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Financial disclosure: none declared.

The provision of optimal nutrition support during critical illness is a fundamental goal of critical care that requires careful assessment of energy needs and provision of macronutrients and micronutrients through the best route. Children (ages 1 month to 21 years) admitted to the pediatric intensive care unit (PICU) may already have some degree of malnutrition. In addition, critical illness places variable energy demands on the child that cannot always be accurately predicted using standard equations for calculating energy expenditure. The accurate measurement of energy expenditure is not always feasible. Thus, critically ill children remain at risk of underfeeding and overfeeding. The PICU environment poses unique challenges to achieving nutrition goals for the critically ill child. Nutrition support in the PICU is often in conflict with the complexity of care provided to acutely ill children, including diagnostic and therapeutic procedures that require fasting. In addition, opportunities to feed children are often missed for a variety of reasons, some of which are avoidable.

Nutrition support in the PICU is achieved via the enteral and/or the parenteral route. There has been a resurgence of interest in the provision of enteral nutrients to the critically ill patient. Based on perceived benefits of enteral nutrition (EN) over parenteral nutrition (PN), the enteral delivery of nutrients has been widely adopted as the preferred mode of feeding critically ill patients with a functional gastrointestinal (GI) tract. However, optimal EN delivery at the bedside requires a sustained and multidisciplinary effort to surmount barriers to enteral feeding during critical illness. The rationale and challenges to the delivery and maintenance of optimal EN, and strategies to achieve optimal EN during critical illness, are discussed. (Nutr Clin Pract. 2009;24:377-387)

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The pediatric intensive care unit (PICU) environment poses unique challenges to achieving enteral nutrition (EN) goals for the critically ill child. Nutrition support in the PICU is often in conflict with the complexity of care provided to acutely ill children. A significant proportion of eligible patients do not receive optimal enteral nutrition for avoidable reasons. Early institution of EN is recommended and the gastric route is preferred because of ease of administration and reduced costs compared with the transpyloric route. In patients with poor gastric emptying or in cases where a trial of gastric feeding has failed, transpyloric or postpyloric feeding may be used to decrease the risk of aspiration and to improve enteral feed tolerance. However, there is no evidence of benefit for routine use of small bowel feeding in all patients admitted to the PICU. The placement of blind nasoenteric feeding tubes can be technically challenging, is not without complications, and requires local expertise and experience for successful placement and maintenance. A protocolized approach to selecting the optimal route and advancing enteral feedings may optimize EN delivery. Institutional practice guidelines based on consensus, available evidence, and national guidelines may decrease time to reaching caloric goal, improve protein balance, and potentially affect clinical outcomes. The rationale and challenges to the delivery and maintenance of optimal EN, and strategies to achieve optimal EN during critical illness, are discussed. (Nutr Clin Pract. 2009;24:377-387)

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such as interleukin-6. Using differential absorption and urinary recovery of lactulose and L-rhamnose, EN has been shown to have beneficial effects on intestinal mucosal permeability in critically ill adults. With the benefits of EN shown in animal models and its perceived role in improving outcomes in adult critical care populations, most PICUs have adopted institutional guidelines promoting early EN. The preference of EN has not been backed by randomized control trials. However, enteral feeding practices have been uniformly promoted by consensus-based guidelines in both adult and pediatric populations, mainly by extrapolation from adult literature. The introduction of specialized enteral nutrients or pharmaconutrients during critical illness with the aim to modulate the stress response is an area of intense investigation. Animal and adult data appear to suggest benefit of using agents such as ω-3 fatty acids, glutamine, growth hormone, and antioxidants in select groups of critically ill patients. The discussion of immunonutrition is beyond the scope of this article, and readers are referred to comprehensive reviews of the subject elsewhere. Future studies will illuminate the clinical utility of these agents, their safety profile, and efficacy in improving specific outcomes during critical illness. The administration of enteral immunonutrients in critically ill children outside the research arena cannot be recommended as yet.

