Enteral nutrition in critically ill patients has been widely debated. Some of the questions include optimal time to begin enteral feeding, gastric versus small-bowel tube placement, and what markers should be used to measure intolerance to enteral nutrition. Although some of these questions are yet to be answered, more evidence has become available since the 1990s to guide practice.

For critically ill patients who cannot consume an oral diet, enteral nutrition is recommended rather than parenteral nutrition because the incidence of infectious complications and costs are lower with enteral nutrition. Enteral feeding should be started within the first 24 to 48 hours of admission in...
critically ill patients who are receiving ventilatory support and whose hemodynamic condition is stable. Artinian et al. found a reduction in intensive care unit (ICU) and hospital mortality when enteral nutrition was started within 24 hours of the start of mechanical ventilation. Continuous feeding is preferable to intermittent feeding because the former may offer additional prophylaxis for stress ulcers, although the mechanism is unknown. Full-strength, undiluted formula should be used for all enteral feeding.

At Saint Joseph Regional Medical Center, South Bend, Indiana, we recognized the need for not only an evidence-based approach but also a standardized method to improve delivery of enteral nutrition. Maintaining consistency in feeding critically ill patients was often difficult because of variations in physicians’ orders and insufficient knowledge of nurses about enteral feeding. For example, a physician might order that enteral feeding be stopped temporarily if a patient had a gastric residual volume greater than 75 mL. If the patient’s nurse did not question this order, feeding would be unnecessarily interrupted. Inappropriate cessation of enteral feeding also occurred during patients’ baths and linen changes. Additionally, much of the literature on enteral nutrition has been published in nutritional and medical journals, which are not often reviewed by staff nurses.

In this article, we review the literature and discuss the development of evidence-based guidelines for enteral feeding. In addition, we address gaps in nurses’ knowledge related to enteral feeding and strategies that can be used by staff nurses to influence enteral nutrition practice.

**Review of Enteral Nutrition Literature**

**Barriers to Meeting Nutritional Goals**

Goals for enteral nutrition are often not achieved in critical care patients because of avoidable causes, such as interruptions in feeding, underordering, and slow increases in the volume of formula administered. In a study by Elpern et al., mean length of interruptions in enteral feeding was 5.23 hours per patient per day. The top 3 reasons for the interruptions were preparation for tests (35.7%), changes in body position (15%), and high gastric residual volumes (11.5%). Almost half (36%-45%) of all interruptions were due to temporary cessation of feeding during other procedures. Of note, in the study by Elpern et al., 150 mL was used as the cutoff point for high gastric residual volumes.

In an investigation by McClave et al., only half of the critically ill patients in the study received their calorie goals, and 66% of cessations in enteral feeding accounted for 19.6% of the potential feeding time. Expert opinion suggests that enteral nutrition be maintained until the start of medical or diagnostic procedures and restarted within 1 hour after a procedure unless specifically contraindicated; in addition, periods longer than 4 hours without nutrition should be avoided. According to anesthesia guidelines, refraining from liquids for 2 to 4 hours before surgery is adequate. Furthermore, in another study, starting nutritional support more than 3 days after admission to the ICU was associated with an increased length of stay.

**Confirmation of Tube Placement**

Malposition of feeding tubes and aspiration are the greatest risks with enteral nutrition. The only reliable method for determining accurate placement of orogastric/nasogastric tubes is radiography. Rassias et al. found that clinical assessment methods were ineffective for detecting inadvertent placement of feeding tubes in the tracheopulmonary system. Results of using capnography and pH testing to assess placement of feeding tubes have been inconsistent. Although auscultatory methods can provide a false assurance of correct placement, many nurses still use this method in their daily practice. A practice alert from the American Association of Critical-Care Nurses recommends using a secondary method to confirm placement of feeding tubes. The method consists of marking the feeding tube with indelible ink at the exit site from the lip or naris at the time of radiography. This mark must be confirmed by a nurse before feeding or administering medication through the feeding tube.

