Pejman Rohani MD

Pediatric Gastroenterology and Hepatology Research Center

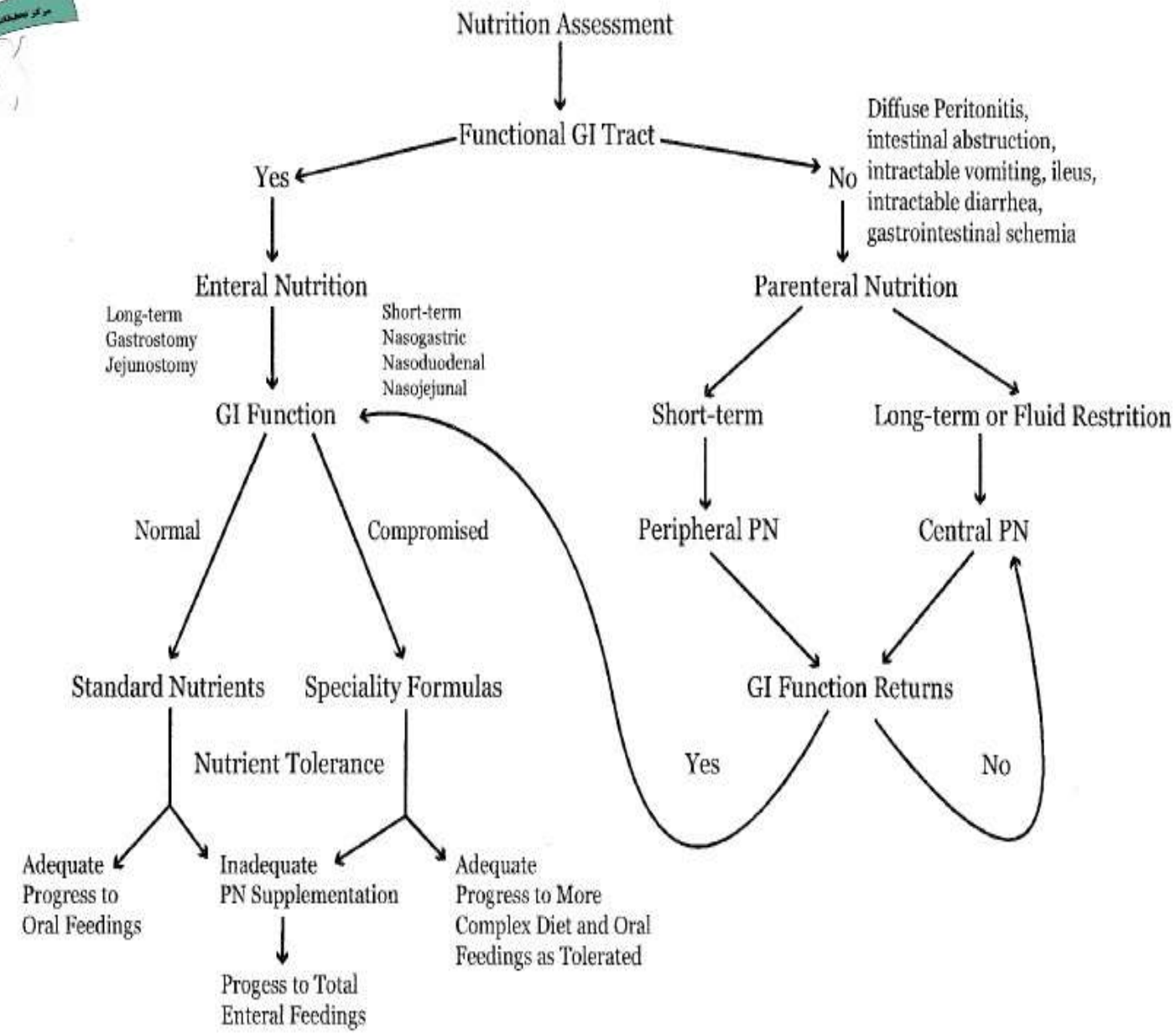
ESPGHAN Member

ESPGHAN PIBD Interest Group

Pediatric Center of Excellence

TUMS

Enteral Feeding in PICU


Nutrition Assessment
Functional GI Tract
Yes
No
Diffuse Peritonitis, intestinal abstruction, intractable vomiting, ileus, intractable diarrhea, gastrointestinal schemia
Enteral Nutrition
Parenteral Nutrition
Long-term
Gastrostomy
Jejunostomy
Short-term
Nasogastric
Nasoduodenal
Nasojejunal
GI Function
Short-term
Long-term or Fluid Restrition
Normal
Compromised
Peripheral PN
Central PN
Standard Nutrients
Speciality Formulas
GI Function Returns
Nutrient Tolerance
Yes
No
Adequate Progress to Oral Feedings
Inadequate PN Supplementation
Adequate Progress to More Complex Diet and Oral Feedings as Tolerated
Progess to Total Enteral Feedings

Q2: In critically ill children, when should enteral nutrition be commenced and how should it be increased?

R2.1: It is recommended to commence early enteral nutrition within 24 h of admission unless contraindicated

R2.2: It is recommended to increase enteral nutrition in a stepwise fashion until goal for delivery is achieved using a feeding protocol or guideline

Q6B. When should EN be initiated?

Q4A. Is EN feasible in critically ill children?

Q4B. What is the benefit of EN in this group?

Q5A. What is the optimum method for advancing EN in the PICU population?

R6B. Based on expert opinion, we suggest that EN be initiated in all critically ill children, unless it is contraindicated. Based on observational studies, we suggest early initiation of EN, within the first 24–48 h after admission to the PICU, in eligible patients. We suggest the use of institutional EN guidelines and stepwise algorithms that include criteria for eligibility for EN, timing of initiation, and rate of increase as well as a guide to detecting and managing EN intolerance

R4A. Based on observational studies, we recommend EN as the preferred mode of nutrient delivery to the critically ill child. Observational studies support the feasibility of EN, which can be safely delivered to critically ill children with medical and surgical diagnoses, and to those receiving vasoactive medications. Common barriers to EN in the PICU include delayed initiation, interruptions due to perceived intolerance, and prolonged fasting around procedures. Based on observational studies, we suggest that interruptions to EN be minimized to achieve nutrient delivery goals by the enteral route

R4B. Although the optimal dose of macronutrients is unclear, some amount of nutrient delivered as EN has been beneficial for gastrointestinal mucosal integrity and motility. Based on large cohort studies, early initiation of EN (within 24–48 h of PICU admission) and achievement of up to two thirds of the nutrient goal in the first week of critical illness have been associated with improved clinical outcomes