Initiating EN: Early EN

Based on the results of prospective, randomized, controlled trials, the Canadian Clinical Practice Guidelines for Nutrition Support strongly recommend the use of early EN (within 24-48 hours after ICU admission) for mechanically ventilated critically ill adults. Despite the absence of sound evidence to support the superiority of one route of feeding over the other, the enteral route has been successfully used for nutrition support of the critically ill child. Early EN is well tolerated in patients with a functional GI tract and decreases time to reach caloric goals. Early aggressive enteral feeding has been shown to increase protein intake resulting in improved protein balance, which is desirable during the acute phase of the stress response. In children with severe burn injury, the administration of early (within 24 hours of admission) EN improves caloric intake and protein balance and decreases mortality, without increased adverse events, when compared with EN delayed for 48 hours after admission. PN may be used to supplement or replace EN in those patients in whom EN alone is unable to meet nutrition goals. On the other hand, among adults admitted to a surgical intensive care unit (ICU) with hypovolemic shock after trauma, early EN was associated with higher rates of GI ischemia and multiorgan dysfunction. In children with hemodynamic instability, EN is often withheld based on the requirement of vasoactive medications. Most medical centers tend to avoid using EN for patients who are receiving multiple vasopressors for hypotension or who have evidence of bowel ischemia, to limit the risk of small bowel necrosis associated with rapid enteral feeding. In a retrospective review of children receiving inotropes or vasopressors during their PICU stay, EN was well tolerated without adverse events. Children in this study were reported to receive dopamine, epinephrine, norepinephrine, or phenylephrine while they were fed enteraly. A majority of children in this study were on dopamine either alone or in combination with another cardiovascular medication (norepinephrine, dobutamine, epinephrine, or phenylephrine). The overall rate of enteral feeding interruption was high (71% had at least 1 episode of stoppage). EN was interrupted for perceived intolerance in 29% of the children in this cohort, accounting for a quarter of the episodes of EN interruptions. Of note, none of the children in this study were on vasopressin infusion, and significant GI bleeding was reported in 2 children, both with multisystem organ dysfunction and coagulopathy. In animal models of septic shock, use of vasopressor infusions has been associated with GI mucosal ischemia and compromised splanchnic microcirculation. In children with septic shock requiring high catecholamine or vasopressin infusions, the benefits of EN must be weighed against the potential effects of these drugs on the splanchnic circulation.

Most centers have adopted strategies to implement early EN in eligible patients, using EN protocols to maximize caloric intake and improve feed tolerance. EN may be delayed or avoided in a subgroup of PICU patients, which includes children requiring endotracheal intubation within 4 hours of ICU admission, patients with hemodynamic instability and increasing vasopressor support, patients with postoperative ileus, patients with active upper GI bleeding, patients with risk of intestinal ischemia, patients with intestinal obstruction, and patients who have undergone allogenic bone marrow transplant or stem cell transplant. In patients in whom EN is contraindicated, PN may be used if the anticipated period of fasting is longer than 5 days or even earlier in patients with existing malnutrition or in neonates with low birth weight. In patients with a functional GI tract, nonvolitional tube feeding into the stomach or intestine is provided when oral feeding is unavailable (Figure 1). The illustrated nutrition support guideline was developed at our institution based on existing local practice and a review of literature where available. A nutrition support plan is developed for each patient in consult with a dedicated registered dietitian in the PICU. Caloric requirements, type of enteral formulation, route of feeding, initial feeding rate, and advancement are planned. In patients with...
a functional GI tract, we prefer to use the enteral route for nutrient delivery where possible. We routinely start with full-strength feedings. The starting volume of enteral feedings depends on the route of feeding and tolerance.