**Gastric Motility and Risk of Aspiration**

Major risk factors for aspiration include brain injuries, decreased level of consciousness, endotracheal intubation, tube malposition, high gastric residual volumes, vomiting, and flat body positioning. An additional risk factor, which may be influenced by nursing practice, is poor oral care. In critically ill patients, gastric motility is impaired by dopamine.
(Intropin), opioids, propofol (Diprivan), neuromuscular blocking agents, and hyperglycemia. Research correlating bowel sounds with gastric motility is lacking, yet many healthcare providers still rely on the presence of bowel sounds to initiate enteral feeding. Experts in enteral nutrition suggest that enteral feeding may be started when bowel sounds are not present. Experts also recommend that enteral feeding be discontinued during periods of hemodynamic instability to reduce risk of aspiration and possible gut ischemia. Although blue food dye was added to formula in the past for assessment of the risk for aspiration, use of the dye has been associated with metabolic acidosis, refractory hypotension, and death and is no longer accepted practice.

**Gastric Residual Volumes**

Debate continues about the validity of gastric residual volumes; opinions vary as to what constitutes a high gastric residual volume, optimal frequency for checking residual volume, time for rechecking, and time to restart feeding. Although little evidence supports using gastric residual volumes to assess gastric emptying, the method is widely accepted, although variable target volumes are used in clinical practice.

Gastric residual volumes greater than 200 to 250 mL are considered high in critically ill patients who have artificial airways in place. Although some findings suggest that gastric residual volumes greater than 100 mL may be high for a gastrostomy tube, this topic is not typically addressed, possibly because most critically ill patients receive enteral nutrition through a nasogastric or orogastric feeding tube. Because secretion of saliva and gastric fluids alone may total 188 mL/h, a gastric residual volume of potassium levels were lower, although not significant statistically, when gastric contents were discarded rather than returned after checks of gastric residual volume. In addition, tube occlusions were more frequent in the patients who had gastric contents reinstalled than in the patients who had the contents discarded, reinforcing the need for routine water flushes after checks of gastric residual volume.

**Prokinetic Agents**

Prokinetic agents have been used to promote gastric motility and prevent unnecessary cessation of feeding. After a meta-analysis of the research literature, Booth et al recommended the use of metoclopramide (Reglan) as a prokinetic agent in patients with consistently high gastric residual volumes. Although erythromycin can increase gastric motility, potential complications such as bacterial resistance may outweigh its benefit as a routine prokinetic agent.

**Gastric Versus Small-Bowel Tube Placement**

Feeding tubes placed beyond the gastric pylorus have been associated with a reduction in both gastroesophageal regurgitation and microaspiration of gastric contents. Small-bowel tube placement, in the duodenum or proximal jejunum, is recommended for patients with potential for impaired gastric motility or high risk of aspiration. Placement of feeding tubes in the small bowel is not feasible for all patients because of a lack of endoscopy or fluoroscopy and unreliable blind insertion methods. For patients with impaired gastric motility as...
indicated by consistently high gastric residual volumes, small-bowel feeding is the suggested route of choice.30

**Body Positioning**

The American Gastroenterological Association recommends elevating the head of bed to a minimum of 30º to 45º to reduce the risk of microaspiration.6,15,31 Elevation to 30º is an accepted standard of care for patients receiving mechanical ventilation to minimize risk of ventilator-associated pneumonia,32 although it is unknown whether placing the head of the bed at 45º may increase the risk for shearing injuries to the skin in critically ill patients.4 Gastric residual volumes are similar in both prone and supine positions when the head of the bed is elevated to 30º.32

**Intolerance to Enteral Nutrition**

Intolerance to enteral nutrition may be due to a number of causes, including diarrhea, constipation, nausea and vomiting, and the feeding formula itself. Despite the common belief that enteral nutrition causes diarrhea, no conclusive research supports this association.4 Consideration of formula as a cause of diarrhea is required; however, other causes such as medications, stool impaction, bacterial contamination, and the effects of *Clostridium difficile* toxin after use of antibiotics must be ruled out.33 Nausea and vomiting may also be related to a variety of causes, such as medications or conditions that delay gastric emptying. Recommendations when a patient has nausea or vomiting include ruling out constipation or impaction, ensuring adequate elevation of the head of the bed, administering antiemetics, and discontinuing offending medications if possible.4