R5A. Based on observational studies, we suggest the use of a stepwise algorithmic approach to advance EN in children admitted to the PICU. The stepwise algorithm must include bedside support to guide the detection and management of EN intolerance and the optimal rate of increase in EN delivery

Q7.3: What is the recommended protein/amino acid intake?	Q3A. What is the minimum recommended protein requirement for critically ill children? Q3B. What is the optimal protein delivery strategy in the PICU? Q3C. How should protein delivery goals be determined in critically ill children?
R7.3a: For critically ill infants and children on enteral nutrition a minimum enteral protein intake of 1.5 g/kg/d can be considered to avoid negative protein balance	R3A. Based on evidence from RCTs and supported by observational cohort studies, we recommend a minimum protein intake of 1.5 g/kg/d. Protein intake higher than this threshold has been shown to prevent cumulative negative protein balance in RCTs. In critically ill infants and young children, the optimal protein intake required to attain a positive protein balance may be much higher than this minimum threshold. Negative protein balance may result in loss of lean muscle mass, which has been associated with poor outcomes in critically ill patients. Based on a large observational study, higher protein intake may be associated with lower 60-d mortality in mechanically ventilated children R3B. Based on results of randomized trials, we suggest provision of protein early in the course of critical illness to attain protein delivery goals and promote positive nitrogen balance. Delivery of a higher proportion of the protein goal has been associated with positive clinical outcomes in observational studies
R7.3b: There is insufficient evidence available to support the use of additional protein/amino acid intake during the acute phase of illness (Strong consensus)	R3C. The optimal protein dose associated with improved clinical outcomes is not known. We do not recommend the use of RDA values to guide protein prescription in critically ill children. These values were developed for healthy children and often underestimate the protein needs during critical illness

Protein requirements for critically ill children

EN protein requirements are age-dependent in children

Age	A.S.P.E.N. recommendations
0–2 years	2–3 g/kg/day
2–13 years	1.5–2 g/kg/day
13–18 years	1.5 g/kg/day

The minimum recommended daily protein intake for critically ill children is 1.5 g/kg body weight/day

Mehta NM, *et al. J Parenter Enteral Nutr* 2009;33:260-276.

