

A.S.P.E.N. Clinical Guidelines: Pediatric Critical Care

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TITLE:

“A.S.P.E.N. Clinical Guidelines: Nutrition support of the critically ill child”.

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BACKGROUND

The prevalence of malnutrition among critically ill patients, especially those with a protracted clinical course, has remained largely unchanged over the last two decades^{1, 2}. The profound and stereotypic metabolic response to critical illness and failure to provide optimal nutrition support therapy during the intensive care unit stay are the principal factors contributing to malnutrition in this cohort. The metabolic response to stress, injury, surgery or inflammation cannot be accurately predicted and the metabolic alterations may change during the course of illness. Although, nutrition support therapy cannot reverse or prevent this response, failure to provide optimal nutrients during this stage will result in exaggeration of existing nutrient deficiencies and result in malnutrition, which may affect clinical outcomes. Both underfeeding and overfeeding are prevalent in the pediatric intensive care unit and may result in large energy imbalances³. Malnutrition in hospitalized children is associated with increased physiological instability and increased resource utilization, with the potential to influence outcome from critical illness^{4, 5}. The goal of nutrition supportive therapy in this setting is to augment the short-term benefits of the pediatric stress response while minimizing the long-term harmful consequences. Accurate assessment of energy requirements and provision of optimal nutrition support therapy through the appropriate route is an important goal of pediatric critical care. Ultimately, an individualized determination of nutrient requirements must be made to provide appropriate amounts of both macro- and micronutrients for each patient at various

times during the illness course. The delivery of these nutrients requires careful selection of the appropriate mode of feeding and monitoring the success of the feeding strategy. The use of specific nutrients, which possess a drug-like effect on the immune or inflammatory state during critical illness, continues to be an exciting area of investigation. The lack of systematic research and clinical trials on various aspects of nutrition support in the pediatric intensive care unit (PICU) is striking and makes it challenging to compile evidence based practice guidelines. There is an urgent need to conduct well-designed, multicenter trials in this area of clinical practice. The extrapolation of data from adult critical care literature is not desirable and many of the interventions proposed in adults will have to undergo systematic examination and careful study in critically ill children prior to their application in this population.

In the following sections, we will discuss some of the key aspects of nutrition support therapy in the pediatric intensive care unit (PICU), examine the literature and provide best practice guidelines based on evidence from PICU patients, where available. While some PICU populations include neonates, A.S.P.E.N. Clinical Guidelines for neonates will be published as a separate series.

METHODOLOGY

The American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) is an organization comprised of health care professionals representing the disciplines of medicine, nursing, pharmacy, dietetics, and nutrition science. The mission of A.S.P.E.N. is to improve patient care by advancing the science and practice of nutrition support therapy. A.S.P.E.N. vigorously works to support quality patient care, education, and research in the fields of nutrition and metabolic support in all health care settings. These clinical guidelines were developed under the guidance of the A.S.P.E.N. Board of Directors. Promulgation of safe and effective patient care by nutrition support practitioners is a critical role of the A.S.P.E.N. organization. The A.S.P.E.N. Board of Directors has been publishing clinical guidelines since 1986⁶⁻⁸. Starting in 2007, A.S.P.E.N. has been revising these clinical guidelines on an ongoing basis reviewing about 20% of the chapters each year in order to keep them as current as possible.

These clinical guidelines were created in accordance with Institute of Medicine recommendations as “systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances”⁹. These clinical guidelines are for use by health care professionals who provide nutrition support services and offer clinical advice for managing adult and pediatric (including adolescent) patients in inpatient and outpatient (ambulatory, home, and specialized care) settings. The utility of the clinical guidelines is attested to by the

frequent citation of this document in peer-reviewed publications and their frequent use by A.S.P.E.N. members and other health care professionals in clinical practice, academia, research, and industry. They guide professional clinical activities, they are helpful as educational tools, and they influence institutional practices and resource allocation ¹⁰.

These clinical guidelines are formatted to promote the ability of the end user of the document to understand the strength of the literature used to grade each recommendation. Each guideline recommendation is presented as a clinically applicable definitive statement of care and should help the reader make the best patient care decision. The best available literature was obtained and carefully reviewed. Chapter author(s) completed a thorough literature review using Medline®, the Cochrane Central Registry of Controlled Trials, the Cochrane Database of Systematic Reviews and other appropriate reference sources. These results of the literature search and review formed the basis of an evidence-based approach to the clinical guidelines. Chapter editors work with the authors to ensure compliance with the author's directives regarding content and format. Then the initial draft is reviewed internally to ensure consistency with the other A.S.P.E.N. Guidelines and Standards and externally reviewed (either by experts in the field within our organization and/or outside of our organization) for appropriateness of content. Then the final draft is reviewed and approved by the A.S.P.E.N. Board of Directors.

The system used to categorize the level of evidence for each study or article used in the rationale of the guideline statement and to grade the guideline recommendation is outlined in Table 1 ¹¹.

Table 1. Grading of Guidelines and Levels of Evidence

Grading of Guidelines	
A	Supported by at least two level I investigations
B	Supported by one level I investigation
C	Supported by level II investigations
D	Supported by level III investigations
E	Supported by level IV or V evidence
Levels of Evidence	
I	Large randomized trials with clear-cut results; low risk of false-positive (alpha) and/or false-negative (beta) error.
II	Small, randomized trials with uncertain results; moderate-to-high risk of false-positive (alpha) and/or false-negative (beta) error.
III	Nonrandomized cohort with contemporaneous controls.
IV	Nonrandomized cohort with historical controls
V	Case series, uncontrolled studies, and expert opinion

(Adapted with permission from Surviving Sepsis document)¹¹

The grade of a guideline is based on the levels of evidence of the studies used to support the guideline. A randomized controlled trial (RCT), especially one that is double blind in design, is considered to be the strongest level of evidence to support decisions regarding a therapeutic intervention in clinical medicine¹². A level of I, the highest level, will be given to large RCTs where results are clear and the risk of alpha and beta error is low (well-powered). A level of II will be given to RCTs that include a relatively low number of patients or are at moderate-to-high risk for alpha and beta error (under-powered). Meta-analyses can be used to combine the results of studies to further clarify the overall outcome

of these studies but will not be considered in the grading of the guideline. A level of III is given to cohort studies with contemporaneous controls, while cohort studies with historic controls will receive a level of IV. Case series, uncontrolled studies, and articles based on expert opinion alone will receive a level of V.