Bacterial contamination of the gastrointestinal tract during enteral nutrition may also lead to intolerance. Aseptic techniques, such as cleaning the tops of formula cans with alcohol swabs before opening, routinely changing the bedside container of formula every 24 hours, and replacing formula every 4 hours in open feeding systems, are used to reduce bacterial contamination.7 Although some institutions use closed feeding systems, evidence that closed systems are better than open systems is lacking.34

**Prevention of Feeding Tube Occlusions**

Occlusions inside feeding tubes are often caused by coagulation of protein-based formulas as the formula comes in contact with acidic environments or certain medications.34 An increase in tube occlusions is also associated with the performance of gastric residual checks.26,35 Although in one study,36 patients who had gastric placement of small-bore tubes had a higher incidence of tube occlusions than did patients with small-bowel placement, in another study,37 the incidence of occlusions in patients with gastric placement did not differ from that of patients with small-bowel placement. Routine water flushes are considered necessary to maintain tube patency, although the volume of water used to flush tubes varies from 20 to 100 mL.38-40 Sterile water, used by some hospitals for flushing feeding tubes, is thought to reduce gastric contamination, although we found no supporting evidence for this practice. Water boluses may also be used during enteral feeding to aid in meeting fluid volume requirements or to normalize serum levels of sodium.

**Treating Feeding Tube Occlusions**

Numerous methods have been used in attempts to unblock feeding tubes. Cranberry juice; the soft drinks Coca-Cola, Mountain Dew, Pepsi, and Sprite; and meat tenderizer have not been consistently effective.34,37 Acidic products may precipitate coagulation of protein-based formulas and actually increase the number of tube occlusions. Flushes with warm water alone have been successful in unblocking some tube occlusions.36,37 For persistent tube occlusions, pancrelipase (Viokase) with the pH increased to 7.9 with sodium bicarbonate has been successful both in unblocking feeding tubes41 and in prolonging time to occlusion when used prophylactically.37

**Development of Enteral Feeding Orders and Guidelines**

Evidence-based protocols can not only enhance delivery of nutrition but also result in improved clinical outcomes in critically ill patients.33 Although no randomized trials have been done to assess the use of enteral feeding protocols, use of a protocol that includes prokinetics and higher gastric residual volumes (250 mL) has been associated with decreased time to reach feeding goals (eg, desired rate of formula administration and percentage of nutritional requirements received).42 Because of perceived barriers to enteral nutrition, we assembled a
multidisciplinary group from 3 campuses of Saint Joseph Regional Medical Center to examine the evidence and develop a plan to improve enteral nutrition in acute care adult patients. The assembled group consisted of dietitians, a gastroenterologist, clinical nurse specialists, a pharmacist, and staff nurses. We planned to optimize enteral nutrition in acutely ill patients by using an evidence-based, standardized approach to feeding. During a 1-year period, we developed and implemented guidelines for enteral nutrition in adults (Table 1). The materials developed included a preprinted physician order form (Figure 1), which contained an algorithm and instructions for tube flushes and management of tube occlusions on the reverse side (Figure 2). Physicians also have the option to delegate authority to the registered dietitian to complete the orders and begin enteral feeding. Extensive revisions were also made to the nursing enteral nutrition policy and procedure. When possible, we used research evidence to develop our guidelines. If no evidence was available, we used expert opinion and practice guidelines from other institutions.

**Highlights of the Enteral Nutrition Guidelines**

**Administration Rate**

Full-strength formula is started at a rate of 25 mL/h, and the head of the bed is elevated to a minimum of 30°. Although our guidelines suggest increasing the rate of enteral feeding every 4 hours, no research evidence was available to support this frequency. However, every 4 hours was common practice in other institutional protocols and the literature.
**Figure 1** Orders for enteral feeding in adults.