Sources of protein (4 kcal/g)

- Key sources of protein for nutritional therapy are:
  - Milk proteins: whey, casein
  - Soy proteins
- All proteins are not digested at the same rate:
  - Whey empties from the stomach more rapidly than casein because it remains liquid and does not form a curd in the acidic environment of the stomach
  - In the small intestine, whey is digested and absorbed faster than casein.
  - Hydrolysed proteins (peptides) are easier to digest and more readily absorbed

Tolia V, *et al. J Pediatr Gastroenterol Nutr* 1992;15:297-301.

Managing protein requirements

- Protein needs can be determined by measuring urinary nitrogen excretion
- Protein retention can be increased by using a balanced glucose/fat solution
- Increasing protein intake cannot reverse protein breakdown, but it can improve nitrogen balance by enhancing protein synthesis

Skillman HE, Mehta NM. *Curr Opin Crit Care* 2012;18:192-198; Isla E, Joosten K. *Crit Care Nurs Clin North Am* 2005;17:385-393

Fat types and sources

Short chain fatty acids (SCFA)	• 2–4 carbons in length • Fermentation product of prebiotics, energy source for the gut wall
Medium chain triglycerides (MCT)	• 6–12 carbons in length • Do not require bile salts or pancreatic lipase for digestion → more rapidly digested and absorbed than LCT • Rapid source of energy
Long chain triglycerides (LCT)	• >14 carbons in length • Major energy source in diet • Essential fatty acids are LCT • Ensure absorption of fat-soluble vitamins
Fish oil	• Supplies long-chain fatty acids with strong anti-inflammatory properties (EPA and DHA)

EPA=eicosapentaenoic acid; DHA=docosahexaenoic acid

Carbohydrate and lipid requirements for critically ill children

Reasonable first-line goals (depending on the age of the child):

Carbohydrate	Lipid
Approximately 50–60% of total energy intake	30–40% of total energy intake

Goday PS, Mehta NM. Pediatric Critical Care Nutrition. McGraw-Hill Education. 2014; Lee JH, *et al. Asia Pac J Clin Nutr* 2015 (accepted).

Considerations for formula selection

Patient's disease state	Metabolic response to stress? Is GI tract accessible? Is gut compromised? Does patient require a disease-specific formula? Food allergy?
Nutritional goals	What are long-term requirements of the patient? Will EN be short- or long-term?
Current nutritional status	In severe malnutrition, gut function is compromised due to the gut wall becoming oedematous
Age	Consider nutritional requirements, nutritional status
Biochemistry/ Laboratory measurements	Very low albumin can be a predictor of oedema in the gut; pre-albumin can be used as an indicator of nutritional status; CRP can be a measure of inflammatory status