PRACTICE GUIDELINES AND RATIONALES

TABLE 2: Nutrition Support Guideline Recommendations in the Critically Ill Child

#	Guideline Recommendations	Grade
1	<p>1A) Children admitted with critical illnesses should undergo nutrition screening to identify those with existing malnutrition and those who are nutritionally-at-risk.</p> <p>1B) A formal nutrition assessment with the development of a nutrition care plan should be required, especially in those with premorbid malnutrition.</p>	<p>D</p> <p>E</p>
2	<p>2A) Energy expenditure should be assessed throughout the course of illness, to determine the energy needs of critically ill children. Estimates of energy expenditure using available standard equations are often unreliable.</p> <p>2B) In a subgroup of patients with suspected metabolic alterations or malnutrition, accurate measurement of energy expenditure using indirect calorimetry is desirable. If indirect calorimetry is not feasible or available, initial energy provision may be based on published formulas or</p>	<p>D</p> <p>E</p>

	nomograms. Attention to imbalance between energy intake and expenditure will help to prevent overfeeding and underfeeding in this population.	
3	There are insufficient data to make evidence based recommendations for macronutrient intake in critically ill children. After determination of energy needs for the critically ill child, the rational partitioning of the major substrates should be based upon understanding of protein metabolism and carbohydrate and lipid handling during critical illness.	E
4	<p>4A) In critically ill children with a functioning gastrointestinal (GI) tract, enteral nutrition (EN) should be the preferred mode of nutrient provision, if tolerated.</p> <p>4B) A variety of barriers to EN exist in the pediatric intensive care unit (PICU). Clinicians must identify and prevent avoidable interruptions to EN in critically ill children.</p> <p>4C) There are insufficient data to recommend the appropriate site (gastric vs. post-pyloric/transpyloric) for enteral feeding in critically ill children. Post-pyloric or transpyloric feeding may improve caloric intake when compared to gastric feeds. Post-pyloric feeding may be</p>	<p>C</p> <p>D</p> <p>C</p>

	considered in children at high risk of aspiration or those who have failed a trial of gastric feeding.	
5	Based on the available pediatric data, the routine use of immunonutrition or immune-enhancing diets/nutrients in critically ill children is not recommended.	D
6	A specialized nutrition support team in the PICU and aggressive feeding protocols may enhance the overall delivery of nutrition, with shorter time to goal nutrition, increased delivery of EN and decreased use of parenteral nutrition (PN). The effect of these strategies on patient outcomes has not been demonstrated.	E

1] NUTRITION ASSESSMENT

- 1A) Children admitted with critical illnesses should undergo nutrition screening to identify those with existing malnutrition or those who are nutritionally at-risk.

Grade D

- 1B) Formal nutrition assessment with the development of a nutrition care plan should be required, especially in those with premorbid malnutrition.

Grade E

Rationale:

The prevalence of malnutrition in hospitalized children has remained unchanged over several years and has implications on hospital length of stay, illness course and morbidity^{4, 5}. Children admitted to the PICU are further at risk of long standing altered nutrition status and anthropometric changes that may be associated with morbidity¹³. Hulst et al observed a correlation between energy deficits and deterioration in anthropometric parameters such as mid-arm circumference and weight in a mixed population of critically ill children¹³. These anthropometric abnormalities accrued during the PICU admission returned to normal by 6 months after discharge¹. Using reproducible anthropometric

measures, Leite et al reported a 65% prevalence of malnutrition on admission with increased mortality in this group⁵. On follow up, a significant portion of these children had further deterioration in nutrition status. Nutrition assessment of children during the course of critical illness is desirable and can be quantitatively assessed by routine anthropometric measurements. Routine monitoring of weight is a valuable index of nutrition status in critically ill children. However, weight changes and other anthropometric measurements during the PICU admission should be interpreted in the context of fluid therapy, other causes of volume overload and diuresis. Nutrition assessment can also be achieved by measuring the nitrogen balance and resting energy expenditure. Albumin, which has a large pool and much longer half-life (14 – 20 days), is not indicative of the immediate nutrition status. Serum albumin concentrations may be affected by albumin infusion, dehydration, sepsis, trauma and liver disease, independent of nutrition status. Thus, its reliability as a marker of visceral protein status is questionable. Prealbumin, (also known as transthyretin or thyroxine binding prealbumin) is a stable circulating glycoprotein synthesized in the liver. It binds with retinol binding protein and is involved in the transport of thyroxine as well as retinol. Prealbumin, so named by its proximity to albumin on an electrophoretic strip, has a half-life of 24-48 hours. Prealbumin serum concentration is diminished in liver disease and may be falsely elevated in renal failure. Prealbumin is readily measured in most hospitals and is a good marker for the visceral protein pool^{14, 15}. Visceral proteins such as albumin and pre-albumin do not accurately reflect nutritional status and response to nutritional intervention during inflammation. In children with burn injury, serum acute-phase protein levels rise within 12 to 24 hours of the stress,

because of hepatic reprioritization of protein synthesis in response to injury¹⁶. The rise is proportional to the severity of injury. Many hospitals are capable of measuring C-reactive protein (CRP) as an index of the acute-phase response. When measured serially (once a day during the acute response period), serum prealbumin and CRP are inversely related (i.e., serum prealbumin concentrations decrease and CRP concentrations increase with the magnitude proportional to injury severity and then return to normal as the acute injury response resolves). In infants after surgery, decreases in serum CRP values to less than 2 mg/dL have been associated with the return of anabolic metabolism and are followed by increases in serum prealbumin levels¹⁷.

Future Research

Standard anthropometric measurements may be inaccurate in critically ill children with fluid shifts, edema and ascites. The prevalence of malnutrition in this group of patients and the dynamic effects of critical illness on nutrition status require the ability to accurately measure body composition in hospitalized children. Body composition measurement in children admitted to the PICU has been limited due to the absence of reliable bedside techniques while existing measurement techniques such as the dual energy X-ray absorptiometry (DEXA) scan are impractical in this cohort. Future research related to validation of simple, noninvasive bedside body composition measurement techniques is desirable and will allow monitoring of relevant parameters such as lean body mass, total body water and fat mass in critically ill children.

Furthermore, long-term follow up studies in survivors of critical illness will provide a better idea of the toll of a PICU course on nutrition status of children. For the purpose of such long-term follow up, qualitative markers of lean body mass integrity and function or indicators of return to baseline activity are examples of outcome variables relevant to nutrition in children surviving critical illness.