Abbreviations: BID, twice a day; FT, feeding tube; HOB, head of the bed; NG, nasogastric; PRN, as needed; QID, 4 times a day; TF, tube feeding; TID, 3 times a day; TX, treatment.

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**Tube Flushes**

Our protocol calls for flushes with 30 mL of tap water every 4 hours, before and after intermittent feeding, before and after administration of medications, and after gastric aspiration procedures. Patients with fluid restrictions are reassessed on an individual basis. The frequency of routine water flushes has not been previously studied, but every 4 hours is common practice. Water flushes are also used when a feeding tube becomes occluded. If water flushes do not restore tube patency, the tube can be flushed with a dose of pancreatic enzyme solution: pancrelipase-8 tablet mixed with 325 mg sodium bicarbonate (crushed) and 5 mL of warm water. An attempt should be made to aspirate the contents of the feeding tube before the enzyme solution is administered. This procedure enables the enzyme solution to have direct contact with the obstruction. The feeding tube is clamped for 5 minutes after administration of the enzyme solution and then flushed with water until the tube is no longer obstructed.

**Assessment of Gastric Residual Volume**

Gastric residual volumes are checked only in patients who have tubes placed in the stomach (ie, not in the small bowel). The stomach is a reservoir that collects formula, whereas the small bowel continually propels contents forward. Implementation of evidence-based practice is not always straightforward. In one study, nurses were reluctant to change their practice despite the presence of research data. Although experts generally define high gastric residual volumes for critically ill patients as 200 to 250 mL, we chose to use 200 mL, because using this volume as a cut-off was a major practice change within our institutions. Previously, volumes less than 200 mL were considered an indication of high gastric residual volume. We will consider increasing the volume defined as high at a later date, once the comfort level of physicians and nurses has increased and outcomes remain favorable. Along with checking gastric residual volumes, nurses reinstill aspirated gastric contents into the feeding tube, up to a total of 200 mL. Any discarded gastric contents are documented as output in the fluid-balance record.

Although use of prokinetic agents is suggested for patients who have high gastric residual volumes, the literature has few recommendations on whether to stop feeding or to maintain or reduce the rate of administration of formula when gastric residual volumes are high. We opted to stop administering formula for 1 hour and then reassess gastric residual volume, because this practice was common in other ICUs. In addition, patients are assessed for indications of intolerance to enteral feeding.

Because the process associated with checking gastric residual volume is the most complex part of our guideline, an algorithm was developed to help nurses comply with the process. This algorithm is printed...
on the reverse side of the order sheet (Figure 2).  

**Interruption of Feeding**

Because a high proportion of feeding interruptions were related to feeding being stopped for procedures, we attempted to address these interruptions in our guidelines. In order to avoid unnecessary cessation of feeding during patients’ repositioning, bathing, or linen changes, nurses are encouraged to place patients in the reverse Trendelenburg position if necessary. If feedings are stopped for procedures, an option on the physicians’ order set allows nurses to make up lost feeding volumes during the remainder of the 24-hour period. This makeup is limited to formulas of 1 to 1.2 cal/mL and is not to exceed the maximum tube feeding rate of 150 mL/h. Our policy suggests that feeding be stopped for 2 hours before procedures or as otherwise ordered. We hope that this policy will discourage the practice of stopping feedings overnight for minor bedside procedures.

Our enteral feeding guidelines also provide prompts to incorporate interventions such as administration of additional water, bowel regimens, and laboratory tests. If a patient’s gastric residual volume is high (>200 mL) for 2 consecutive checks, the algorithm suggests that an order for the promotility agent metoclopramide should be obtained.

**Miscellaneous Practice Issues**

The revised policy and procedure document also provides prompts for nurses to notify a physician or dietitian of any complications, such as diarrhea, nausea/vomiting, feeding tube occlusions that persist despite use of a pancreatic enzyme solution, or presence of dry mouth or dry skin turgor. The occurrence of these problems may indicate feeding intolerance or other complications that may increase the risk of tube malposition, aspiration, or inadequate delivery of nutrition.

