Enteral Nutrition in the PICU: Current Status and Ongoing Challenges

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Abstract

Malnutrition in the critically ill or injured child is associated with increased morbidities and mortality in the pediatric intensive care unit (PICU), whether present upon admission or acquired during the PICU stay. Particular subpopulations such as those with congenital heart disease or severe thermal injury are at highest risk for malnutrition which can worsen with illness progression. A growing body of evidence suggests the presence of a positive association between nutrition support during critical illness and patient outcomes. Enteral nutrition (EN), the preferred route of nutrient delivery, may be a crucial component of care provided in the PICU which modifies the response to critical illness or injury, resulting in improved outcomes. Numerous challenges exist in the delivery of the EN goal in critically ill children. These include accurate assessment of nutrient requirements, hemodynamic instability, feeding intolerance, feeding interruptions, and the lack of a standardized approach to nutrition support. This article describes the current state of the science and challenges related to EN prescription and delivery in the critically ill child. Suggestions for improving EN practice are then presented, in addition to a platform for further research inquiry.

Keywords

- pediatric critical care
- enteral nutrition
- pediatric nutrition

Introduction

Nutrition support during critical illness is an important therapeutic intervention to diminish the systemic reactions that result from alterations in the metabolic response to disease and injury. Optimal nutrient provision is essential in combating the metabolic changes that accompany acute illness and injury, mitigate immune system dysfunction, promote tissue repair, prevent lean muscle mass loss, and

minimize weight loss. Enteral nutrition (EN) is the preferred route of nutrient delivery and is now recognized as a necessary component of care; what, when, and how to provide nutrition support has become a predominate question in pediatric critical care. In children, the response to illness and/or injury is impossible to predict. It is a result of complement of factors including age; pre-illness nutrition status; and the extent, intensity, and duration of the illness or injury. Whether the degree of illness incites a nutritional

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deterioration or the child presents with a preexisting malnourished state, suboptimal nutrition combined with critical illness may contribute to prolonged metabolic dysfunction, exacerbate the response to illness and put the child at risk for poor health outcomes.

Clinical Significance

In recent years, the role of nutrition support as therapy during critical illness has become an area of active research and inquiry. Recognition of malnutrition in pediatric critical illness was noted more than two decades ago when Pollack and colleagues found malnutrition, defined as deficient protein:energy ratio, in 16% of 50 children admitted to their pediatric intensive care unit (PICU).¹ Years later, Hulst et al reported a 39% weight loss and 40% lean body mass loss in 98 critically ill, mechanically ventilated children which they attributed to the cumulative energy deficit of 100 kcal/kg and accompanying cumulative protein deficit of 10 gm/kg.² Tume et al found more than 55% of the 47 PICU children studied received less than half of their estimated caloric requirements, with the cardiac group receiving the least amount of calories at 27%.³ Recently, Mehta et al, in an international investigation of nutritional practices in critically ill children reported a greater than 30% prevalence of malnutrition at PICU admission.⁴ Kyle and colleagues reported inadequate energy and protein delivery over an 8-day PICU stay.⁵ Only 40% of their 240 participants received EN on the second day of admission. By day 8 of PICU admission, 59% were receiving EN and 20% were receiving parenteral nutrition, leaving approximately 20% receiving solely intravenous (IV) fluids. The literature is replete with reports of insufficient energy and protein delivery during critical illness in children. These and other studies corroborate the ongoing prevalence of malnutrition in the PICU population, which can substantially worsen during hospitalization and has been associated with prolonged mechanical ventilation, increased length of stay, and poor patient outcomes.^{6–9}

EN is preferred in those children with a functioning gastrointestinal (GI) tract.^{10,11} Demonstrated to be cost-effective, EN is more physiologic and well tolerated by many critically ill children.^{10–13} The physiologic advantages of EN include maintenance of intestinal mucosal integrity preventing bacterial translocation, decreased rate of infection, improved immune response, and mitigation of the stress response to the inciting illness or injury, all of which may decrease morbidity and mortality.^{6,14–17} Nutrition support is often a secondary consideration when compared with the acute physiologic needs of the critically ill child; however, evidence is mounting to support its recognition as a key therapeutic modality.