**Oral route unavailable**
- OR
- Unable to protect airway

**Nutrition assessment, Weight on admission**
- Identify caloric goal

**HEAD OF BED** elevated 30° unless contraindicated

**EVALUATE FOR RISK OF ASPIRATION**
- (+) ASPIRATION RISK
- (-) NO ASPIRATION RISK

**TRANSPYLORIC (Nasojejunal / Gastrojejunal) FEEDINGS**
- With gastric decompression

**NASOGASTRIC / Gastric Tube FEEDINGS BS**
- BS present / No gastric distension

**GOAL CALORIES**
- START: 1-2 mL/kg/hr (max 25mL/hr) (or 0.5mL/kg/hr if risk of gut ischemia)
- ADVANCE:
  - <1 yr: 1-5mL/hr q4hrs
  - >1 yr: 5-20mL/hr q4hrs until goal reached.

**TROPHIC FEEDING**
- 1-2 mL/kg/hr or
- 20 mL/hr
- Full-strength formula or breast milk

**GOAL CALORIES**
- START: ½ Goal volume (Full-strength feeding volume required to reach caloric goal). Bolus feedings divided q 3 hr (if<6 months) or q 4 hrs (if > 6 months of age).
- If volume intolerant, try smaller volumes more frequently or continuous feedings.
- ADVANCE: Increase each feeding by 25% volume until goal reached.

**ENTERAL FEEDING INTOLEANCE**
- Gastric residual volumes (GRV) recorded prior to each bolus feed or q 4 hrs in patients on continuous gastric feedings with abdominal discomfort, distension or emesis.
- If GRV>150 mL; or 5mL/kg, or > ½ volume of previous feeding; or > total 2 hourly infusion rate in patients on continuous feeding –hold feedings and repeat GRV after 2 hrs. If repeat GRV is elevated, hold feedings and monitor GRV of 4 hrs.
- If abdominal distension, (abdominal girth increased for 2 consecutive measurements) or abdominal discomfort or emesis x 2 –hold feedings for 4 hrs and reassess.

**CONSTIPATION**
- (For age >1 month / non-neutropenic)
- NO STOOL AFTER 48 HOURS OF EN

**Day#1**
- Prune juice

**Day#2**
- Glycerin supp.

**Docucate**
- (< 3yrs: PO 10 mg BID)
- (3-6 yrs: PO 20 mg BID)
- (6-12 yrs: PO 50 mg BID)
- (>12 yrs: PO 100 mg BID)

**Senna** (Discontinue after 2 normal stools)
- (1 mo-2 yrs: PO 2.5 mL BID)
- (2-5 yrs: PO 3.75 mL BID)
- (5-12 yrs: PO 7.5 mL BID)
- (>12 yrs: PO 1 Tab BID)

**Fleet Enema** (for age > 2 yrs)
- Pediatric Fleet enema: 2-12 yrs (66 mL/bottle)1 enema
- Adult Fleet enema: ≥12 yrs

**DIARRHEA**
- (>4 Loose stools/24 hrs)
- Discontinue laxatives (senna) and stool softeners (docucate)
- Discontinue any sorbitol-containing medication
- Review osmolarity of formula
- Consider withdrawal from opiates
- Consider change in formula, or hold tube feedings until diarrhea resolves
- Stool viral studies / Clostridia (C.) difficile
- Stool C. difficile toxin and culture (if on antimicrobials).