TABLE 3. Anthropometric changes during pediatric critical illness and role of nutrition assessment

Study	Population	Sample	Clinical Outcome	Comments
Year	Intervention	size	Results	
Grade	Outcome measured			
Hulst ^{1, 13, 18} 2004 Level III	Children in a multidisciplinary ICU a) Total actual intakes of calories and protein recorded. Balance calculated by subtracting actual intake from recommended daily allowance (RDA), over a max of 14 days. Relations between balance and clinical factors and change in anthropometry. b) Patients were also followed up to 6 months for anthropometric parameters.	N = 261	Mean Energy deficits (over a maximum of 14 days) were; 27 kcal/kg – Preterm neonates 20 kcal/kg – Term neonates 12 kcal/kg – Older children Mean Protein deficits; 0.6 g/kg/day – Preterm 0.3 g/kg/day – Term Newborns 0.2 g/kg/day – Children Cumulative deficits – related to decrease in weight and arm circumference SD-scores. Negative correlation with age, length of stay (LOS) in the ICU and duration of mechanical ventilator support.	Mixed population. Negative energy and protein balance in this population correlated with decreasing anthropometric parameters. A 14-day period of monitoring may not be adequate for anthropometric changes. Energy balance was calculated from estimates of RDA and not measured by indirect calorimetry. At 6 months follow up, almost all children had recovered their nutrition status.
Hulst ¹⁸ 2006 Level III	Children in a multidisciplinary PICU Serum urea, albumin, triglycerides and magnesium were measured in 105 children (age, 7 days-16 years) within the first 24 hours after admission. Association with anthropometric outcomes parameters.	N = 105	Prevalence of hypomagnesemia, hypertriglyceridemia, uremia and hypoalbuminemia were 20%, 25%, 30% and 52%, respectively, with no significant associations between the different disorders.	Except for uremia, no significant association was found between abnormalities in biochemical parameters and changes in S.D. scores of anthropometric measurements.
Leite ⁵ 2003	PICU Anthropometry at admission and follow-up.	N = 46	65% of the patients presented with indices of malnutrition. Of these chronic malnutrition was predominant. Mortality was higher in malnourished individuals (20% vs. 12.5%).	A significant number of patients are nutritionally-at-risk at the time of hospital admission, and there is an association between nutrition status and hospital

2] ENERGY REQUIREMENT IN THE CRITICALLY CHILD

- 2A) Energy expenditure should be assessed throughout the course of illness, to determine the energy needs of critically ill children. Estimates of energy expenditure using available standard equations are often unreliable.

Grade D

2B) In a subgroup of patients with suspected metabolic alterations or malnutrition, accurate measurement of energy expenditure using indirect calorimetry is desirable. If indirect calorimetry is not feasible or available, initial energy provision may be based on published formulas or nomograms. Attention to imbalance between energy intake and expenditure will help to prevent overfeeding and underfeeding in this population.

Grade E

Rationale:

Acute injury markedly alters energy needs. Acute injury induces a catabolic response that is proportional to the magnitude, nature, and duration of the injury. Increased serum counter-regulatory hormone concentrations induce insulin

and growth hormone resistance, resulting in the catabolism of endogenous stores of protein, carbohydrate, and fat to provide essential substrate intermediates and energy necessary to support the ongoing metabolic stress response¹⁹. In mechanically ventilated children in the PICU, a wide range of metabolic state has been reported with an average early tendency towards hypermetabolism²⁰. Children with severe burn injury demonstrate extreme hypermetabolism in the early stages of injury whereby standard equations have been shown to underestimate the measured resting energy expenditure (REE)²¹. Failure to provide adequate energy during this phase may result in loss of critical lean body mass and worsen existing malnutrition. Stress or activity correction factors have been traditionally factored into basal energy requirement estimates to adjust for the nature of illness, its severity and the activity level of hospitalized subjects^{22, 23}. On the other hand, critically ill children who are sedated and mechanically ventilated may have significant reduction in true energy expenditure, due to multiple factors including decreased activity, decreased insensible fluid losses and transient absence of growth during the acute illness⁸. These patients may be at a risk of overfeeding when estimates of energy requirements are based on age-appropriate equations developed for healthy children and especially if stress factors are incorporated. The application of a uniform stress correction factor for broad groups of patients in the ICU is simplistic, likely to be inaccurate and may increase the risk of overfeeding. Indirect calorimetry testing may be considered before incorporating stress factor correction to energy estimates in critically ill children. Therefore, the application of correction

factors for activity, insensible fluid loss and the energy or caloric allotment for growth, which is substantial in infancy, must be reviewed.

To account for dynamic alterations in energy metabolism during the critical illness course, REE values remain the only true guide for energy intake. It is likely that resource constraints and lack of available expertise restricts the regular use of IC in the PICU. Estimating energy expenditure needs based on standard equations has been shown to be inaccurate and significantly underestimate or overestimate the REE in critically ill children (See Table 4). This exposes the critically ill child to potential underfeeding or overfeeding during the ICU stay, with significant morbidity associated with each scenario. While the problems with underfeeding have been well documented, overfeeding too has deleterious consequences^{24, 25}. It increases ventilatory work by increasing carbon dioxide production and can potentially prolong the need for mechanical ventilation²⁶. Overfeeding may also impair liver function by inducing steatosis and cholestasis, and increase the risk of infection secondary to hyperglycemia. Hyperglycemia associated with caloric overfeeding has been associated with prolonged mechanical ventilator requirement and PICU length of stay²⁷. The use of the respiratory quotient (RQ) as a measure of substrate use in individual children cannot be recommended. However, a combination of acute phase proteins (CRP) and RQ may reflect transition from the catabolic hypermetabolic to the anabolic state. There are no data in general pediatric populations for the role of hypocaloric feeding. The application of hypocaloric feeding in a

select group of chronically ill children at high risk of obesity is currently sporadic. In general, the energy goals should be assessed and reviewed regularly in critically ill children.

Table 4 summarizes studies examining the performance of estimated energy needs in relation to measured REE in critically ill children requiring mechanical ventilator support. In general, these small sized, prospective or retrospective cohort studies demonstrate the variability of the metabolic state and the uniform failure of estimated energy needs in accurately predicting the measured REE in critically ill children. In the absence of REE, some investigators recommend that basal energy requirements should be provided without correction factors to avoid the provision of calories and/or nutrition substrates in excess of the energy required to maintain the metabolic homeostasis of the injury response. Criteria for targeting a select group of children in the PICU for IC measurement of REE may be useful for centers with limited resources for metabolic testing. Some children in the PICU are likely to be at risk of altered metabolism or malnutrition, where estimates of energy expenditure using standard equations are likely to be inaccurate. If resources are limited, this subset of the population may benefit from targeted indirect calorimetry for accurate measurement of REE to guide energy administration.

Future Research

Indirect calorimetry remains sporadically applied in critically ill children in the setting of mounting evidence of the inaccuracy of estimated basal metabolic rate using standard equations. This could potentially subject a subgroup of children in the PICU to the risk of underfeeding or overfeeding. In the era of resource constraints, indirect calorimetry may be applied or targeted for certain high-risk groups in the PICU. Selective application of indirect calorimetry may allow many units to balance the need for accurate REE measurement and limited resources (Appendix 1). Studies examining the role of simplified indirect calorimetry technique, its role in optimizing nutrient intake, its ability to prevent overfeeding or underfeeding in selected subjects, and the cost-benefit analyses of its application in the PICU are desirable. The effect of energy intake on outcomes needs to be examined in pediatric populations especially in those on the extremes of body mass index.