Recognizing the advantages of EN is an initial step, however, of parallel importance is identifying the ideal time for initiation of EN. In a 2009 joint clinical guideline statement, the Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) and the Society of Critical Care Medicine endorsed the use of EN in the initial 24 to 72 hours of admission in critically ill adults.¹⁸ Similarly, the 2003 and updated 2013 Canadian

Clinical Practice Guidelines recommend initiation of EN within 24 to 48 hours of admission in critically ill adults.^{19,20} Few studies directly address timing of initiation for EN in critically ill children. In 1996, Chellis et al²¹ demonstrated safety and efficacy of early EN in a PICU population. The 2009 A.S.P.E.N. clinical guidelines for nutrition support in critically ill children endorse EN; however, there is no specific recommendation for timing of EN initiation.¹⁰ Briassoulis and colleagues demonstrated improved protein balance using an aggressive early EN protocol that reduced the duration of catabolism known to accompany critical illness.²² In a retrospective review, Taylor et al reported initiation of EN within 24 hours of PICU admission.²³ Using a postpyloric feeding tube in a recent small case series of older children, Khlevner et al successfully initiated EN within 24 hours of admission and attained target feeds within 48 hours of tube placement.¹⁵ Current evidence suggests early EN is a viable option to provide nutrition support to critically ill children, yet defining “early” remains obscure in the literature. Rigorous prospective investigations are necessary to firmly establish best practice recommendations.

Literature Search

To better understand the current science underpinning nutrition support in critically ill children, a literature search was conducted in five databases: PubMed, EMBASE, CINAHL, Cochrane Trials, and SCOPUS. Word combinations of Controlled Vocabulary (Mesh terms for PubMed and Emtree terms for EMBASE) and Keywords (used exclusively in SCOPUS) were used to search the following concepts: Enteral Nutrition, Critical Illness, and Procedures (see ►Table 1). We combined similar Controlled Vocabulary terms with Keywords using the Boolean Connector “OR” within each concept, followed by the Boolean Connector “AND” to combine terms between sets of concepts.

Variant keywords were used in PubMed and EMBASE to maximize the number of citations that fit within the concepts represented by the Controlled Vocabulary terms. Results were limited to English and Humans as appropriate for each database. Age limits were set for newborn through young adulthood. Final citation lists yielded 256 articles which were reviewed for duplication. Further examination was conducted of titles and abstracts along with reference lists from pertinent articles. After critical appraisal of those articles which met criteria, 92 were used to elucidate current nutritional practice in pediatric critical care.

Estimating Nutritional Needs and Energy Requirements

The energy needs of critically ill children differ from that of healthy children owing to the wide range of the metabolic demands of the illness or injury. In addition, baseline metabolism and individual requirements for growth make generic prescription of energy and protein needs difficult. Standard prediction equations are commonly used to estimate energy and protein needs for the critically ill child; however, these

Table 1 Search terms and strategies

Concept	PubMed Mesh terms	Keywords used in PubMed	EMBASE Emtree terms	Keywords used in EMBASE	Keywords used in SCOPUS
Enteral nutrition	"Enteral Nutrition"[Mesh]		Enteric Feeding/exp	"enteral nutrition"	"enteral feed*" "enteral nutrition"
Critical illness	"Critical Illness"[Mesh] "Critical Care"[Mesh] "Critical Care Nursing"[Mesh]		"Intensive Care"/exp "Critical Illness"/ "Pediatric Intensive Care Nursing"/exp	"critical care"	"intensive care" "critical care" nursing icu*
Procedures	"Gastrostomy"[Mesh] "Intubation, Gastrointestinal"[Mesh]	Jejunostomy "nasogasatric tube" "tube feeding" "duodenal feeding"	"Nasogastric Tube"/exp "Nose Feeding"/exp "Jejunostomy"/exp "Duodenostomy"/exp	"duodenal feeding" "jejunal feeding"	Jejunostomy "duodenal feeding" "tube feeding" "nasogastric tube"
Filters					
Age	Child: from birth to 18 y Young adult: 19–24 y		Newborn Infant Child Adolescent Young Adult		Pediatric Newborn Infant Child Adolescent Teen Toddler "young adult"
Species	Human		Human		
Language	English		English		English
TOTAL	47 citations		199 citations		101 citations

