance of the new feeding schedule improved, to assess the feasibility of transitioning to full-volume bolus feedings, thus eliminating the need for a feeding pump at home.

Answer: Patients who do not tolerate bolus feedings are good candidates for home continuous or intermittent feeds using a feeding pump, but adequate documentation must be provided to the insurance company for payment of needed supplies. Smaller, portable pumps are available for home use. For instances when it is preferable not to use the pump, such as social settings, a large-volume syringe can be used, with the rate of delivery of formula controlled by raising or lowering the formula-filled syringe or adjusting the rate of pressure applied when using the syringe plunger.

Rationale: Patients with dysphagia, such as this stroke patient, may require EN because they are at risk to aspirate oral secretions and orally ingested foods and beverages. Reflux can result in aspiration of stomach contents, including the enteral formula. This patient with abdominal distension and nausea is at high risk for reflux that could lead to aspiration due to his inability to swallow safely, increasing his risk for aspiration, pneumonia, and further complications. Therefore, it is appropriate to change the feeding schedule to include continuous feeding to reduce the risk of aspiration.41–43

Initiation and Advancement

While assessment of GI function is necessary, initiation of EN should not be delayed in the absence of overt signs of GI contractility, such as bowel sounds or bowel movements, even in the critically ill population, because delayed EN will increase the risk of compromising the GI mucosal barrier and immune function.2 Initial rate and advancement regimens should be individualized and based on the patient's clinical status, including acuity of illness, risk for refeeding, and expected tolerance of EN.

Stable noncritically ill patients generally tolerate EN initiated at the goal rate. If EN is not started at the goal rate, it should be rapidly advanced to the goal within 24 to 48 hours to maximize nutrient delivery.1 Standard EN protocols for noncritically ill patients often include starting full strength feeds at 50 mL per hour and advancing by 15 mL per hour every 4 hours until the goal rate is met.44 Bolus feedings can be advanced by volumes of 60 to 120 mL every 8 to 12 hours until goal volume is reached; more rapid advancement may be well tolerated by some patients at low risk for refeeding.1

In critically ill patients, EN is commonly started at a volume of 10 to 40 mL per hour and advanced to the goal rate by 10 to 20 mL per hour every 8 to 12 hours.1 However, initiation at lower rates and slow advancement to the goal has been shown to be a major contributor to energy and protein deficits in this population.45,46 Many critically ill patients can tolerate rapid advancement of EN to the goal rate within 24 to 48 hours, which results in smaller energy and protein deficits.2,46 In fact, several studies have

reported no difference in tolerance between critically ill patients who were started at the goal rate vs those whose EN was advanced more slowly.46–48

Volume-based feeding, in which EN is prescribed in terms of the goal volume per day rather than the goal volume per hour, is a more recent feeding method used in the critically ill population. Parameters vary by protocol, but they generally include starting EN at the goal rate, or rapidly advancing to the goal. The use of EN protocols, including those that are volume-based, such as FEED ME (Feed Early Enteral Diet Adequately for Maximum Effect) and PEP uP (Enhanced Protein-Energy Provision via the Enteral Route Feeding Protocol), have been shown to significantly improve nutrient delivery.49–52

EN initiation should be delayed in those critically ill patients who are considered hemodynamically unstable, generally defined as those with a mean arterial blood pressure of less than 50 mmHg, or those who are starting vasopressor medications or require increasing doses to maintain blood pressure. Although a rare complication in patients receiving EN, ischemic bowel may occur as a result of reduced blood flow to the gut, a potential consequence of low blood pressure. EN may be initiated in patients on low-dose stable vasopressors, but these patients should be monitored closely for signs of intolerance.2 (See Chapter 23.)

Goal

EN should be advanced to the goal rate, as tolerated, within 24 to 48 hours in those patients who are determined to be at high nutrition risk or malnourished, with the goal of providing more than 80% of estimated energy and protein needs within 48 to 72 hours. In this high-risk population, rapid advancement to the goal reduces mortality and infection rates.2 However, meeting 80% to 100% of estimated energy needs as soon as possible may not benefit all patients. Critically ill obese patients, regardless of diagnosis, may benefit from high-protein hypocaloric EN to minimize the metabolic complications of feeding, preserve LBM and mobilize fat stores. Hypocaloric feeding is defined as 65% to 70% of energy needs as estimated by IC; if IC is not available, calculations should be used to determine an appropriate hypocaloric regimen for the obese population.2 (See Chapter 35 for more information on obesity.)

In patients with sepsis, guidelines2 suggest that 60% to 70% of energy needs be provided in the first week of EN; EN should then be advanced to provide more than 80% of needs after the first week. It should be noted, however, that sufficient protein should be provided for all patients, if possible, as adequacy of protein provision is more closely correlated with positive outcomes than is adequate energy provision.2

Patients with ARDS or acute lung injury who are expected to be ventilated for more than 72 hours, and who are not at high nutrition risk or malnourished may receive either trophic EN (defined as 10 to 20 mL/h or up to 500 kcal/d) or full EN; no difference in outcomes has been demonstrated between these feeding regimens.2 (See Chapter 23.)