**Figure 1.** Enteral nutrition support algorithm.
- GE, gastroesophageal; BS, bowel sounds; EN, enteral nutrition; PO, per oral; BID, twice daily; q, every
small volumes on a frequent basis may be tried. Failing these measures, continuous gastric feedings may be started for a subgroup of patients. In patients who are intolerant to gastric feeding or are deemed to be at high risk of aspiration, enteral feeding into the small intestine is initiated via a transpyloric nasoenteric or surgically placed feeding tube. Small-volume continuous enteral feeding (trophic feeding) to prevent gut mucosal atrophy has become a standard treatment of critically ill patients. Animal studies demonstrate a trophic effect of low-volume enteral feeding on the intestinal epithelial border. Trophic feedings do not provide significant nutrition value (usually <25% of daily nutrition needs) but are thought to have some positive GI or systemic benefit. Compared with enteral feeding abstinence, trophic feedings maintain intestinal microvillus height and structure; stimulate intestinal secretion of brush border enzymes, endogenous peptides, and secretory immunoglobulin A and bile salts; preserve epithelial cell tight junctions; increase intestinal motility; and promote intestinal blood flow. These local effects reduce systemic inflammation by helping prevent translocation of bacteria or bacterial products across the intestinal epithelial barrier and into the circulation. In very low birth weight infants, minimal EN resulted in improved intestinal function and fewer septic complications, ventilator days, and hospital length of stay compared with PN without enteral feeding. Despite advocating for early enteral feedings, the Canadian Clinical Practice Guidelines admit that the scarcity of data available regarding the optimal volume of early enteral feedings renders making any recommendation impossible. Although the exact volume required to confer these effects in adult humans is unknown, observational studies in mechanically ventilated patients (many of whom did not have acute respiratory distress syndrome) have found that moderate volumes of feedings are associated with improved clinical outcomes, including reduced risk of bloodstream infection and mortality. Other similarly designed studies have shown that low-volume feedings are associated with improved outcomes. Based on these reports, we make every attempt to provide minimal enteral nutrients in patients who are unable to tolerate full-volume feeding. For patients receiving continuous feedings, the feeding rate may be advanced by 1–5 mL/h (for infants) or 5-20 mL/h (for children older than 1 year of age) every 4 hours. In cases where EN is interrupted, the previously established feeding method and schedule should be resumed if possible.

In summary, we believe that critically ill children with a functioning GI tract benefit from early administration of at least some EN, within 24–48 hours after admission to the PICU. A protocolized approach to increasing feedings as tolerated will allow goal EN to be reached. The next section describes some considerations for selecting the site of delivery of enteral nutrients.

Route of Enteral Feeding: Gastric vs Postpyloric

In critically ill children on EN, there are insufficient data to make recommendations regarding the optimal route of enteral feeding (gastric vs postpyloric). In general, gastric feedings are preferred because of ease of administration and reduced costs and expertise required in comparison to transpyloric feedings. In patients with poor gastric emptying or in cases where a trial of gastric feeding has failed, transpyloric or postpyloric (small bowel) feeding may be used to decrease the risk of aspiration and to improve EN tolerance. However, there is no evidence of benefit for routine use of small bowel feeding in all patients admitted to the PICU. In a study examining the role of small bowel feeding in 74 critically ill children, randomized to received either gastric or postpyloric feedings, there was no significant difference in the incidence of microaspiration, tube displacement, and feeding intolerance between the 2 groups. The study was not powered to detect differences in mortality. Of note, enteral feedings were interrupted in a large number of subjects in this study. Although caloric goals were only met in a small percentage of the population studied, the proportion of subjects who achieved their daily caloric goal was higher in the small bowel group compared with the gastric fed group. The evidence for benefits of postpyloric feeding remains equivocal even in the adult critical care population. It may be prudent to consider postpyloric feedings in selected patients who do not tolerate gastric feeding or those who are at a high risk of aspiration. Patients with depressed mental status, absent or depressed gag reflexes, severe respiratory distress, recurrent emesis, gastroesophageal reflux, history of aspiration, and delayed gastric emptying are deemed at high risk of aspiration. The available expertise and resources in individual PICUs may limit the application of postpyloric feeding. Surgical placement of gastrostomy or jejunostomy tube allows long-term EN in selected patients during intensive care and after discharge from the ICU. The advent of percutaneously placed gastric and jejunal tubes has minimized cost, time, and morbidity. Stoma site infection, obstruction, and tube dislodgement are common complications and must be identified and managed early. Tube tip malposition is frequently encountered with any of these devices either at placement or during the course of use. Bedside screening methods for achieving correct tip position range from auscultation during air insufflation to ultrasound-guided tip localization. However, feedings should be held when malposition of tip is suspected, and when in doubt, radiographic confirmation of correct tip position must be obtained before recommencing feedings.

