PARENTERAL NUTRITION IN PEDIATRIC INTENSIVE CARE UNIT: PRACTICAL APPROACH

Nutrition in critically ill children: Systems Approach and “Omics Sciences”

Parenteral Nutrition – Indications

- Very low birth weight infants (birth weight < 1500 g)
- Inability to tolerate enteral feeds e.g. paralytic ileus, chemotherapy, radiation enteritis
- Small bowel obstruction
- Radiation enteritis
- Gastrointestinal fistula
- Hemodynamic instability with high risk of mesenteric ischemia (e.g., NEC in preterm infants, ECMO, shock, acute critical illness)
- Conditions associated with intestinal failure e.g., short bowel syndrome, diarrhea with irreversible malabsorption, pseudo-obstruction, intestinal epithelial disorders (microvillus inclusion disease, tufting enteropathy)

Parenteral Nutrition - Route of Administration

- Central versus peripheral venous access
  - Defined by where the tip of the catheter is positioned
  - Central
    - Tip is positioned in the superior or inferior vena cava or right atrium
    - Types: peripherally inserted central catheter (PICC), tunneled and non-tunneled central catheters, umbilical venous catheter, implanted port
  - Peripheral
    - Tip is not positioned in the superior or inferior vena cava or right atrium
    - Type: peripheral intravenous catheter
- Intradialytic PN

Fuhrman. *Nutr Clin Prac.* 2009;24(4):470-80
Brewer. *Am J Kidney Dis.* 1999;33:205-207.
ASPEN et al. *J Parenter Enteral Nutr.* 2002;26(1 Suppl):1SA-138SA.

Parenteral Nutrition - Peripheral vs. Central

Peripheral PN

- Used for <2 weeks
- Patient has no fluid restriction and nutrient needs can be met
- Osmolality 900-1000 mOsmol/L *
  - Maximum 10-12.5% dextrose

Central PN

- Used for >2 weeks
- Patient is fluid restricted and nutrient needs cannot be met by peripheral PN
- Peripheral access limited
- Can use hypertonic solutions

* Mirtallo et al. *J Parenter Enteral Nutr.* 2004;28(6):S39-70.

Parenteral Nutrition - Administration

- Type of solution
  - 2-in-1: dextrose and amino acids
  - 3-in-1: dextrose, amino acids and lipids
- Filters

0.22 micron filters	1.2 micron filters
Remove most pathogenic bacteria	Removes only *Candida* and large lipid droplets
Used only with 2-in-1 solutions; Lipid solutions are sheared by the smaller filters	Can be used with 3-in-1 solutions
Never remove a filter!	

Components of PN

- Non-protein energy
  - Carbohydrates (dextrose)
  - Fat (lipid)
- Protein (amino acids)
- Electrolytes
- Minerals, vitamins, trace elements
- Water
- Miscellaneous: heparin, medications (e.g. ranitidine)

Components of PN - Macronutrient Guidelines

	A.A.P.		A.S.P.E.N.	
	Weight	Daily Recommendation	Weight / Age	Daily Recommendation
Protein	10-20 kg	1-2.5 g/kg	>10 kg or 1-10 yrs	1-2 g/kg
	>20 kg	0.8-2 g/kg	11-17 yrs	0.8-1.5 g/kg
Energy / Caloric	10-20 kg	60-90 kcal/kg	>1-7 yrs	75-90 kcal/kg
	>20 kg	30-75 kcal/kg	>7-12 yrs	50-75 kcal/kg
			>12-18 yrs	30-50 kcal/kg
Fluid	>10-20 kg = 1000 mL + 50 mL/kg >10 kg			
	>20 kg = 1500 mL + 20 mL/kg >20 kg			
Carbohydrates (Dextrose)	10-20 kg	8-28 g/kg	Carbohydrates should comprise 40% to 60% of total caloric intake.	
	>20 kg	5-20 g/kg		
IV Fat Emulsion	>10kg	1-3 g/kg	The minimum fat requirement is determined by essential fatty acid need, and the daily maximum is 50% to 60% of energy.	

Kleinman RE. *Pediatric Nutrition Handbook 6th Edition* 2009:519-540.
Forchielli ML, Miller SJ. *The ASPEN Nutrition Support Practice Manual* 2005:38-53.
Pediatric Nutrition Support Core Curriculum. Editor: M Corkins. ASPEN, 2010.