Appendix 1:

Children at high risk for metabolic alterations who are suggested candidates for targeted measurement of resting energy expenditure in the PICU

- Underweight (Body Mass Index BMI < 5th percentile for age), at risk of overweight (BMI > 85th percentile for age) or overweight (BMI > 95th percentile for age)
- Children with more than 10% weight gain or loss during ICU stay.
- Failure to consistently meet prescribed caloric goals
- Failure to wean or need to escalate respiratory support.
- Need for muscle relaxants for over 7 days.
- Neurologic trauma (traumatic, hypoxic and/or ischemic) with evidence of dysautonomia
- Oncologic diagnoses (including children with stem cell or bone marrow transplant)
- Children with thermal injury
- Children requiring mechanical ventilator support for over 7 days.
- Children suspected to be severely hypermetabolic (status epilepticus, hyperthermia, systemic inflammatory response syndrome, dysautonomic storms etc.) or hypometabolic (hypothermia, hypothyroidism, pentobarbital or midazolam coma, etc.)
- Any patient with ICU length of stay over 4 weeks may benefit from IC to assess adequacy of nutrient intake.

TABLE 4: Estimated Energy Expenditure vs. Measured Resting Energy Expenditure

Study	Population Intervention Outcome measures	Sample size	Clinical Outcome Results	Comments
De Klerk ²⁸ 2002 Level III	Children needing > 24 hours of mechanical ventilator support in a PICU Serial measured resting energy expenditure (REE) Respiratory Quotient (RQ) Actual energy intake/Total Daily Energy Expenditure = Energy Balance	N = 18	Variability in total daily energy expenditure (40-64 kcal/kg/d) Coefficient of variation was < 10% Positive energy balance in many children (n=8) [Average RQ in this group was 0.89] Negative balance (n=10) [Average RQ in this group was 0.84]	Single measurement appears to accurately reflect total daily energy requirement. Results of this study <u>do not</u> suggest the need for serial REE. RQ was marginally affected by energy balance
White ²⁹ 1999 Level III	Mechanically ventilated children in the PICU 24 h indirect calorimetry measurement 30 minute steady state REE compared to 24-h total energy expenditure Daily Coefficient of Variation (CV) in	N = 11	30-minute REE; CV was 7.2% +/- 4.5% 30-min vs. 24 h: No difference (p<0.69) No diurnal variation Between-day CV = 21% +/- 16%	Small numbers. No correlation examined with clinical state. 30-minute REE accurately represented the 24-h values. The authors

	measured REE was calculated			<u>recommend</u> serial REE measurements based on significant between-day CV.
White ³⁰ 2000 Level III	Mechanically ventilated children in a PICU Clinical variables REE by indirect calorimetry	N = 100 (derivation) N = 25 (validation)	A new equation for estimated REE was derived; incorporating age, weight, temperature, days in the PICU and disease.	The authors concluded that there is no substitute for measured REE. Their derived equation performed better than existing standard equations.
Derumeaux-Burel ³¹ 2004 Level III	Obese children BMI z score ≥ 2 Measured REE Fat free mass – obtained by bioelectric impedance assessment (BIA) Predicted equations	N = 471 (derivation) N = 211 (validation)	REE equation – using free fat mass changes performed better than standard equations	Special equations may be necessary for obese children. Body composition is an important factor in REE. Measured REE is ideal.
Mlcak ³² 2006 Level III	Children <18 years with total body surface area burn > 40%, and consent to return at 6, 9, and 12 months for post-burn follow up. Measured REE vs. Harris-Benedict equation and corrected by body mass index (BMI). REE measurements were repeated at 6, 9, and 12 months post burn when the patients returned for outpatient surgery.	N = 100 (40 female)	REE was expressed in 3 different ways: actual REE in kcal per day, percent of predicted REE, and actual REE divided by the BMI. Hypermetabolism persisted 12 months after burn injury. Female children exerted a decreased hypermetabolic response compared with male children.	Increased REE persisted for over 12 months after burn injury.

<p>Framson³³</p> <p>2007</p> <p>Level III</p>	<p>Children admitted to a PICU. Both spontaneously breathing and mechanically ventilated patients were included. No children with chronic disease.</p> <p>Resting energy expenditure measurement within 24 hours of admission; then 48 hours after the first measurement and finally within 24 hours before discharge from the PICU.</p> <p>Measured REE was compared to estimates from equations (Schofield and White et al).</p> <p>Hypermetabolism was defined as measured resting energy expenditure REE) >110% Equation estimated energy expenditure</p> <p>Hypometabolism = REE<90% equation estimated energy expenditure</p>	<p>N = 44 (29 males)</p>	<p>In general, equations performed well.</p> <p>Mean REE for all measurements was 821 +/- 653 kcal/24 hours.</p> <p>The Schofield equation estimate was 798 +/- 595 kcal/24 h and the White equation estimate was 815 +/- 564 kcal/24 h (<i>p</i> not significant).</p> <p>45% of REE were within 90% to 110% of that predicted by the Schofield.</p> <p>The White equation was inaccurate (not within 10% of REE) in 66 of 94 measurements (70%). The discrepancy was greatest (100%) in children with REE<450 kcal/24 h.</p>	<p>The hypermetabolic response apparent in adults was not evident in these critically ill children.</p> <p>Authors <u>do not</u> recommend the use of REE estimates from equations as a guide for caloric intake in critically ill children.</p>
<p>Vazquez Martinez³⁴</p> <p>2004</p> <p>Level III</p>	<p>Mechanically ventilated children in a PICU.</p> <p>Measured REE was compared to estimates from various equations/formulas; such as: Harris-Benedict, Caldwell-Kennedy, Schofield, FAO/WHO, Maffeis, Fleisch, Kleiber, Dreyer and</p>	<p>N = 43 (18 female) 35 Surgical and 8 Medical</p>	<p>Measured REE = 674 +/- 384 kcal/day.</p> <p>Patients noted to be hypometabolic in the first 6 h after admission to PICU.</p> <p>Most equations overestimated measured REE in ventilated, critically ill children during the early</p>	<p>Children may be hypometabolic in the first 6 h after PICU admission.</p> <p>Equations overestimate energy expenditure.</p>

	Hunter equations.		post-injury period. Measured and predicted energy expenditure differed significantly ($p < .05$) except when the Caldwell-Kennedy and the Fleisch equations were used.	Authors do not recommend equations for predicting energy expenditure in critically ill children.
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3] MACRONUTRIENT INTAKE DURING CRITICAL ILLNESS

There are insufficient data to make evidence based recommendations for macronutrient intake in critically ill children. After determination of energy needs for the critically ill child, the rational partitioning of the major substrates should be based upon basic understanding of protein metabolism and carbohydrate and lipid handling during critical illness.