To optimize benefits and minimize risks with EN delivery, standard guidelines must include criteria to help
clinicians identify patients who would benefit from small bowel feeding. Postpyloric or transpyloric tube feedings may be used in patients who are at risk of aspiration or who have failed a trial of gastric feeding. A majority of children requiring transpyloric feeding include those with depressed cough or gag reflexes, delayed gastric emptying, intolerance to gastric feeding, and significant gastroesophageal reflux. Children with active upper GI bleeding, risk of GI ischemia, intestinal obstruction, coagulopathy, recent allogenic bone marrow transplant, or stem cell transplant are usually not candidates for transpyloric feeding.

Placement of transpyloric tubes requires expertise and takes longer than placement of intragastric tubes. Placement of transpyloric tubes may not be feasible at all centers, and the success of the placement relies on the technique used, the experience and expertise of the operator, and backup support from radiologists in cases where bedside placement has not been successful. Transpyloric feeding tubes must be placed by healthcare providers who have received adequate training and demonstrated competence in the performance of this procedure. A variety of procedural techniques for transpyloric feeding tube placement have been described, including the use of modified tubes; air insufflation; videoscopic, echocardiographic, or external magnet assistance; and pH-assisted and spontaneous passage with or without promotility agents. No single method has been shown to be superior. Although individual centers have reported high success rates, the overall incidence of complications such as pneumothorax and malpositioned enteral tubes is not negligible. Strict aseptic precautions must be observed during the procedure. After aspiration of 10 mL of air, failure to aspirate more than 2 mL of air predicts transpyloric placement with reasonable consistency. Tube tip confirmation needs to be documented radiographically. Following successful placement, documentation and monitoring of tube marking at the nares with attention to securing the catheter could prevent unintended tube displacements. Overall, transpyloric feeding is well tolerated in critically ill children and may allow early goal caloric intake by improving tolerance in carefully selected patients. The benefit of transpyloric enteral feeding compared with PN, in terms of decreased complications and costs, must be further examined.

Sustaining EN in the PICU

Interruptions to EN

After EN is successfully established during critical illness, enteral feedings are often held or discontinued for varying periods of time for diagnostic or therapeutic interventions. The goal of fasting prior to elective endotracheal intubation, general anesthesia, procedural sedation, extubation, and other such interventions is to lower the corresponding risk of aspiration. Although EN is often interrupted in the intensive care setting because of conflicts with necessary procedures and the complexity of care, many interruptions might be avoidable. In an audit of 117 patients admitted to our PICU over a period of 1 month, we examined factors responsible for EN deprivation. Following early institution, EN was interrupted in nearly one–third of the patients at an average of 3.7 ± 3.1 times per patient (range, 1-13), for a total of 88 episodes accounting for 1483 hours of EN during the study period. Table 1 illustrates some of the common factors associated with EN interruptions in critically ill patients. The use of PN alone or as a supplement for nutrient provision in such cases may expose the patient to increased costs and the risks associated with PN administration. The achievement of caloric and volume goals using EN remains challenging in the ICU. Prospective cohort studies and retrospective chart reviews have reported the inability to achieve daily caloric goal in critically ill children. The most common reasons for suboptimal enteral nutrient delivery in these studies are fluid restriction, interruptions to EN for procedures, and EN intolerance attributable to hemodynamic instability. The percentage of estimated energy expenditure actually administered to these subjects was remarkably low. In multiple studies examining the actual nutrient intake, caloric goals were not met in a significant proportion of children in the PICU. Nutrition goals were reportedly achieved in 25%-50% of these children. Consistently underachieved EN goals are thought to be one of the reasons for the absence of beneficial effect in multiple