Other Considerations

In the administration of EN, it is important to address numerous factors, including water provision, medication administration, and issues affecting the safety of EN.

Water Flushes

Flushing the enteral feeding tube with water helps prevent tube obstruction. Factors that increase the risk for clogging the feeding tube include the use of a fiber-containing formulas, use of small-diameter tubes, use of silicone rather than polyurethane tubes, checking gastric residual volumes (GRVs), and improper medication administration via the tube.5 In addition to the minimum water flushes needed to maintain tube patency, water flushes should be provided to meet hydration needs, especially if the patient is not receiving IV hydration or drinking fluids.

The most frequently studied flush solutions to maintain tube patency are water, carbonated beverages, and cranberry juice. Water is the superior choice because it maintains patency the best and helps keep the patient adequately hydrated.8 Sterile water is often used in the hospital, but tap water is generally used by patients at home. The 2009 ASPEN EN practice guidelines recommend flushing feeding tubes with at least 30 mL of water every 4 hours during continuous feeding or before and after intermittent or bolus feedings in adult patients.8 The feeding tube should also be flushed with 30 mL of water after GRV checks.

Medication Administration

Many patients who depend on EN for nutrient delivery must also use the same access device for medication administration. The coadministration of formula and medications must be carefully managed to avoid tube obstruction and ensure medication safety and efficacy. When possible, a pharmacist should be consulted before the medication regimen or EN modality is changed. See Table 10-5 for helpful tips for administering medications via the enteral feeding tube,53 and refer to Chapter 18 for information on drug-nutrient interactions.

TABLE 10-5 Tips for Administering Medications via the Enteral Feeding Tube

- Medication form:

– Use liquid or suspension forms whenever possible. However, liquid medications may contain sorbitol or be hyperosmotic, which can lead to diarrhea. If diarrhea does occur, an alternate medication regimen may be needed.

– If a tablet form must be used, consult with the pharmacist to ensure it can be safely crushed and dispersed in water prior to administration. Enteric-coated, sublingual, or sustained-release tablets generally should not be crushed.

– Confirm appropriate medication delivery route with the pharmacist. Medications that depend on gastric acid for breakdown or absorption may need to be substituted or given by an alternate method if feeding tube placement is in the duodenum or jejunum.

- Medication administration:

– Stop EN prior to the administration of medications; restart as soon as possible to ensure adequate nutrient delivery. Only delay restarting EN when it is necessary to avoid altered drug bioavailability.

– Flush the tube with at least 30 mL of water before and after giving medications through the tube.

– Give each medication separately and flush the tube with 5 mL of warm water between medications.

– Do not mix medications or dosage forms, as this can affect drug stability and efficacy.

– If the tube is smaller than 12 French, avoid using it to give crushed medications, if possible.

– Do not add medications to the EN formula, as this can increase the incidence of tube occlusions, interfere with medication and nutrient bioavailability, affect GI function, and increase the risk of microbial contamination.

EN, enteral nutrition; GI, gastrointestinal.

Source: Data are from reference 53.

Safety Considerations

Safety of EN delivery can be compromised by microbial contamination or tubing misconnections, both of which can have potentially fatal consequences.

Open vs Closed Feeding Systems

Ready-to-use EN formulas come in either closed or open systems. A closed system consists of a sterile container of prefilled formula that is ready to administer to the patient and is spiked with an administration set. Open systems involve cans, bottles, or tetra-paks of formula that must be poured into an EN feeding bag or syringe before delivery to the patient. Patient safety and ease of use should be evaluated when determining which system to use. The EN delivery system least likely to contribute to infection through bacterial contamination is the safest, whereas the system with the fewest required administration steps is generally the easiest to use.

The risk of microbial contamination increases as manipulation and handling of the formula and administration set increase.54–58 Contamination can occur during preparation if additional modular components must be added to the formula, when the feeding is transferred to the administration container, during assembly of the feeding system, and during administration to the patient.17,59,60 To reduce the risk of bacterial contamination of a closed or open system, individuals who prepare and deliver formula must use clean preparation techniques and properly wash their hands.16 Improper hand washing is one of the major causes of contamination of EN.17–19

Many studies support the use of closed over open systems because a closed system involves less manipulation of and human/environmental contact with the EN formula and feeding administration sets.59,61–65 However, some studies imply that as long as proper administration procedures and hygiene rules are followed, an open system formula can be safely used,66–68 and there is no benefit of using one system over another.17,69,70 In addition to a decreased risk of bacterial contamination with a closed system, administration of formulas using a closed system requires fewer steps than administration of formulas using an open system,71 thus saving time and healthcare resources.17,72

The administration of bacteria-contaminated formulas can cause complications including abdominal distension,73 diarrhea,60,74,75 and bacteremia.76,77 Other rare but serious complications may include sepsis, pneumonia, and infectious enterocolitis, all of which ultimately lead to increased patient burden, longer hospital stays, and higher healthcare costs.16,17,60,63,64,75,78–81 (See Chapter 13 for additional information on EN complications.)