**Influence of Nursing Knowledge on Enteral Nutrition Practice Nursing Education**

Several enteral nutrition practices are directly influenced by nurses, including timing of prompting physicians to implement feeding, timeliness of increasing the rate of administration of formula to reach the desired nutritional goals, interruptions in feeding, elevation of the head of the bed, and preventing occlusions of feeding tubes. The number of such interventions suggests that nurses’ knowledge related to enteral nutrition is essential to achieve optimal outcomes for patients. Available research supports the premise that nurses’ knowledge can directly influence the success of a nutritional support program.

**Evaluation of Nurses’ Knowledge**

The test questions were answered by nurses in 5 critical care units at 2 campuses. The critical care units consisted of an ICU, a stroke unit, a progressive care unit, a mixed progressive care/ICU, and a cardiac recovery unit. Test results were analyzed for a total of 55 nurses, 52% of the total number of critical care nurses (Figure 3). Although 65% of
the nurses had completed both tests at the end of the 4-week period, we excluded the results of tests completed after a presentation on enteral nutrition at our institution’s annual critical care conference to avoid skewing the data. The mean score for the 5 critical care units before completion of the educational module was 45%. After the educational program, the mean score increased to 84%, a total increase of 39% in nurses’ knowledge among the sample population.

Although the EduCode program provided detailed test analysis, the answers to a given question on the tests taken before completion of the educational module could not be separated from the answers to the same question on the tests taken after completion of the module. Of interest, 30% of the answers suggested that enteral feeding could not be started in patients who did not have bowel sounds. In addition, 31% of the answers indicated that feeding should be stopped during bathing and changes in bed linen. Answers about gastric residual volumes varied, but 41% of the test answers indicated that enteral feeding should be stopped when gastric residual volumes were less than 200 mL (Figure 4). Again, it was not possible to separate answers to individual questions on the basis of the time the tests were taken (ie, before or after the educational module). Plausibly, the majority of incorrect answers were associated with the tests taken before completion of the module.

One unexpected finding was the amount of discussion generated among the nursing staff after the educational program. Several staff nurses were surprised by some of the research findings on enteral nutrition; the nurses remarked that they had been feeding patients for years and thought they knew this practice. Many were also surprised at the disparity between the research evidence and their knowledge base prior to the educational program. In

Figure 3 Mean percentage of correct answers, by critical care unit (n = 55 nurses), before and after completion of an educational module on enteral nutrition.

Figure 4 Percentage of answers for each option to the test question: Enteral feeding should be held when gastric residual volumes are greater than _____. Options were 50 mL, 100 mL, 150 mL, and 200 mL.
addition to the educational module, informal discussion has further added to nurses’ awareness of enteral feeding practice at our institutions.

**Implementation**

Nurses, radiology technicians, physicians, and dietitians were involved with the practice changes related to enteral nutrition. On each unit, nurses were solicited to become “change champions” to help promote the use of the new guidelines. Change champions are skilled nurses who become expert in the evidence-based guidelines and model the practice change. Our nurse champions are the informal “go to” people on the topic of enteral nutrition. In addition to the formal educational program, practice changes were communicated in a number of formats, including newsletters for nurses, physicians, and other hospital personnel; staff meetings; and informal reminders.

Other measures being monitored with our new guidelines include the process of marking the feeding tube to verify placement, gastric residual volume used as an indicator to stop feeding, and the length of time feedings are stopped before procedures. Outcome measures being evaluated include the time elapsed between the writing of an order for feeding and the start of feeding, elapsed time between the writing of an order and assessment by a dietitian, elapsed time to reach desired rate of administration of formula, and percentage of desired nutritional requirement received within 24 hours of initiating enteral feeding. We plan to assess these outcomes and make any necessary adjustments to our protocol at a later time.