<table>
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<tr>
<th>Reason for EN interruption</th>
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<tr>
<td>Intolerance to enteral feeding</td>
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<tr>
<td>High gastric residuals/abdominal girth/discomfort</td>
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<tr>
<td>Emesis/diarrhea</td>
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<tr>
<td>Feeding tube issues</td>
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<td>Failure to place tube or tube becomes displaced</td>
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<tr>
<td>Blocked feeding tube</td>
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<tr>
<td>Preprocedural fasting (longer than recommended time)</td>
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<td>Bedside procedures</td>
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<td>Extubation/intubation</td>
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<tr>
<td>Operating room procedures</td>
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<td>Procedures in the radiology suite</td>
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Table 1. Common Factors Impeding Optimal Enteral Nutrition (EN) Intake in the Pediatric Intensive Care Unit
Decisions to interrupt EN must not be based solely on arbitrary GRV values but must be individually assessed after accounting for other signs of EN intolerance such as abdominal distension, discomfort, vomiting, and diarrhea. GRV must not be routinely measured, although gastric decompression may be performed through a separate gastric port if available in patients on continuous transpyloric feedings. In patients receiving intermittent bolus feedings, GRV measurement may be performed prior to each feeding. Although not based on evidence, one suggested method for using GRV is as follows: GRV of 5 mL/kg or 150 mL or more than half the previous feeding volume has been deemed as significant. If GRV is elevated, repeat measurement may be obtained after 2 hours without increasing the rate or volume of enteral feeding. If 2 consecutive measurements are elevated, EN is held and GRV monitored every 4 hours until it decreases. At this time, feedings may be restarted at 50% of the previously tolerated rate and volume and advanced as tolerated. Ultimately, the utility of GRV as a measure of feeding intolerance in critically ill children is unclear, and management decisions will need to be based on consensus and evidence from well-designed studies in the future.

Upper GI dysmotility in critically ill patients, especially during mechanical ventilatory support, is of significant concern in both the fasted and fed state. Abnormalities in fundal relaxation, antral motility, and pyloric activity are seen even with small-volume nutrient delivery into the small intestine, resulting in delayed gastric emptying. The etiology of the upper GI motor dysfunction in the critically ill patient is likely to be multifactorial, and potential risk factors include inflammation, hypoperfusion, electrolyte abnormalities, and drugs. In the absence of a reliable diagnostic test, many centers have used pharmacologic adjuncts such as erythromycin, cisapride, metoclopramide, and opioid antagonists as prokinetic agents to assist feeding tolerance. However, the use of these agents either individually or in combination has been moderated by side effects or lack of adequate assessment in the critically ill population. We do not routinely use promotility drugs in the PICU in patients with high GRV, delayed gastric emptying, or emesis. However, promotility drugs may be used in selected patients with careful monitoring for side effects. The optimal dose of prokinetic drugs in the pediatric age group remains unclear.

In patients with persistent feeding intolerance, EN is discontinued, provided in the form of trophic feeding, or combined with PN to meet the caloric goal. Newer methods aimed at measuring gastric emptying and hence enteral feeding tolerance in critically ill children will illuminate this area in the future. A uniform definition of EN intolerance is desirable with institutional practice guidelines that address each step along the guideline systematically and in great detail and clarity. Constipation and diarrhea are common manifestations of enteral feeding intolerance in critically ill children. High osmolality of the enteral formula, enteropathy attributable to prolonged fasting during critical illness, infectious colitis, high sorbitol content medications, and withdrawal from opiates may be associated with debilitating diarrhea (usually 3 or more watery stools per day, or increased
frequency and volume of stool) in PICU patients. Persistent diarrhea may necessitate withholding or reduction of feedings or modification of formulations. Constipation is a significant problem in PICU patients, especially in patients with high opioid requirements or certain postoperative states associated with ileus. Opioids activate opioid receptors in the GI tract, decreasing intestinal transit time and increasing water absorption from the intestinal lumen, with the overall effect being dryer and harder stools. Commonly used agents for constipation in the PICU include suppositories, stool softeners, laxatives, and enemas. An aggressive guideline for evaluation and intervention, with practical stepwise management options, may curtail the incidence of severe constipation and EN discontinuation in critically ill patients. In non-neutropenic children older than 1 month who have been on enteral feedings for over 48 hours without stool, a stepwise approach with escalating levels of intervention to address constipation may be beneficial. Diet modification where possible with prune juice may be followed by a series of adjuncts such as glycerin suppository, stool softeners, laxatives, and enema to facilitate regular and soft stools. An independent constipation guideline incorporated into the EN protocol is desirable.