estimates are often unreliable.^{10,12,24–26} Prediction equations are based on demographics from healthy children, and do not account for alterations in weight affected by fluid status, body mass, or use of sedation and/or neuromuscular blocking agents often used in delivery of care in the PICU. The most commonly used pediatric prediction equations are Schofield,²⁷ the Food and Agriculture Organization/World Health Organization/United Nations University,²⁸ and the Dietary Reference Intake (Recommended Daily Allowances and the Dietary Reference Intake Ref is as follows: Subcommittee on the Tenth Edition of the RDAs. http://www.nap.edu/open-book.php?record_id=1349. Accessed July 17, 2015).²⁹ Inaccuracies of these equations put the patient at risk for under- or overfeeding, as they cannot incorporate the metabolic changes that accompany critical illness or injury. The equations cannot account for the dynamic changes necessary to shift energy from tissue accretion and growth to that required for tissue repair and offset the effects of catabolism. In addition, these equations are often used with an added activity/stress factor that is applied at the discretion of the individual using a prediction equation to calculate energy requirements of the critically ill child.^{30,31}

The use of indirect calorimetry is considered the gold standard for determination of energy requirements in critically ill children; however, equipment and personnel costs

and the required expertise to administer and interpret these measurements prohibit its use in many PICUs.^{10,26,32} Energy requirements are dynamic and fluctuate throughout the course of illness and the PICU admission. Providers should be mindful of this dynamic state and employ the expertise of pediatric registered dietitians to assist with interval nutrition assessments and the prescription of appropriate energy and protein intake to meet the individual metabolic requirements of the patient.^{12,33}

Barriers to Adequate Prescription and Delivery of Enteral Nutrition

Barriers to the successful attainment of target EN for each patient are multifactorial and include prescriptive and delivery components. Hemodynamic instability, fluid restriction, and variability in feeding practice have been identified as key obstacles in the prescription of adequate EN. Interruptions in feeding, lack of measures and thresholds to define feeding intolerance along with clinician knowledge deficits of current evidence regarding EN delivery have all been identified as detrimental to the attainment of feeding goals.^{10,34,35} Each of these factors contributes to delays in initiation and advancement of feeds, hindering the provision of necessary energy and protein to meet metabolic requirements.^{10,34,36–40}

A primary factor known to influence feeding practice is the concern for the introduction of EN into a potentially ischemic gastrointestinal (GI) tract. Hypoxia, hypovolemia, and/or hemodynamic instability may result in the shunting of blood from the splanchnic vascular bed, thus risking ischemia. Feeding a potentially ischemic GI tract puts the patient at risk for severe mucosal injury, which may be progressive and lead to tissue death. Factors contributing to gut injury are multifactorial and include gut immaturity, altered bacterial colonization, translocation of bacteria into the bloodstream, gut barrier dysfunction from disruption of the endothelium, and/or abnormal intestinal vasoregulation.⁴¹ However, delay in the initiation of feeding produces a reduction in the thickness of the mucosa, contributing to barrier dysfunction.⁴² Consequently, it is imperative for the clinician to recognize the benefits of early EN while balancing the risk of additional metabolic stress on the gut.

Vasoactive agents commonly prescribed in the PICU are believed to compromise splanchnic perfusion, resulting in reluctance by clinicians to introduce EN.^{34,35,43} A recent large, retrospective study by Panchal et al examined 339 patients who received one or more vasoactive agents.⁴⁴ The sample was divided into subjects who were enterally fed (55%) and those who were not enterally fed in the first 96 hours of PICU admission. There were no differences in GI outcomes (intolerance, GI bleeding) between the groups, including incidence of necrotizing enterocolitis (NEC). Mortality rates were lower in the fed group compared with the non-fed group (6.9 vs. 15.9%; odds ratio: 0.39; 95% confidence interval: 0.18–0.84; $p < 0.01$).⁴⁴ These findings corroborate reports from the adult critical care literature that patients may be safely fed while receiving vasoactive agents while simultaneously experiencing improved outcomes.^{45,46} Additional prospective randomized trials are needed in critically ill children to quantify safe parameters within which EN and vasoactive medications can be simultaneously administered.