Components of PN - Dextrose

- Major source of non-protein calories is D-glucose
- Typically provide 40 - 55% of caloric intake
- Monohydrate form provides 3.4 kcal/g
- Stepwise increase to allow appropriate response of endogenous insulin preventing glucosuria & osmotic diuresis
- Glucose increases osmolality (risk of phlebitis)

Estimation of Glucose Infusion Rate (GIR)

- GIR varies with the age of the patient
- Need 3 - 4 mg/kg/min to meet glucose utilization needs and to maintain normal blood glucose levels
- Maximal glucose oxidation rate under most circumstances 7 - 13 mg/kg/min
  - Above this rate, fat synthesis significantly increases leading to increased RQ (CO_2/O_2)
  - In presence of pulmonary disease, large energy intake may lead to CO_2 retention
  - Maximal glucose oxidation rate occurs with the following GIR
    - neonates and infants: 12.5 mg/kg/min
    - children & adolescents: 6 mg/kg/min
- GIR (mg/kg/min) = $\frac{\text{[Dextrose(g/dL) * Infusion Rate(ml/hr) * 0.167]}}{\text{wt (kg)}}$

  OR use an online calculator at:

  http://www-users.med.cornell.edu/~spon/picu/calc/glucinfr.htm

  or http://www.nicutools.org/ *(choose "glucose delivery " from list of calculators)*

Bresson et al. *Pediatr Res.* 1989; 25(6):645-8. Jones et al. *J Pediatr Surg.* 1993;28:1121.
Yunis et al. *J Pediatr.* 1989;115:127. Samor et al. *Handbook of Pediatric Nutrition 3rd* Ed. 2005: 533.
Koletzko et al. *J Pediatr Gastroenterol Nutr.* 2005;41(Suppl 2):S1-87.

Components of PN - Protein

- Functions of protein
  - Provides structure (e.g., muscle)
  - Provides function (e.g., enzymes, transport proteins)
  - Acts as a nitrogen donor to other compounds (e.g., nucleic acids, carnitine, taurine)
- Protein should not serve as an energy source
- Protein requirements vary by age and disease state
- Infants
  - Infants need conditional amino acids like histidine, taurine and cysteine because of immature synthetic abilities
  - Infant amino acid solutions are based on the serum amino acid pattern seen in breastfed infants
- Excess protein intake leads to hyperazotemia

Shulman et al. *J Pediatr Gastroenterol Nutr.* 2003;36:587–607.
Kleinman RE. *Pediatric Nutrition Handbook 6th Edition* 2009:519-40.
Forchielli et al. *The ASPEN Nutrition Support Practice Manual* 2005:38-53.

Examples of Amino Acid Solutions (per 100 mL)

		STANDARD		INFANT	
		Aminosyn® 10%	Novamine® 10%	Premasol™ 10%	TrophAmine® 10%
Essential	Isoleucine	0.72 g	0.6 g	0.82 g	0.82 g
	Leucine	0.94 g	0.73 g	1.4 g	1.4 g
	Lysine	0.72 g	0.58 g	0.82 g	0.82 g
	Methionine	0.40 g	0.40 g	0.34 g	0.34 g
	Phenylalanine	0.44 g	0.56 g	0.48 g	0.48 g
	Threonine	0.52 g	0.42 g	0.42 g	0.42 g
	Tryptophan	0.16 g	0.18 g	0.20 g	0.20 g
	Valine	0.8 g	0.58 g	0.78 g	0.78 g
Nonessential	Aspartic Acid	-	-	0.32 g	0.32 g
	Serine	0.42 g	0.50 g	0.38 g	0.38 g
	Glutamic Acid	-	-	0.50 g	0.50 g
	Alanine	1.28 g	2.07 g	0.54 g	0.54 g
	Proline	0.86 g	0.68 g	0.68 g	0.68 g
Conditionally Essential	Arginine	0.98 g	1.15 g	1.2 g	1.2 g
	Glycine	1.28 g	1.03 g	0.36 g	0.36 g
	Glutamine	-	-	0.50 g	0.50 g
	Taurine	-	-	0.025 g	0.025 g
	Cysteine	-	-	<0.016 g	<0.016 g
	Histidine	0.3 g	0.48 g	0.48 g	0.48 g
	Tyrosine	0.044 g	0.04 g	0.24 g	0.24 g

Amino Acid Requirements in PN

- Amino acids

	g/kg/day
Preterm	2.5-4.0
Term infant	2.2-3.5
Child: 5-20 kg 20-40 kg	1.0-2.5 1.0-2.0
Adolescent	0.8-2.0 *

*150 g/day maximum

- Increased protein needs
  - Malnutrition
  - Enteric/urinary protein loss
  - Stress
  - Drugs (e.g. corticosteroids)
  - Burns

Kashyup S. *Curr Opin Pediatr.* 2008;20:132
Denne SC. *Semin Neonatol.* 2001;6:377-82
Shulman et al. *J Pediatr Gastroenterol Nutr.* 2003;36:587–607.