Complications of EN

Malpositioned Feeding Tubes

Bedside placement of gastric and transpyloric tubes via the nasal route requires expertise and may be associated with unintended consequences. Although gastric tube placement is rapid and safe, transpyloric feeding tube placement may take additional time. Patient discomfort should be assessed during feeding tube placement and appropriate comfort measures used. Malpositioned tube tips have been reported and may be associated with perforation of the pharynx, esophagus, stomach, or intestine; tracheobronchial malposition may result in pneumothorax. These complications may occur at the time of feeding tube insertion or as a result of subsequent migration. In addition, the likelihood of displacement of tube tip after successful placement exposes patients to risk of aspiration. Proper maintenance of feeding tube requires teaching, protocolized management, and approach to problems and surveillance for complications.

Aspiration Pneumonia

Enteral feeding is favored in critically ill patients because of its perceived physiological benefits, ease, safety, and potential reduction of infectious morbidity. However, not all patients are eligible for safe use of the GI tract. The incidence of gastric dysmotility or ileus in some critically ill patients attributable to opiate use, GI surgery, or disease may result in intolerance to enteral feeding. Gastric distension, high residuals, and pulmonary aspiration of gastric contents are likely risks in these patients being fed into the stomach. There does not seem to be a significant difference in the incidence of these outcomes between bolus intermittent or continuous gastric feeding. Although the role of transpyloric feeding in such cases aimed at improving tolerance, increasing intake, and decreasing aspiration risk is attractive, no convincing benefit has been shown in adult or pediatric trials. The role of enteral feeding in the etiology of aspiration pneumonia, especially in mechanically ventilated patients, has been explored with conflicting results. The aspiration of gastric contents and the translocation of organisms colonized along the GI tract to the airways may contribute to the development of nosocomial pneumonia. The use of early EN was shown to increase the risk of ventilator-associated pneumonia in critically ill adults. However, this result has not been replicated in other studies. Overall, lack of a gold standard for detecting small-volume aspiration has hindered the ability to study the incidence and risk of aspiration pneumonia in enteral feeding patients. Glucose content of tracheal secretions, lipid-laden macrophages in bronchial lavage fluid, use of enteral dye, and residual volumes are some of the diagnostic modalities used to detect the incidence of aspiration with very poor sensitivity. Following a series of case reports regarding the association between blue dye and serious complications including death, the FDA issued an advisory in 2003 and recommended immediate suspension of this and other related dyes as food additives to diagnose aspiration. A safe and efficacious diagnostic test for early detection of microaspiration in PICU patients is urgently required and must remain a focus for future research. Until then, the relationship between aggressive early EN and aspiration and ventilator-associated pneumonia will remain unclear.

Other GI side effects of enteral feeding, such as abdominal distension, or complications such as diarrhea, necrotizing enterocolitis, and GI hemorrhage, are infrequent but require vigilance for early detection.

Practice Guideline (Algorithm) for Enteral Feeding

Clinical practice guidelines, developed by multidisciplinary expert consensus and evidence, help improve nutrition support practices in the ICU. The Canadian Clinical Practice Guidelines (www.criticalcarenutrition.com) provide a model for evidence-based, consensus-derived generation of practical recommendations, dissemination
of recommendations, and the systematic evaluation of their impact on patient outcomes. Adherence to these guidelines has been shown to increase EN intake and decrease hospital length of stay, and perhaps carries a trend toward decreased mortality.8,92-94 In the absence of sound clinical trials in the PICU population, the development of evidence-based guidelines is challenging. Although more clinical research is urgently needed to address the multitude of issues related to nutrition support in the PICU, institutionally developed practice guidelines may help to address the variability in practice. Guidelines for EN and PN for the critically ill child have recently been revised by the Guidelines Committee and Board of Directors of the American Society of Parenteral and Enteral Nutrition (A.S.P.E.N.).6