Fluid volume restrictions consumed by IV infusions and medications often result in inadequate remaining volume to provide optimal nutritional support.^{7,35,38} Specific subpopulations who are particularly at risk for nutritional deprivation related to fluid restriction are children with acute or chronic kidney injury and those with congenital heart disease. Numerous investigations have demonstrated significant under provision of energy and protein intake in these populations.^{39,47–49} Cumulative nutritional deficits may hinder recovery from the acute illness or injury.^{49,50}

Feeding intolerance is often cited as a limiting factor in EN delivery.^{4,10,51} GI dysmotility in critical illness, driven by sympathetic nervous system stimulation and compounded by common PICU therapies (immobilization, use of opiates and other medications), is likely an underlying driver in the incidence of feeding intolerance.^{52,53} Neither the measures which represent true feeding intolerance nor their critical thresholds which dictate need for feeding cessation have been well defined.^{4,54,55} Commonly used measures include diarrhea, increased gastric residual volumes (GRV), abdominal distension, constipation, abdominal pain, and emesis. Recent large multicenter trials in adult critical care have de-empha-

sized GRV and focused on emesis as the primary indicator of EN intolerance, resulting in equivalent safety profiles and significantly improved delivery of EN.^{56–58} While several single-site studies have articulated variable criteria for feeding intolerance with inconsistent outcomes, no prospective multicenter pediatric studies to evaluate these criteria were identified.^{34,51,55,59} Moore and Wilson recently defined feeding intolerance as a theoretical construct in neonatal patients but was similarly unable to establish a consensus for operational definitions despite decades of study in this population.⁶⁰ The use of prokinetic agents to enhance GI motility and decrease feeding intolerance has yielded mixed results in both adult and pediatric patients with no clear therapeutic recommendations.^{61–63} Identification of valid and reliable measures and thresholds which define feeding intolerance in the critically ill pediatric patient is needed to optimize safety while avoiding unnecessary cessation of feeds.^{54–56,64–67}

Variability in practice related to the prescription and delivery of EN is reported by numerous investigators.^{4,51,68,69} Unless contraindicated, current recommendations suggest gastric feeding as the initial mode of EN delivery.¹⁰ While the use of intermittent versus continuous gastric feeds has not been well investigated, continuous feeding is the predominant approach.^{4,10,54,55} However, several adult studies and two PICU studies have demonstrated similar or improved EN delivery via bolus feeding with no increased risk of aspiration or pulmonary complications.^{54,70–72} Postpyloric feeding may be used when gastric feeding is unsuccessful, or as the primary feeding mode in some centers. Variable outcomes have been reported when comparing gastric versus postpyloric feeding approaches and their impact on intolerance along with challenges in safe feeding tube placement.^{73–75} Development of best practices for initiation of EN and response to feeding intolerance are needed to improve enteral nutrient delivery.

An additional source of nutritional practice variability is the lack of a standard approach to the delivery of nutrition support. Various feeding protocols are emerging in the literature, yet no one protocol has demonstrated superior performance. Numerous studies have demonstrated improved EN delivery, including feeding advancement to goal with limited interruptions, intolerance measures, and cessation criteria when a comprehensive protocol was implemented.^{6,51,76} However, not all authors clearly outline their feeding protocol, hampering replication, evaluation, and implementation. Findings by Wakeham et al suggest that documentation of feeding goals in the medical record by pediatric registered dietitians who are part of the clinical team improves EN delivery³³ and should be incorporated into a feeding protocol. In the studies to date evaluating feeding protocols, improved outcomes included shortened time to goal feeds, decreased protein and energy deficits, increased weight gain, decreased loss of lean muscle mass, decreased use of parenteral nutrition, decreased incidence of gut injury, and shortened length of PICU stay.^{51,59,77–80}

Feeding interruptions have been acknowledged as a limiting factor in EN delivery in multiple studies.^{7,81,82} Interruptions may be classified as avoidable or unavoidable.³⁴

Examples of avoidable interruptions include feeds held longer than required for procedures, nonadherence to protocols, and feeding tube dysfunction.⁸³ Unavoidable interruptions include feeding intolerance, and worsening hemodynamic/cardiovascular or respiratory clinical status. To optimize nutritional support in critically ill children, it is imperative for clinicians to develop practices to eliminate avoidable feeding interruptions.

Lastly, knowledge deficits related to the importance of EN, its prescription and delivery, remains a barrier.¹⁰ Recent clarification of the definition of pediatric malnutrition was published, articulating etiologic domains for the origin of the malnourished state.⁸⁴ These definitions are complimented by A.S.P.E.N. clinical guidelines for inpatient pediatric nutrition support including critically ill children which provide direction for the development of nutrition support teams, nutritional assessment, implementation of a nutrition care plan, and evaluation of patient outcomes.⁸⁵ After implementing multifaceted nutritional education for ICU medical staff, Castro and colleagues reported a positive impact with improved quality of nutrition therapy and shortened length of ICU stay.⁸⁶ These reports demonstrate a need to heighten the awareness of clinicians for further research to drive development of evidence-based standards for nutrition support.