Components of PN - Fat

- Fat
  - Concentrated source of calories
  - In children, only use 20% emulsion (provides 2 kcal/mL)
  - Currently in the U.S., lipid solutions are composed of triglycerides from soybean oil and safflower and emulsified by egg yolk phospholipid
- Minimum of 1-2% of calories from a combinations of linoleic and linolenic acid to meet EFA needs (met with 0.5-1.0 g/kg per day fat)
  - Serum triene:tetraene ratio is reflective of EFA status
  - A triene:tetraene ratio < 0.2 is generally considered to reflect EFA sufficiency
- Infused over 24 hours to maximize tolerance
- Monitor triglycerides to assess tolerance

Pediatric Nutrition Support Core Curriculum. Editor: M. Corkins. ASPEN, 2010.
Shulman et al. *J Pediatr Gastroenterol Nutr.* 2003;36:587-607.
Wolfram et al. *J Parent Ent Nutr.* 1978;2:634

Comparison of Lipid Emulsions*

Fatty Acids	Soy	Fish Oil	SMOF#
Linoleic	50	4	37
Linolenic	9	2	5
Oleic	24	15	55
Eicosapentaenoic	0	20	5
Docosahexaenoic	0	12	5
Arachidonic	0.1	2	1

* Approximate % total fatty acids

Soybean oil, medium chain triglycerides, olive oil and fish oil

http://www.fresenius-kabi.com/

nutrients MDPI

Review

Parenteral Nutrition and Lipids

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Table 2. Selected commercially available intravenous fat emulsion products.

Product Name	Lipid Source	Linoleic (%)	α-Linolenic (%)	ω-6: ω-3 Ratio	α-Tocopherol, mg/L	Phytosterols, mg/L
Intralipid® 10%, 20%, 30%	100% soybean oil	44–62	4–11	7:1	38	348 ± 33
Structolipid® 20%	64% soybean oil 36% MCT	35	5	7:1	6.9	NA
Lipofundin® MCT/LCT 10%, 20%	50% soybean oil 50% MCT oil	27	4	7:1	85 ± 20	NA
ClinOleic® 20%	20% soybean oil 80% olive oil	18.5	2	9:1	32	327 ± 8
SMOFlipid® 20%	30% soybean oil, 30% MCT, 25% olive oil, 15% fish oil	21.4	2.5	2.5:1	200	47.6
Omegaven® 10%	100% fish oil	4.4	1.8	1:8	150–296	0

MCT: medium-chain triglyceride, ω-6: ω-3 Ratio: ratio of ω-6 fatty acids to ω-3 fatty acids, NA: not available. A Adapted from [3,6,14].

SMOFlipid 20%

óleo de soja + triglicerídeo de cadeia média + óleo de oliva + óleo de peixe

Forma farmacêutica e apresentações:
Emulsão injetável

200 mg/mL
Caixa contendo frasco de vidro com 100 mL ou 500 mL.

USO INTRAVENOSO

USO ADULTO E PEDIÁTRICO

COMPOSIÇÃO:
Cada 1.000 mL contêm:
óleo de soja....................................60,0 g (6%)
triglicerídeo de cadeia média...........60,0 g (6%)
óleo de oliva...................................50,0 g (5%)
óleo de peixe...................................30,0 g (3%)
água para injetáveis q.s.p................1000,0 mL
Excipientes: lecitina de ovo, glicerol, oleato de sódio, hidróxido de sódio, racealfatocoferol e água para injetáveis.

Osmolaridade teórica.. aprox. 290 mOsm/L
Valor de pH...aprox. 8,0
Energia total:...8,4 MJ/L (= 2000 kcal/L)

0,2g lipid/ml

Suggested Doses for Lipids

	Starting Dose (g/kg/day)	Maximum Dose (g/kg/day)
Neonate/Infant	1	3
Children	1	2
Adolescent/Adult	0.5	1

Pediatric Nutrition Support Core Curriculum. Editor: M. Corkins. ASPEN, 2010.
ASPEN. *J Parenter Enteral Nutr.* 2002;26(1 Suppl):1SA-138SA

Calcium and Phosphorus

- There are limitations to amounts of Ca and Phos that can be supplied in PN
- Ca and Phos can precipitate depending on the amounts added to the PN solution
- Cysteine lowers pH and may be added to neonate/infant PN (by using TrophAmine®) to increase solubility of Ca and Phos

Pediatric Nutrition Support Core Curriculum. Editor: M. Corkins. ASPEN, 2010.
Greene et al. *Am J Clin Nutr.* 1988;48:1324-42