In a retrospective chart review, nutrition data were examined in PICU patients before and after institution of an aggressive enteral feeding protocol. The feeding protocol was developed by a multidisciplinary group which provided age-based recommendations for initiating EN, selecting formula, estimating energy needs, advancing EN, and monitoring and managing enteral feeding intolerance. In addition, a constipation management regimen was incorporated in the protocol. The authors reported early institution of EN, shortened time to reaching nutrition goal, and decreased interruptions to established EN in the group after implementation of the protocol. Figure 1 outlines a suggested methodological approach to initiating and advancing EN in children admitted to the PICU. Such guidelines may be developed at the institutional level after reviewing local practices and identifying gaps that must be addressed. The guideline provides a stepwise approach to promoting EN and includes recommendations for determining route of feeding, assessing aspiration risk, monitoring GRV, intervening in cases with persistently high GRV, standardizing prescription of EN, and suggesting fasting times prior to common PICU procedures.

Administration of nutrients in the GI tract requires careful screening for eligibility, expertise in placement of transpyloric tubes, a protocolized approach to managing intolerance to enteral feedings, and monitoring for complications. A multidisciplinary approach to nutrition support, which includes a dedicated nutrition support team and ongoing education of healthcare workers, can improve the success of EN, decrease reliance on PN, and potentially affect patient outcomes.19 The impact of dedicated nutrition support personnel may be clouded by many other factors that might impede the provision of optimal nutrients in the PICU.95 Many PICUs have developed local nutrition support teams to assist with nutrient provision in critically ill patients.96 Their role in early nutrition assessment, careful estimation or measurement of energy requirements, and monitoring of nutrient intake is crucial to achieving optimal nutrition goals. A dedicated nutrition professional must be a part of the pediatric critical team

Table 2. Elements of a Critical Care Enteral Nutrition (EN) Practice Bundle

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<tr>
<td>Nutrition assessment on admission</td>
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<tr>
<td>Caloric goal (measured resting energy expenditure or estimate)</td>
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<tr>
<td>Early EN (within 24 hours of admission)</td>
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<tr>
<td>Head-of-bed elevation (≥30°)</td>
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<tr>
<td>Daily checklist for EN status/protocolized EN advancement</td>
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making key contributions in day-to-day management and collaborating in quality improvement and research projects related to nutrition support in the PICU.

**EN Practice Bundle**

Care bundles have been implemented in the critical care environment to group together high-impact evidence-based practice interventions aimed at improving patient outcomes. We recently implemented a Critical Care Enteral Nutrition Practice Bundle developed by a multidisciplinary group at our center (Table 2). The basic elements of the bundle included nutrition assessment at admission, identification of individual caloric goal, early initiation of EN, elevation of head of bed, and use of an institutional guideline to maintain optimal EN. The EN practice bundle was introduced as part of a multifaceted intervention optimizing sedation practice and reducing central line–associated infections in the PICU. Using a checklist, the PICU team incorporates the elements of the EN bundle into the daily care plan reviewed at patient rounds. We are currently in the process of examining the effects of this nutrition practice bundle.

**Conclusions**

EN should be initiated early in hospitalized children with established peristalsis. Postpyloric EN may be used in children with a high risk of aspiration or when gastric feeding either is contraindicated or has failed. Enteral administered feedings can meet nutrition requirements in critically ill children with functional GI systems and have the advantages of cost, manageability, safety, and preservation of GI function. Early introduction of enteral feedings in critically ill patients helps to achieve positive protein and energy balance and improves nitrogen balance during the acute state of illness. Despite the perceived benefits of EN, current practice in ICUs is heterogeneous and a significant proportion of eligible patients do not receive optimal EN.97 Administration of optimal EN support will require a multidisciplinary effort at the bedside, with the help of a dedicated nutrition support team, prudent consensus-based guidelines, and implementation of evidence-based practice bundles. The
safe provision of EN will require ongoing education and vigilance among healthcare workers. Future research aimed at identifying gaps in bedside nutrition support practice may allow implementation of novel measures to ensure sustained EN in the PICU. The potential benefit of enteral immunonutrients during pediatric critical illness is promising. The efficacy and safety profile of immunonutrients in the critically ill child requires systematic examination.

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