Recommendations and Best Practices for Delivery of Enteral Nutrition

Since the 2009 A.S.P.E.N. Guidelines for Nutrition Support in Critically Ill Children¹⁰ were published, significant work has been undertaken to address the gaps in the literature and the deficits in practice. Investigations in the identification of energy requirements, recognition, and utilization of available EN support resources are a first step to improve nutrition delivery to critically ill children. Identification of at-risk groups, safety and efficacy of feeding routes and use of feeding protocols, education of clinicians, safety of EN during vasopressor infusions, and appropriate formula selection have advanced the practice of EN therapy in the PICU environment.

Implementation of a nutrition algorithm has demonstrated improved EN delivery by numerous investigators; however, there is no agreement on a single most effective feeding protocol.^{3,51,76,87,88} Such an approach requires an interdisciplinary collaboration, with members from various specialties having an integral role in optimizing EN delivery.⁸⁵ Utilization of indirect calorimetry to identify energy needs is considered the gold standard, although it is most important to have consistent, frequent, and systematic assessment of energy and protein needs to provide individualized nutrition prescriptions. Adequate dietitian resources are instrumental to achieve target feeds.³³ Systems that allow nurses to function to their full scope of practice, utilizing feeding protocols, may be an untapped resource to enhance EN delivery. Given nutrition education pertinent to critical care, physicians and advanced practice providers are poised to lead the initiation and monitoring of EN as a therapeutic modality.

Selection of Appropriate Enteral Nutrition Formula

Selection of appropriate formulas from the vast possibilities can be daunting. Formula prescriptions are age based while also considering GI function and tolerance; this often determines the form of nutrients recommended. The American Academy of Nutrition and Dietetics algorithm (►Fig. 1) presents a systematic approach for the selection of a clinically appropriate formula (Algorithm for Clinically Appropriate Formula Selection, Assessment of Weight Change, taken from *The Pediatric Nutrition Care Manual*, Chicago®, copyright 2014 Academy of Nutrition and Dietetics). Human milk is the feeding of choice for infants. The caloric content of human milk is variable and estimated to be between 18 and 21 kcal/oz. Caloric content of commercially produced full-term infant formulas varies between 19 and 20 kcal/oz, while nutrient-enriched formula yields 22 kcal/oz. In the intensive care setting, fluid restriction may necessitate higher caloric density of breast milk or formula (up to 30 kcal/oz) to meet nutritional requirements. Recent investigations in the role of vitamin D deficits and its association to critical illness may result in the need for supplementation to meet the current American Academy of Pediatrics (AAP) recommendations of 400 international units per day.⁸⁹ See ►Table 2 for characteristics of preterm and term infant formula types. Preterm infants possess unique physiologic requirements and nutritional needs and are not the focus of this article. However, since every PICU has a variable contingency of these patients; formulas for premature infants are included in ►Figure 1 and ►Table 2.

Pediatric products are designed to meet the daily recommended intake (DRI) for children 1 to 8 years of age in 1,000 mL daily and 1,500 mL daily for children between 9 and 13 years.⁸⁹ In choosing an adult formula for a child, special attention must be given to the formula composition. Vitamins and minerals may require supplementation and solute loads should be monitored. Caloric density in pediatric products ranges from 1 to 1.5 kcal/mL, while adult products may be as high as 2 kcal/mL and may be beneficial for those patients with fluid restriction and/or increased energy requirements. Reduced calorie pediatric products are also available; these provide approximately 0.6 kcal/mL and are indicated for children with lower energy needs (e.g., degenerative neuromuscular disorders). Enteral formulas are available with or without fiber and high protein formulations are available for those patients who exhibit increased protein needs (trauma or thermal injury). See ►Table 3 for a summary of pediatric and adolescent formulas.