Multivitamin Requirements with Examples of some Multivitamin Products

	Preterm (per kg)[+]	Term infants & children > 1 yr[++]	MVI Ped® (5ml)[+++]	MVI 12® (5 ml)[++++]
Vitamin A, IU	700-1500	2300	2300	3300
Vitamin E, IU	3.5	7	7	10
Vitamin D, IU	40-160	400	400	200
Vitamin K, mg	0.1	0.2	0.2	0
Thiamine, mg	0.2-0.35	1.2	1.2	6
Riboflavin, mg	0.15-0.2	1.4	1.4	3.6
Vitamin B6, mg	0.15-0.2	1	1	6
Niacin, mg	4-6.8	17	17	40
Biotin, mcg	8	20	20	60
Pantothenic acid, mg	1-2	5	5	15
Folate, mcg	56	140	140	600
Vitamin B12, mcg	0.3	1	1	5
Vitamin C, mg	15-25	80	80	200

+Tsang RC et al. *Scientific Basis and Practical Guidelines*, 2ndEd 2005; pp.415-16.
++ Greene et al. *Am J Clin Nutr.* 1988;48:1324-42.

Dosing Recommendations for Pediatric Parenteral Multiple Vitamins *

Manufacturer Recommendations		NAG-AMA Recommendations◊	
Weight (kg)	Dose (mL)	Weight (kg)	Dose (mL)
< 1	1.5	< 2.5	2 mL/kg
1-3	3.25	> 2.5	5 mL
> 3	5		

* MVI-Pediatric®; assumes normal organ function

◊ Nutrition Advisory Group-American Medical Association

Nutrition Advisory Group AMA. *J Parenter and Enter Nutr.* 1979;3(4):258-262.
Shulman et al. *Pediatric Nutrition Support.*. 2007;p273-85.

Components of PN - Trace Elements

Mineral	Multitrace®-4 (per mL)	Multitrace®-4 (per mL)	Multitrace®-5 Concentrate (per mL)
	Neonatal	Pediatric	(Adolescent/Adult)
Zinc (as Sulfate)	**1.5 mg**	**1 mg**	**5 mg**
Chromium (as Chloride)	**0.85 mcg**	**1 mcg**	**10 mcg**
Selenium (as Selenious Acid)	**none**	**none**	**60 mcg**
Copper (as Sulfate)	**0.1 mg**	**0.1 mg**	**1 mg**
Manganese (as Sulfate)	**25 mcg**	**25 mcg**	**0.5 mg**

American Regent Product Catalog. http://www.americanregent.com/

Components of PN - Iron (Fe)

- Not typically part of standard PN though Fe deficiency is common in patients receiving PN
- Addition of parenteral Fe is controversial because of the potential risk of increased sepsis and because Fe is an oxidant
- Consider in patients who have been NPO for > 2 months
- Avoid Fe in infants until age 2 months because of frequent blood transfusions and the possibility of Fe overload
- Parenteral Fe preparations
  - Fe dextran is the only iron prep that can be given in PN
  - Fe dextran is incompatible with fat emulsions and 3-in-1 solutions
  - Consider daily or weekly dose in bags that do not contain lipid or in 2-in-1 solutions
- Intravenous dose for Fe dextran
  - 0.1 - 0.2 mg/kg per day for infants (age > 2 months) and children
  - 2 – 6 mg per day for older children and adolescents
- Continued monitoring of Fe status is recommended to prevent Fe overload

Khaodhiar et al. *J Parenter Enteral Nutr.* 2002;26(2):114-19.

Components of PN - Miscellaneous

- Heparin 0.5 - 1 Unit/mL
  - May be added to prevent thrombophlebitis
  - Stimulates lipoprotein lipase and improves triglyceride clearance
- Insulin
  - May be used in patients with hyperglycemia
- Ranitidine
  - Compatible with PN when required
- Iodine
  - Not typically added to PN solutions
  - Currently may need to be added because of decreased use of iodine containing topical antiseptics.
- Be aware of compatibility issues with additives
  - Consult with your pharmacist

Components of PN - Designing a Regimen

- Estimate energy needs
  - Based on age of patient, disease state, severity of illness, activity level and need for catch-up growth
- Calculate fluid needs
- Estimate protein needs
- Obtain baseline laboratory values of serum electrolytes, minerals and triglycerides
- Start with 10% dextrose solution
- Can start with intravenous lipid at lowest end of dose range and make sure triglyceride levels are within acceptable levels when increasing dose
- Advance regimen to goal caloric and fat intake based on laboratory testing and other clinical evidence

Pediatric Nutrition Support Core Curriculum. Editor: M. Corkins. ASPEN, 2010.