Grade: E

Rationale:

Critical illness and recovery from trauma or surgery are characterized by increased protein catabolism and turnover. An advantage of high protein turnover is that a continuous flow of amino acids is available for synthesis of new proteins. Specifically, this process involves a redistribution of amino acids from skeletal muscle to the liver, wound, and other tissues involved in the inflammatory response. This allows for maximal physiologic adaptability at times of injury or illness. Although children with critical illness have increases in both whole body protein degradation and whole-body protein synthesis, it is the former that predominates during the stress response. Thus, these patients manifest net negative protein and nitrogen balance characterized by skeletal muscle wasting, weight loss, and immune dysfunction. The catabolism of muscle protein to generate glucose and inflammatory response proteins is an excellent short-term

adaptation, but it is ultimately limited because of the reduced protein reserves available in children and neonates. Unlike during starvation, the provision of dietary carbohydrate alone is ineffective in reducing the endogenous glucose production via gluconeogenesis in the metabolically stressed state³⁵. Therefore, without elimination of the inciting stress for catabolism (i.e., the critical illness or injury) the progressive breakdown of muscle mass from critical organs results in loss of diaphragmatic and intercostal muscle leading to respiratory compromise, and the loss of cardiac muscle. The amount of protein required to optimally enhance protein accretion is higher in critically ill than in healthy children. Infants demonstrate 25% higher protein degradation after surgery and a 100% increase in urinary nitrogen excretion with bacterial sepsis^{36, 37}. The provision of dietary protein sufficient to optimize protein synthesis, facilitate wound healing and the inflammatory response, and preserve skeletal muscle protein mass is the most important nutrition intervention in critically ill children. The quantities of protein recommended for critically ill neonates and children are based on very little data. Certain severely stressed states, such as significant burn injury, may require additional protein supplementation to meet metabolic demands. Excessive protein administration should be avoided as toxicity has been documented, particularly in children with marginal renal and hepatic function. Studies using high protein allotments of 4 to 6 g/kg/day have been associated with adverse effects such as azotemia, metabolic acidosis, and neurodevelopmental abnormalities³⁸. A similar evaluation of the effects of high protein administration using newer formulae is desirable. Although the precise amino acid composition to best increase whole-body protein balance has yet to be fully determined, stable isotope techniques now

exist to study this issue. Estimated protein requirements for injured children of various age groups are as follows: 0 to 2 years – 2 to 3 g/kg/day; 2 to 13 years – 1.5 to 2 g/kg/day and 13-18 years – 1.5 g/kg/day.

Once protein needs have been met, safe caloric provisions using carbohydrate and lipid energy sources have similar beneficial effects on net protein synthesis and overall protein balance in critically ill patients. Glucose is the primary energy used by the brain, erythrocyte, and renal medulla and is useful in the repair of injured tissue. Glycogen stores are limited and quickly depleted in illness or injury, resulting in the need for gluconeogenesis. In injured and septic adults, a 3-fold increase in glucose turnover and oxidation has been demonstrated as well as an elevation in gluconeogenesis. A significant feature of the metabolic stress response is that the provision of dietary glucose does not halt gluconeogenesis. Consequently, the catabolism of muscle protein to produce glucose continues unabated and attempts to provide large carbohydrate intake in critically ill patients have been abandoned.

The Surviving Sepsis Campaign has recommended tight glucose control in critically ill adults based on results of a single trial that showed decreased mortality in critically ill adults randomized to this strategy. Subsequent studies examining the role of strict glycemic control in adults have yielded conflicting results and the incidence of hypoglycemia in these studies is concerning³⁹. Hyperglycemia is prevalent in critically ill children and has been associated with poor outcomes in retrospective studies^{27, 40, 41}. The etiology of hyperglycemia during the stress response is multifactorial. Despite the prevalence of hyperglycemia in the pediatric intensive care population, no data exist currently evaluating the effects of

tight glycemetic control in the pediatric age group. Both hypoglycemia and glucose variability also are associated with increased length of stay and mortality and hence undesirable in the critically ill child⁴². In the absence of definitive data, aggressive glycemetic control cannot be recommended as yet in the critically ill child.

Lipid turnover is generally accelerated by critical illness, surgery, and trauma⁴³. Recently, it has been shown that critically ill children do, indeed, have a higher rate of fat oxidation⁴⁴. Thus, this suggests that fatty acids are, in fact, the prime source of energy in metabolically stressed children. Because of the increased demand for lipid use in critical illness coupled with the limited fat stores in the pediatric patient, critically ill children are susceptible to the evolution of biochemically detected essential fatty acid deficiency if administered a fat-free diet⁴⁵. Clinically, this syndrome presents as dermatitis, alopecia, thrombocytopenia, and increased susceptibility to bacterial infection. To avoid essential fatty acid deficiency in critically ill or injured infants, the allotment of linoleic and linolenic acid is recommended at concentrations of 4.5% and 0.5% of total calories, respectively. The provision of commercially available intravenous fat emulsions (IVFE) to parenterally fed critically ill children reduces the risk of essential fatty acid deficiency, results in improved protein use, and does not significantly increase CO₂ production or metabolic rate⁴⁶. Most centers, therefore, start IVFE supplementation in ill children at 1 g/kg/day and advance over a period of days to 2 - 4 g/kg/day, with monitoring of triglyceride levels. IVFE administration is generally restricted to a maximum of 30 to 40% of total calories, although this practice has not been validated by clinical trials.

4] ROUTE OF NUTRIENT INTAKE (ENTERAL NUTRITION)

4A) In critically ill children with a functioning gastrointestinal (GI) tract, EN should be the preferred mode of nutrient provision, if tolerated.

Grade C

4B) A variety of barriers to enteral nutrition exist in the PICU. Clinicians must identify and prevent avoidable interruptions to EN in critically ill children.

Grade D

4C) There are insufficient data to recommend the appropriate site (gastric vs. post-pyloric/transpyloric) for enteral feeding in critically ill children. Post-pyloric or transpyloric feeds may improve caloric intake when compared to gastric feeds. Post-pyloric feeding may be considered in children at high risk of aspiration or those who have failed a trial of gastric feeding.

Grade C

Rationale: Following the determination of energy expenditure and requirement in the critically ill child, the next challenge is to select the appropriate route for delivery of nutrients. In the critically ill child with a functioning GI tract, the enteral route is preferable to PN. EN is physiologic and has been shown to be more cost-effective without the added risk of nosocomial infection inherent with PN^{47, 48}. However, the optimal route of nutrient delivery has not been systematically studied in children and no there is no RCT comparing the effects of EN vs. PN. Current practice in many centers includes the initiation of gastric or post-pyloric enteral feeding within 48 - 72 hours after admission. PN is being used to supplement or replace EN in those patients where EN alone is unable to meet the nutrition goal.