Tubing Misconnections

Hospitalized patients receive nutrition, medication, and fluids through a variety of tubes and catheters that are often connected using small-bore connectors such as Luer connectors. Enteral misconnections can occur when an enteral feeding system is inadvertently connected to another system, such as an IV catheter or a peritoneal dialysis catheter, and formula is delivered outside of the GI tract to the lungs, bloodstream, or abdominal cavity. Historically, connectors were often compatible between different delivery systems, leading to patient injury and death when medicines, enteral formulas, or air were accidentally delivered through the wrong tubing.

The International Organization for Standardization provided safety requirements for new EN connectors, and a workgroup including manufacturers, clinicians, and governmental agencies developed a new design, now referred to as the ENfit connector.82 In February 2015, the US Food and Drug Administration published final guidance for manufacturers of small-bore EN connectors to reduce the risks of misconnections. Enteral tubing misconnections will be much less likely to occur once manufacturers have fully implemented these recommendations.83 (See Chapter 12 for more about enteral access and devices.)

Monitoring

The hospitalized patient receiving EN must be monitored to quickly identify and treat complications such as refeeding, aspiration, and GI intolerance, as well as to assess whether nutrients and fluids are adequately provided. Monitoring should include physical assessment, laboratory data, anthropometrics, vital signs, and measurement of intake and output.1

Tolerance

Traditionally, GRVs have been regularly used to assess EN tolerance; however, the most recent Society of Critical Care Medicine/American Society for Parenteral and Enteral Nutrition (SCCM/ASPEN) guidelines for nutrition support in critical illness do not recommend checking GRV.2 A number of factors

can compromise the accuracy of GRV checks, including feeding tube type, diameter, and position; viscosity of GRVs; technique, including size of the syringe and time and effort spent; and the position of the patient.84,85

GRVs have not been found to correlate with incidence of pneumonia86,87 or aspiration; furthermore, checking GRVs can increase episodes of feeding tube occlusion, reduce the total volume of EN delivered, and take up valuable nursing time.24 High GRVs have been identified as one of the primary reasons EN is held; holding EN repeatedly or for prolonged periods can increase the risk for development of an ileus.2

Some experts assert that checking GRVs may still be of value in some patient populations, namely those that are at high risk for GI dysfunction, such as patients in the surgical ICU and the most severely ill patients.84 However, to provide adequate nutrient intake, EN should not be routinely held for high GRVs, and other methods of assessing GI function should be used. These indicators include passage of flatus and stool, stool frequency and consistency, physical examination to assess bowel sounds and abdominal girth, and abdominal radiographs. If GRVs are checked, the SCCM/ASPEN guidelines suggest that, in the absence of other signs of intolerance such as vomiting or abdominal distention, EN should not be held for GRVs of less than 500 mL.2

For most individuals on long-term stable EN, no formal assessment of GI tolerance is necessary. This is especially true for patients in the home setting, and for individuals who can effectively communicate any GI issues they may experience, such as nausea, bloating, or abdominal discomfort. (See Chapter 13 for information on EN complications and Chapter 38 for a discussion of home nutrition support.)

Hydration

Fluid is an important component of any EN regimen, especially in patients who are not receiving fluids intravenously or by mouth. Patients at high risk for dehydration include those with increased fluid losses. In addition to urine, excessive losses may occur in patients with high-volume GI output from diarrhea, colostomies, ileostomies, or fistulas; also, patients with high fevers, burns, or extensive wounds may lose higher than normal amounts of fluid from the skin. Although most risk factors for dehydration are related to medical issues, EN may contribute to dehydration if the formula provided is highly osmolar, which may result in osmotic diuresis related to an increased renal solute load.

Patients receiving EN should be assessed for signs of dehydration, including poor skin turgor, dry mucous membranes, and elevated serum blood urea nitrogen, creatinine, and sodium.

Excessive fluid intake may also be an issue, especially in patients with heart failure or renal dysfunction. In these populations, input, output, and weight should be monitored daily; additionally, regular physical assessment should be conducted to examine extremities for edema. Fluid management should be coordinated with the primary care provider, as fluid restrictions or diuretic medications may be necessary. (See Chapter 7 for discussion of fluid requirements and Chapter 29 for information about renal disease.)