Specialty products are available for specific disease states such as renal and lymphatic abnormalities for both infants and pediatric patients (see ►Table 4). Additionally, adult products for conditions such as acute respiratory failure, diabetes mellitus, impaired skin integrity, and the immune-compromised patient are also available. There is little evidence to support the use of immune-modulatory formulas in pediatric patients.^{10,90}

Fig. 1 Algorithm for clinically appropriate formula selection (Used with permission from *The Pediatric Nutrition Care Manual*, Chicago®, copyright 2014 Academy of Nutrition and Dietetics).

Table 2 Characteristics of preterm and full-term infant formulas

Product category	Product features
Standard preterm formula	Milk based with higher protein, vitamins, minerals for growing preterm infant weighing <2,000 g; volume intake for those weighing >2,000 g may supply excessive vitamin intake
Nutrient enriched formula	Milk based with higher protein, vitamins, minerals for preterm infant weighing >2,000 g than for full-term infant formula
Standard cow's milk-based formula	Intact nutrients to be used for the full-term infant as a supplement or replacement for human milk
Soy formula	Milk and lactose free. Appropriate for infants with galactosemia
Lactose-free formula	Milk-based formula for those sensitive to lactose
Extensively hydrolyzed protein formula	Hypoallergenic and lactose free for those intolerant to milk and soy
Extensively hydrolyzed protein formula with >30% MCT	Hypoallergenic, lactose free, and a blend of MCT and LCT for those with protein maldigestion, food allergies, fat malabsorption
100% free amino acid formula	Amino acid based, lactose free with MCT for those intolerant to hydrolyzed protein, severe food allergies, short bowel syndrome, and gastric disorders such as eosinophilic esophagitis

Abbreviations: LCT, long chain triglycerides; MCT, medium chain triglycerides.

Table 3 Characteristics of pediatric and adolescent formulas

Product category	Product features
Standard casein based	Intact nutrients; lactose free
Soy based	Milk and lactose free
Semi elemental protein hydrolysate with MCT	Hypoallergenic, lactose free, and a blend of MCT and long chain triglycerides for those with protein maldigestion, food allergies, fat malabsorption
100% amino acid–based elemental	Amino acid based, lactose free with MCT for those intolerant to hydrolyzed protein, severe food allergies, short bowel syndrome, and gastric disorders such as eosinophilic esophagitis

Abbreviation: MCT, medium chain triglycerides.

Table 4 Additional formula modifications

Product category	Product features
Low electrolyte	Milk based; low electrolyte for renal impairment. Iron supplementation may be needed for infant formula. Caloric density in pediatric/adult products vary
Fat modified	High MCT (>80%) for those with defects in fat breakdown, fat absorption, or defective lymphatic transport. Risk of essential fatty acid deficiency due to minimal LCT

Abbreviations: LCT, long chain triglycerides; MCT, medium chain triglycerides.

Recommendations for Future Research

Since the publication of the A.S.P.E.N. guidelines for nutrition support in critically ill children, a significant body of science has emerged.¹⁰ Despite this enhanced knowledge, many questions and gaps in knowledge remain. In review of the six main recommendations from these guidelines, the most significant advancements have been made in the following areas:

- Improved utilization of nutrition assessment in critically ill children
- Implementation of algorithms which include nutrition screening of all PICU patients and full nutritional assessment for those identified as at risk
- Identification of and steps to eliminate barriers to EN delivery, including safe delivery of EN during vasoactive medication infusions
- Use of an organized nutrition support team or service and aggressive feeding protocols have demonstrated improved delivery of EN and decreased utilization of parenteral nutrition
- Limited evidence suggesting attainment of target protein intake may be beneficial in the face of suboptimal energy intake

Significant gaps absent from the original A.S.P.E.N. recommendations include:

- Lack of specific nutrition assessment tools that account for the changes that occur during the course of critical illness
- Identification of best route and approach to EN delivery (gastric vs. postpyloric, intermittent vs. continuous feeds)
- Lack of validated measures and thresholds to define feeding intolerance and the impact on EN delivery.

Conclusion

A growing body of evidence has been presented recognizing EN as a therapeutic modality in the critically ill child which may alter their response to illness and improve outcomes. Consequently, momentum is increasing to address the many remaining unanswered questions. The questions of identifying appropriate energy and protein requirements, selection of appropriate formulas to meet these requirements, nutrition education for PICU clinicians, and solutions to overcome barriers are all fertile areas for ongoing investigation into nutrition support for critically ill children. Optimal nutrition therapy must continue to be in the forefront in pediatric critical care to improve patient outcomes.

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