In children fed with EN, there are insufficient data to make recommendations regarding the site of enteral feeding (gastric vs. post-pyloric). Meert et al examined the role of small bowel feeding in 74 critically ill children, randomized to received either gastric or post-pyloric nutrition⁴⁹. The study was not powered to detect differences in mortality. Enteral nutrition was interrupted in a large number of subjects in this study and caloric goals were met in a small percentage of the population studied. This unblinded RCT did not show difference in microaspiration, enteral access device displacement and feed intolerance between the gastric or post-pyloric fed groups. A higher percentage of subjects in the small bowel group achieved their daily caloric goal, compared to the gastric fed group. Sanchez et al report better tolerance in critically ill children receiving early (less than 24 hours after PICU admission) vs. late (started after 24 hrs) post-pyloric nutrition⁵⁰. Of

the 526 children in their cohort who were deemed to have intolerance to enteral nutrition, 202 received early post-pyloric nutrition and had decreased incidence of abdominal distension. Despite evidence to suggest that it is reasonably tolerated, the routine use of postpyloric feeding in the critically ill child cannot be recommended. It may be prudent to consider this option in patients that do not tolerate gastric feeding or those who are at a high risk of aspiration. Postpyloric or transpyloric feeding may be limited by the ability to obtain small bowel access and the expertise and resources in individual PICUs are likely to be variable. A standardized approach to optimizing benefits and minimizing risks with EN delivery will help clinicians identify patients who would benefit from small bowel feeding.

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 child⁵¹⁻⁵³. In another unblinded RCT, Horn et al randomized 45 children admitted to the PICU, to receive gastric tube feeding either continuously or intermittently every 2 hours. The main outcome measure examined in this study was tolerance of enteral feeds. The small sample size and the short observation period of less than 66 hours, makes any meaningful interpretation difficult. However, the number of daily stools, diarrheal episodes or vomiting episodes was similar between the 2 groups. Intolerance to enteral feeds may limit intake and supplementation with PN may be required. Prospective cohort studies and retrospective chart reviews have reported the inability to achieve daily caloric goal in critically ill children.^{54, 55} The most common reasons for suboptimal

enteral nutrient delivery in these studies are fluid restriction, interruptions to EN for procedures and EN intolerance due to hemodynamic instability. The percent of estimated energy expenditure actually administered to these subjects was remarkably low. In a study examining the endocrine and metabolic response of children with meningococcal sepsis, goal nutrition was achieved in only 25% of the cases ¹⁹. Similar observations have been made in a group of 95 children in a PICU where patients received a median of 58.8% (range 0-277%) of their estimated energy requirements. In this review, EN was interrupted on 264 occasions for clinical procedures. In another review of nutrition intake in 42 patients in a tertiary-level pediatric intensive care unit over 458 ICU days, actual energy intake was compared with estimated energy requirement ⁵⁵. Only 50% of patients were reported to have received full estimated energy requirements after a median of 7 days in the ICU. Protocols for feeding use of transpyloric feeding tubes and changing from bolus to continuous enteral nutrition during brief periods of intolerance are strategies to achieve estimated energy goals in this population. Consistently underachieved EN goals are thought to be one of the reasons for the absence of beneficial effect in multiple studies and meta-analysis of the efficacy of immunonutrition in preventing infection ⁵⁶. Awareness of these factors hindering the achievement of EN goals is essential in order to address preventable interruptions in enteral feeding in critically ill children. There is not enough evidence to recommend the use of prokinetic medications or motility agents (for EN intolerance or to facilitate enteral access device placement), prebiotics, probiotics or synbiotics in critically ill children.

Future research

Future studies may be directed at examining methods to ensure optimal prescription and delivery of nutrient intake at the bedside, identifying and preventing common reasons for avoidable interruptions in nutrient intake, selection of children at risk of aspiration in the PICU and the role of enteral nutrition (gastric vs. postpyloric feeds) in this subgroup. The advantages of EN in terms of its role in gut immunity, prevention of PN related complications and the cost benefit analysis when compared to PN need further evaluation.

TABLE 5: Clinical Outcomes Associated with Enteral Feeding

Citation	Population Intervention Outcome measures	Patient #	Clinical Outcome	Comments
Meert ⁴⁹ 2004 Level II	<p>Critically ill children (<18yrs) in a PICU</p> <p>RCT comparing gastric vs. small bowel continuous tube feeds.</p> <p>Percentage of caloric goals achieved, pepsin positive tracheal secretions, and feed tolerance (vomiting, diarrhea or abdominal distension) were the main outcome variables.</p>	N = 74	<p>Daily caloric goal achieved was significantly lower ($p < 0.01$) in gastric group (30 +/- 23%) vs. small bowel group (47 +/- 22%).</p> <p>Proportion of patients with microaspiration, tube displacement, EN intolerance were similar between the 2 groups.</p>	<p>Small number of patients studied. Difficult to blind such a study at the bedside (due to need for radiographic confirmation of placement of tip of enteral access device).</p> <p>Fairly high number of subjects in the study experienced EN interruptions and percent of caloric goals met was low in both groups.</p>
Horn ⁵⁷ 2003 Level II	<p>Children < 18y in a PICU with EN.</p> <p>RCT comparing gastric EN administered either continuously or every 2 h.</p> <p>Tolerance – number and type</p>	N = 45	<p>Number of stools/d (1.5 vs. 1.6), mean episodes of diarrhea/d (0.32 vs. 0.64), mean number of vomiting episodes/person (0.64 vs. 0.22) were similar between the continuous and intermittent gastric fed group.</p>	<p>Small number of patients studied.</p> <p>The duration of study was too small to detect meaningful differences – median 64.5 and 66 hours for the 2 groups.</p>

	of stools, diarrhea and vomiting.			
De Oliveira Iglesias ⁵⁸ 2007 Level III	Children in a PICU with EN \geq 2 d. Required (estimates) vs. prescribed vs. delivered calories were recorded. Variables associated with not achieving caloric goals were recorded.	N = 55	EN started on Day 3 \pm 1 and maintained for 6 \pm 3 d. 71% received the required calories (38% of which reached caloric goal by d 5 of PICU admission). Daily average caloric intake was 60% of required and 85% of prescribed. Barriers to EN were: procedures, clinical instability, use of inotropic agents, enteral access device displacement, postoperative fasting and feeding intolerance (abdominal distension, vomiting and diarrhea).	Energy requirements were estimates and not measured. Barriers to EN remain a significant challenge to ensuring the delivery of prescribed calories to patients in the PICU.
Sanchez ⁵⁰ 2007 Level III	Children admitted to a PICU, were eligible for transpyloric tube placement if they were deemed to not tolerate enteral feeds within 24-48hrs after admission. Tolerance of feeds was compared between patients started on transpyloric feeds early (< 24 hours after admission) vs. those started late (> 24 hrs)	N = 526 Over 10 years. 202 – fed early	Clinical characteristics, nutrients delivered and incidence of diarrhea were similar in both groups. Abdominal distension was less frequent in early EN group (3.5%) vs. late (7.8%); $p < 0.05$.	Retrospective cohort. Children tolerate early postpyloric feeds.