**Conclusion**

Although use of enteral feeding protocols increases nutritional intake in critically ill patients, our new guidelines were implemented only recently. These evidence-based guidelines will be used with all acute care adult patients, not just those in critical care. We recognize that the development of evidence-based guidelines is only one step toward changing practice. Educating nurses and physicians about the guidelines must be ongoing, both to promote use of the guidelines and to prevent unnecessary interruption of feeding.

Although we had predicted an increase in nurses’ knowledge after the educational program, the scores on the tests taken before the program were lower than we had anticipated. Our test questions focused on local practice changes, but much of the literature to support these practice changes had been published 4 years earlier or more. This finding further supports the theory that although research is performed and published, barriers such as lack of access, time, knowledge, and other resources often prevent research from being implemented in the clinical setting.

If you do not have an enteral nutrition protocol in your ICU, we challenge you to evaluate your current practice. If nutritional goals are not being met within a timely manner, consider adopting consistent evidence-based standards of enteral nutrition for your patients. Additional guidelines, analysis of research findings, and tools for implementing evidence-based nutrition into clinical practice are available at www.criticalcarenutrition.com.

Did your own knowledge related to enteral nutrition increase as you read this article? If the answer is yes, most likely others could also benefit from this information. Consider becoming a champion for enteral nutrition on your unit. Talk to your nursing leaders, dietitians, and physicians to find out how you can help implement evidence-based practice within your institution and contribute to positive outcomes for patients.

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None reported.

**References**


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1. A reduction in hospital mortality occurred when enteral nutrition was initiated within how many hours of the start of mechanical ventilation?
   a. 12 hours
   b. 24 hours
   c. 36 hours
   d. 48 hours

2. Which of the following formulas should be used for all enteral feeding?
   a. Quarter strength
   b. Third strength
   c. Half strength
   d. Full strength

3. Which one of the following practice issues is responsible for the majority of interruptions in enteral feeding?
   a. Changes in body position
   b. High gastric residual volumes
   c. Preparation for tests
   d. Hemodynamic instability

4. Unless contraindicated, enteral nutrition should be restarted within how many hours following a diagnostic procedure?
   a. 1 hour
   b. 2 hours
   c. 3 hours
   d. 4 hours

5. Which one of the following is the only reliable method for determining accurate placement of orogastric and nasogastric tubes?
   a. Capnography
   b. Auscultation
   c. pH testing
   d. Radiography

6. Which one of the following is a secondary method to confirm placement of feeding tubes?
   a. Volume of aspirate
   b. pH testing
   c. Marking tube exit site
   d. Color of aspirate

7. Which one of the following gastric residual volumes is considered high in critically ill patients with an artificial airway?
   a. Greater than 50 mL
   b. Greater than 100 mL
   c. Greater than 150 mL
   d. Greater than 200 mL

8. Which one of the following should be performed for a gastric residual volume of 150 mL?
   a. Maintain or increase feeding rate as ordered
   b. Discard gastric residual volume
   c. Decrease tube feeding rate by 25 mL/h
   d. Discontinue enteral feeding

9. Which one of the following is the minimum head of bed elevation to reduce the risk of microaspiration and ventilator-associated pneumonia?
   a. 15°
   b. 30°
   c. 45°
   d. 60°

10. Which one of the following should be used to reduce bacterial contamination of the gastrointestinal tract?
    a. Cleaning the top of formula cans with water
    b. Replacing open system formula every 12 hours
    c. Changing the bedside formula container every 24 hours
    d. Flushing feeding tubes with sterile saline

11. Which one of the following should be used to prevent feeding tube occlusions?
    a. Water flushes
    b. Saline flushes
    c. Pancrelipase (Viokase)
    d. Sodium bicarbonate

12. Which one of the following should be used as the initial rate for tube feedings?
    a. 10 mL/h
    b. 25 mL/h
    c. 40 mL/h
    d. 55 mL/h
Development of Evidence-Based Guidelines and Critical Care Nurses’ Knowledge of Enteral Feeding
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