Q8: In critically ill children, do different feed formulas (polymeric vs. semi-elemental feed, standard vs. enriched formula) impact on clinical outcomes?	**NA**
R8.1 Polymeric feeds should be considered as the first choice for enteral nutrition in most critically ill children, unless there are contraindications	NA
R8.2 Protein and energy-dense formulations may be considered to support achievement of nutritional requirements in fluid-restricted critically ill children	NA
R8.3 Peptide-based formulations may be considered to improve tolerance and progression of enteral feeding in children for whom polymeric formulations are poorly tolerated or contra-indicated	NA
Q9: In critically ill children, does pharmaconutrition (glutamine, lipids and/or micronutrients) impact on clinical outcomes?	**Q8. What is the role of immunonutrition in critically ill children?**
R9.1 There is insufficient evidence to recommend the use of pharmaconutrition in critically ill children	R8. Based on available evidence, we do not recommend the use of immunonutrition in critically ill children
Q10: In critically ill children, does continuous feeding compared to intermittent bolus gastric feeding impact on outcomes?	**NA**
R10.1: There is no evidence to suggest that either continuous or intermittent/bolus feeds are superior in delivering gastric feeds in critically ill children	NA
Q11: In critically ill children, does gastric feeding compared to post-pyloric feeding impact on clinical outcomes?	**Q6A. What is the best site for EN delivery–gastric or small bowel?**
R11.1: Gastric feeding is as safe as post pyloric feeding in most critically ill children	R6A. Existing data are insufficient to make universal recommendations regarding the optimal site to deliver EN to critically ill children. Based on observational studies, we suggest the gastric route be the preferred site for EN in patients in the PICU. The post-pyloric or small intestinal site for EN may be used in patients unable to tolerate gastric feeding or those at high risk for aspiration. Existing data are insufficient to make recommendations regarding the use of continuous vs intermittent gastric feeding
R11.2: Gastric feeding is not inferior to post pyloric feeding in the majority of critically ill children	

Types of EN formula

Polymeric (intact protein/standard formula)	• Provide 1–2 kcal/mL, may or may not contain fibre • Require that patients can absorb intact macronutrients
Semi-elemental (peptide-based/ hydrolysed)	• Provide 1–1.5 kcal/mL • Contain pre-digested macronutrients (such as small peptides and MCT), making it easier for a partially dysfunctional GI tract to absorb them
Elemental (amino acid-based)	• Provide 1–1.5 kcal/mL • Contain 100% free amino acids with variable amount of MCT, making it easier for a severely impaired GI tract to absorb them
Modular	• Vary in energy content • Contain single macronutrients (protein, glucose polymers, or lipids)
Disease-specific	• Vary in protein, carbohydrate, lipid and vitamin and mineral content • For patients with disease-specific conditions such as renal impairment, hepatic disease, diabetes, and pulmonary disease, etc.

Examples of EN formulas for use in PICU (0–12 months)

Normal Gut Function	Impaired Gut Function
Expressed breast milk	Expressed breast milk
Standard infant formula or follow-on formula (>6 month) ± Fortifiers: • Formula • Carbohydrate powder • Fat	Lactose-free formula Semi-elemental (peptide-based/hydrolysed) Extensively hydrolysed formula Elemental formula *(All formulas above can be fortified)*
	Modular feed if above formulas not well tolerated. *(If used, will require individual manipulation and careful monitoring)*

Examples of EN formulas for use in PICU [1–6 years (8–20 kg)]

Normal Gut Function	Impaired Gut Function
Standard paediatric formulas (with or without fibre) • 1–1.5 kcal/mL	Hydrolysed paediatric formula (1 kcal/ml; may be concentrated up to 1.5 kcal/ml)
	Elemental paediatric formula (kcal/ml)

Examples of EN formulas for use in PICU [Liver/metabolic/renal disease]

- Metabolic
  - PKU, MSUD-specific feeds are available
- Renal
  - Low-to-moderate protein, low phosphate and potassium (pre-dialysis)
  - Moderate-to-high protein, low phosphate, normal potassium (on dialysis)
- Liver
  - 80% MCT, whole protein
  - 50% MCT, hydrolysed protein
- Chylothorax
  - High proportion of fat as MCT

Enteral feeding protocol (bolus and continuous)

	Bolus feeding			Continuous feeding		
	0-12 mo	1-6 y	＞7 y	0-12 mo	1-6 y	＞7 y
Initiation	10-15 mL/kg every 2-3 hours	5-10 mL/kg every 2-3 hours	90-120 mL/kg every 3-4 hours	1-2 mL/kg every hour	1 mL/kg every hour	25 mL/kg every hour
Advance	10-30 mL per feeding	30-45 mL per feeding	60-90 mL per feeding	1-2 mL/kg every 2-8 hours	1 mL/kg every 2-8 hours	25 mL every 2-8 hours
Suggested tolerance volumes	20-30 mL/kg every 4-5 hours	15-20 mL/kg every 4-5 hours	330-480 mL every 4-5 hours	6 mL/kg every hour	1-5 mL/kg every hour	100-150 mL every hour