	Calories delivered, duration of nutrition, abdominal distension and diarrhea were recorded.			
Rogers ⁵⁵ 2003 Level III	Children admitted to a PICU with length of stay >3 d and EN intake. The proportion of patients reaching estimated energy requirement goals was recorded.	N = 42 (18 Cardiac surgical)	Patients received 37.7% (median) of their EER. Cardiac Surgical patients had lower caloric intake than others. Only 52% of the pts received full energy intake goal at any time during the PICU stay. Significant weight decrease was noted in cardiac surgical patients. Major barrier to caloric intake– fluid restriction. Minor barriers – feed interruption for procedures and intolerance.	PICU patients do not receive their energy goals. Cardiac Surgical patients do worse. <u>Fluid restriction</u> in both groups is the major reason for inability to meet energy goal. Fasting for procedures and EN interruptions due to intolerance were other barriers to nutrition in this study.
Taylor ⁵⁴ 2003 Level III	Children admitted to PICU with length of stay \geq 3 d. Information on nutrition delivery recorded.	N = 95	59% were fed within 24 hours of admission EN was administered 54% of time. 10% received PN; 9.5% did not receive any nutrition support PICU pts received 58.8%, median (range 0 – 277%) of their energy intake goal. Energy intake was greater when supplemented by PN.	Poor % energy intake goal achieved with EN. Procedure-related feeding interruptions were significant. The study highlights the need for a proactive approach to bridge the gap between desirable and achieved nutrient

			<p>EN was interrupted 264 times (mainly for procedures). For up to 75% of study time, children had abnormal bowel patterns. 79% were constipated for 3-21 days. And 43% had diarrhea of unknown etiology.</p>	<p>intake.</p>
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5) IMMUNONUTRITION IN PICU

Based on the available pediatric data, the routine use of immunonutrition or immune-enhancing diets/nutrients in critically ill children is not recommended.

Grade D

Rationale:

The use of specific nutrients aimed at modulating the inflammatory or immune response has been reported for several years. Despite several RCTs employing immunonutrition in critically ill patients, a positive treatment effect of immunonutrition or the use of immune-enhancing diets (IED) has not been demonstrated. These studies are flawed by their poor methodology and small sample size. The studies were conducted using a variety of nutrients in combination that were administered to heterogeneous patient populations. The studies do not allow meaningful interpretation of the safety or efficacy of individual nutrients and fail to detect significant differences in relevant clinical outcomes. Arginine, glutamine, aminopeptides, omega-3 fatty acids and antioxidants are some of the nutrient studied for their immune modulation effects. Systematic review of immunonutrition studies in adults have cautioned against the use of arginine and other nutrients due to potential for harm in septic and critically ill patients⁵⁹. Fish oils, borage oils and antioxidants may

have a role in patients with acute respiratory distress syndrome (ARDS). Glutamine may have beneficial effects in adults with burn injury and trauma.

The role of immune-enhancing EN in children during critical illness has not been extensively studied. Briassoulis et al reported their results of a blinded RCT in children admitted to the PICU with expected length of stay (LOS) and need for mechanical ventilation of ≥ 5 d²². EN was started in these patients within 12 h of admission to PICU. Patients were randomized to receive either a formulation containing glutamine, arginine, omega-3 fatty acids and antioxidants or standard age-appropriate formulation. Protocolized increase in EN ensured that goal feeds were reached by d 4. The study did not show any outcome differences in the 25 children in each arm, although authors report a trend towards a decrease in nosocomial infection rates and positive gastric aspirate culture rates in the treatment arm. The immunologically active formula used in this study was not specifically tailored for children and transient diarrhea was noted in children receiving this formula, which had a higher osmolarity compared to the control formula. Another small pilot RCT reported improved outcomes in children fed with a glutamine-enriched formulations, although the numbers are too small for meaningful conclusions⁶⁰. The use of a specialized adult immune modulating enteral formula in pediatric burns victims with burn injury has been associated with improvement in oxygenation and pulmonary compliance in a retrospective review⁶¹.

Future Research:

Future pediatric studies in this field must focus on examining the effects of single (vs. combination of) nutrients, in large (multicenter) trials, on homogeneous PICU populations designed to detect differences in important outcome measures.

This approach will ensure that results allow meaningful inferences to be made about sound hypotheses on single immune modulating nutrients and prevent the current absence of strong conclusions despite a large amount of investment in this area of research in the adult ICU populations.

TABLE 6: Immune-Enhancing Nutrients in Critically Ill Children

<p>Briassoulis ²² 2005 Level II</p>	<p>Children admitted to the PICU, with an expected LOS and need for mechanical ventilation of ≥ 5 d. No renal disease No chronic gastrointestinal disease No PN EN started within 12 h of admission.</p> <p>Intervention group received the study Formula = Glutamine/Arginine/antioxidants (Zn, Vitamin E, beta carotene, copper, selenium) and omega-3 fatty acids</p> <p>Masking of formulations</p> <p>Protocols for EN delivery – Energy intake = 0.5, 1.1.25, 1.5 and 1.5 times predicted estimated energy requirement on d 1, 2,3,4 and 5 respectively. Thus, gradual increase in intake with goal</p>	<p>N = 50 (25 patients in each group)</p>	<p>Negative nitrogen balance noted on Day 1 in both groups.</p> <p>Increased serum osmolality, urea and sodium in intervention group.</p> <p>64% patients with positive nitrogen balance in intervention vs. 40% in control group by day 5.</p> <p>Caloric intake was 120% predicted basal metabolic rate.</p> <p>No changes in mortality.</p> <p>Decreasing trends in nosocomial</p>	<p>Mortality was not affected (but sample size is small). The trends in decreased nosocomial infection and gastric cultures are not statistically significant. Formulation not adapted to children.</p>
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	<p>feeds to be reached by d 4.</p> <p><u>NOTE:</u> Energy intake was predicted using FAO equations with Schofield modifications and with stress factors.</p>		<p>infection rates and positive gastric aspirate culture rates; $p < 0.05$.</p> <p>Transient diarrhea - possibly due to increased osmolarity of study formulation.</p>	
<p>Barbosa⁶⁰</p> <p>1999</p> <p>Level V</p>	<p>Infants (1 m – 2 y of age) admitted to PICU and tolerating EN for at least 5 d. Diagnosis of sepsis / respiratory failure</p> <p><u>Exclusion:</u> Shock, Multiple organ failure, AIDS, HIV positivity, immunosuppressant drugs, cancer, chemotherapy, recent surgery, diabetes mellitus, hepatic or renal failure.</p> <p>2 groups randomized to receive glutamine (commercial EN formulation), casein + semi-elemental formulation.</p> <p>100 kcal/kg/d and 3 g protein/kg/d</p>	<p>N = 9 5 – Glutamine 4 - control</p>	<p>Bacterial infections in 75% of placebo (3/4) vs. 20% in treatment group.</p> <p>Deaths 2/4 in placebo and 0/5 in glutamine group</p> <p>Duration of mechanical ventilation, LOS in ICU and hospital were similar in both groups.</p>	<p>Very small study.</p>

6) NUTRITION SUPPORT TEAM AND FEEDING PROTOCOLS

A specialized nutrition support team in the PICU and aggressive feeding protocols may enhance the overall delivery of nutrition, with shorter time to goal nutrition, increased delivery of EN and decreased use of PN.