Glycemic Control

Hyperglycemia is common in hospitalized patients, even in those without diabetes, particularly in the ICU setting. Causes are multifactorial and include increased release of counterregulatory hormones that stimulate gluconeogenesis, proinflammatory cytokines that result in insulin resistance, provision of steroid and adrenergic medications, and excess dextrose administration via IV fluid solutions and medications. Hyperglycemia negatively affects patient outcomes, resulting in higher infection rates, longer hospital stays, and increased mortality.88

Although earlier studies indicated improved outcomes with tight blood glucose (BG) control, more recent research has shown the opposite effect, presumably because higher incidences of hypoglycemia are associated with tight BG control. Therefore, according to the SCCM/ASPEN Guidelines, a target BG range of 140 to 180 mg/dL is recommended for hospitalized patients.2 BG levels in patients with diabetes should be monitored regularly, generally every 4 to 6 hours; in the critically ill population, even for patients without diabetes, the same monitoring schedule should be followed if BG levels are greater than 180 mg/dL.88

Sliding-scale insulin regimens and the use of oral hypoglycemia medications should not be used because they can delay the achievement of BG control and are associated with a higher incidence of renal dysfunction in hospitalized patients. Several professional groups, such as the American Academy of Physicians and SCCM, have published specific guidelines on the use of insulin protocols to manage hyperglycemia in hospitalized patients.88

BG control can be achieved via continuous insulin drips; therefore, EN initiation and advancement to the goal rate should not be postponed because a critically ill patient has elevated BG levels. Although high-fat, low-carbohydrate formulas with fiber have been developed for patients with hyperglycemia, their efficacy has not been established.2 Use of these products is generally not recommended because the higher fat content may delay gastric emptying, affecting tolerance and thereby limiting the ability to achieve goal volumes. (See Chapter 34 for more information about diabetes and glycemic control.)

Adequacy

The assessment of whether nutrition provision is adequate can be challenging in the acute care setting. Albumin and prealbumin, traditionally used as markers of nutrition status, are now known to be indicative of inflammatory status and not nutrition intake. No serum laboratory values effectively indicate nutrition status or adequacy of nutrition provision.

Especially in the ICU, body weight measurements are often unreliable if bed scales are not properly calibrated; furthermore, linens, dressings, tubing and other equipment on the bed can contribute to unreliable measurements. Weight should still be monitored; however, in the short term, weight changes are more likely to indicate changes in fluid status rather than adequacy of nutrition provision. In patients receiving long-term EN, weight should be monitored regularly because weight trends generally reflect adequacy of EN provision. However, it is important to consider the effects of inflammation and

immobility in patients who are chronically critically ill, as both factors are associated with loss of LBM and are not completely attenuated by adequate nutrition provision.2

Radiographic imaging techniques, such as CT, magnetic resonance imaging (MRI), and ultrasound, are emerging as instruments to measure LBM. These tools are most beneficial in a hospital setting, where scans are already performed for the purpose of medical diagnosis. There are drawbacks to each type of radiographic imaging, including high radiation exposure with CTs, cost of CTs and MRIs, and the need for skilled ultrasound technicians.89 Although radiographic imaging may be useful in assessment of LBM, and thus perhaps in estimation of nutrient needs, using these methods to monitor changes in LBM as a measure of nutrition support adequacy has not been studied. Changes in LBM in the setting of acute illness, especially in the critically ill population, are more likely a result of immobility and increased protein losses caused by the inflammatory process.

Nitrogen balance (NB) can be used as a tool to assess adequacy of protein provision. Measurement of urinary urea is used to estimate nitrogen losses, and 24-hour urine collection is required for accurate measurement, although some practitioners have collected urine for shorter time periods and extrapolated results to 24 hours. Research suggests, however, that collections of less than 12 hours may be less reliable.90 Measurement of protein intake during the same time period is also required; for this reason, estimations are most accurate for patients receiving EN or PN as the sole source of nutrition. A positive NB suggests adequate protein provision. Accuracy of NB can be limited by multiple factors, including impaired renal function; also, incomplete collection of GI losses from fistulas, stool, or ostomies can affect NB results. (See Chapter 6 for a discussion of how to calculate and interpret NB.)

Conclusion

Current evidence indicates that EN is a safe and effective mode of nutrient delivery in patients who cannot meet nutrition needs via oral intake. Benefits of EN include maintenance of gut integrity and immune function, reduced incidence of infectious complications, and attenuation of some negative metabolic consequences of illness. Many factors must be considered when developing an EN regimen, including indications for EN, as well as the individual patient's nutrition status, risk for complications, severity of illness, and comorbidities. Decisions regarding EN regimens, including when to initiate, formula selection, and enteral access, modality, advancement, and goals, will affect the efficacy and safety of feeding. Patients receiving EN feedings should be monitored for signs of complications such as refeeding, GI intolerance, and hyperglycemia.