The effect of these strategies on patient outcomes has not been demonstrated.

Grade E

Rationale:

Despite its widespread application, the practice of providing EN in the PICU is highly variable. A significant portion of children on EN do not meet their caloric goal due to a multitude of reasons. Some studies have assessed the role of a dedicated nutrition team and the use of protocols and standardized prescriptions for nutrition support therapy to implement optimal nutritional practices in the PICU. A dedicated nutrition support team (NST) has become an integral part of the multidisciplinary critical care group. Recent surveys demonstrate the presence of such a team during rounds and their availability for expert advice and help in many centers around the world. The role of the NST is evolving and the clear benefit on patient outcomes in the PICU is debatable. Gurgueira et al examined historical cohorts of children admitted to their PICU at different intervals during a phased implementation of a specialized NST⁶². In their single center retrospective review of 323 patients over 5 years, the authors reported an increase in EN rate from 25% to 67% with a

significant decrease in PN rates. The enhanced use of EN correlated with the implementation of the NST. Children in this study, who received EN during >50% of their LOS, had 83% lower risk of death. A similar historical cohort review by Lambe et al failed to show any significant difference in nutrition outcomes (time to achieve sustained optimal caloric goal, energy and protein balance) in the PICU population before and after implementation of a specialized NST⁶³.

Feeding protocols may assist in implementing early enteral feeds in critically ill children. Although the benefits of such an approach in affecting important clinical outcomes in the PICU population have not been examined in RCTs, prospective cohort studies have demonstrated reasonable tolerance of feedings and improved time to achieving goal EN^{52, 64}. If indeed early EN is associated with improved patient outcomes, implementation of an early aggressive EN protocol may be desirable and could be assisted by a specialized nutrition support team. Such protocols may identify caloric goal, route and time of initiation of EN, type of formulation, rate of increase in infusion rate and time to reach caloric goal. In addition, protocols may use prokinetic medication therapy to enhance EN tolerance⁶⁵. However, despite the sporadic application of feeding protocols and guidelines in the PICU, there is lack of systematic evidence to support their use.

Future Research

The role of a specialized nutrition support team in the PICU in improving the accuracy of prescribed nutrition support, monitoring of nutrition status, identification of metabolic alterations, selecting subjects for indirect calorimetry and overall cost benefit of such a team needs further examination.

TABLE 7: Nutrition Support Team and Protocolized Feeding

Citation	Population Intervention Outcome measures	Patient #	Clinical Outcome	Comments
Gurgueira ⁶² 2005 Level IV	Children in a PICU Retrospective examination of variables during a phased introduction of nutrition support team (NST) EN vs. PN, EN d/ LOS (d) x 100 PN d/ LOS (d) x 100 No nutrition (d) / LOS x 100	N = 323 (Historical cohorts from 5 time periods studied)	EN administration increased from 25% to 67% by 5 years (medical patients) PN administration decreased from 73% (medical) and 69% (surgical) to 0%; p = 0.0001. 83% lower risk of death in pts receiving EN for > 50% LOS; OR 0.17 (CI 0.06 – 0.41); p < 0.001).	Single center experience. Retrospective data analysis. However, significant reduction in PN use and associated mortality benefit.
Lambe ⁶³ 2007 Level IV	PICU Retrospective review. Time to achieve SOCI (sustained optimal caloric intake), cumulative caloric and protein deficits. Cohorts compared; before and after nutrition support team (NST) institution	N = 82 41 in each time period	No significant difference in outcomes between the 2 groups.	Retrospective review. Weekly NST intervention may not be enough to impact on outcomes in this study.
Petrillo-Albarano ⁶⁴ 2006 Level III	PICU patients who were fed via nasogastric tube. <u>Early EN protocol</u> – start within 6h of admission; physician order; min of twice weekly weighing;	N = 91 (Pre protocol) N = 93 (Post protocol)	Protocol vs. Retrospective group; Time to Goal (18.5 h vs. 57.8 h); p<0.0001 Diarrhea (12% vs. 2%); p=0.009.	This study demonstrates improved time to goal and tolerance to EN after introduction of an aggressive early

	<p>prealbumin level every 7 days; goal feeding and fluid requirements according to age; defined feed intolerance (aspiration, abdominal distention, vomiting and diarrhea 6/d). metoclopramide, docusate + senna) for constipation or prophylactic if on narcotics.</p> <p>Comparison chart review – Time to achieving goal nutrition, tolerance and LOS.</p>		<p>Constipation (51% vs. 33%); p=0.012.</p> <p>Rates of abdominal distension, aspiration and actual feed interruption for intolerance were not significantly different between the 2 groups.</p>	EN protocol in the PICU.
<p>Briassoulis⁵² 2001 Level III</p>	<p>PICU Prolonged mechanical ventilation requirement</p> <p>Full strength gastric tube feeds started within 12 h of study entry and gradually increased to a caloric target.</p> <p>Caloric intake was recorded.</p>	N = 71	<p>Caloric intake equal to the predicted basal metabolic rate and predicted energy expenditure were achieved by day 2 and 4 respectively. Patients tolerated the early aggressive EN well (success rate 94.4%). Successful protocolized feeding was correlated with survival (p < .0001).</p> <p>The PICU mortality rate (5.6%) was different between success (1.5%) and failure (75%) groups (p < .0001) and was lower than the one predicted by the</p>	The authors have demonstrated an association between achieving predicted caloric goals (using early EN initiation) and outcome.

			<p>admission severity scores (12.1 ± 2%).</p> <p>Fifty-four of the study patients were discharged on intragastric feedings (76.1%) and 15 on oral feedings (21.1%).</p>	
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Notice

These A.S.P.E.N. Clinical Guidelines are general. They are based upon general conclusions of health professionals who, in developing such guidelines, have balanced potential benefits to be derived from a particular mode of medical therapy against certain risks inherent with such therapy. However, the professional judgment of the attending health professional is the primary component of quality medical care. The underlying judgment regarding the propriety of any specific procedure must be made by the attending health professional in light of all the circumstances presented by the individual patient and the needs and resources particular to the locality.

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