Components of PN - Minerals & Acid-Base Balance

- Determining starting doses
  - Use accepted guidelines
  - Consider baseline electrolyte and mineral levels
  - Consider other sources of electrolyte and minerals (intravenous fluids, other sources of electrolytes and minerals)
- Check labs within 24 hours of initiation of PN and adjust levels accordingly
  - Consider other additional electrolyte and mineral supplements patient received and adjust PN dosages accordingly
- Acid-base abnormalities can be treated by addition or removal of sodium or potassium acetate
  - Acetate = bicarbonate precursor
  - Bicarbonate contraindicated in PN
    - Ca/Phos precipitation
    - high Na load

Pediatric Nutrition Support Core Curriculum. Editor: M. Corkins. ASPEN, 2010.

Parenteral Nutrition - Transitioning to Enteral Feeds

- Enteral feeds should be started as soon as possible in trophic amounts (<20% of goal calories/volume)
- Once enteral feeds are tolerated, PN volume is weaned as feeds are increased
- Goal fluid volume for feeds may not result in goal caloric intake and enteral feeds may need to be concentrated to achieve goal caloric intake
- Cycling PN during the transition to enteral feeds is useful: in infants and young children, continuous feeds will help with maintenance of normal serum glucose levels and tolerance of cycled regimen

Parenteral Nutrition - Monitoring

- Growth
  - Weight
  - Length/height
  - Head circumference
- Laboratory
  - Electrolytes/minerals
  - Triglycerides
  - Liver and renal function
  - Hemoglobin
  - Trace element, carnitine and vitamin levels

Szeszycki et al. The aspen pediatric nut support core curriculum. 2010;1st edition:460-76.
Mascarenhas et al. Pediatric Gastrointestinal Disease. 2010;4th edition:964-77.

Parenteral Nutrition - Monitoring

	Initial	With Every Change in PN	Weekly until Stable	Monthly as indicated
Electrolytes	√	√	√	
Glucose	√	√	√	
Calcium	√	√	√	
BUN	√	√	√	
Creatinine	√	√	√	
Magnesium	√	√	√	
Phosphorus	√	√	√	
ALT	√		√	
AST	√		√	
Alkaline phosphatase	√		√	
Total protein	√		√	
Albumin	√		√	
GGT	√		√	
Prealbumin	√		√	
Triglycerides	√	√	√	
Conjugated bilirubin	√		√	
CBC	√		√	√
Iron studies				√
Trace elements				√
Vitamins				√

Parenteral Nutrition - Complications

- Infectious
- Mechanical
  - Infusate-related
  - Catheter-related
  - Occlusions
- Metabolic
  - Electrolyte-, mineral-, trace element- and vitamin-related
  - PN-Associated Liver Disease (PNALD)
  - Bone disease
  - Overfeeding and underfeeding
  - Refeeding syndrome
  - Allergy
  - Miscellaneous e.g. nephropathy

Pediatric Nutrition Support Core Curriculum. Editor: M. Corkins. ASPEN, 2010.

Parenteral Nutrition
Lipids & Essential Fatty Acid Deficiency (EFAD)

- EFAD can be seen within days of fat-free PN in neonates
- Deficiency is cumulative
- Can cause
  - decreased growth
  - skin and hair changes
  - increased susceptibility to infection,
  - poor wound healing
  - alterations in platelet function

- To avoid EFAD need minimum of
  - 2% to 4% of the total caloric intake as linoleic acid
  - 0.25% to 0.5% of total caloric intake as alpha linolenic acid
  - Met with minimum of 0.5g/kg per day IVFE
- Diagnosis: triene:tetraene ratio > 0.2 or linoleic acid levels
- In premature infants EFAD can be prevented by supplying 0.6 to 0.8 g/kg per day IVFE

Uauy et al. *Semin Pereinatol.* 1989;13:118-30.

Parenteral Nutrition - Refeeding Syndrome

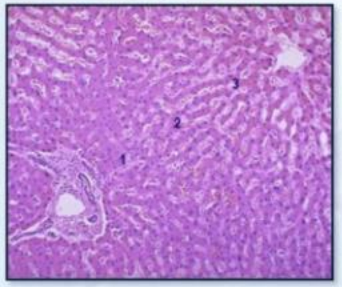
- Definition
  - Severe fluid and electrolyte shifts (especially Phos and K) in malnourished patients undergoing rapid nutritional rehabilitation either enterally or parenterally. Can be avoided by supplementation with Phos, Mg and K.
- Risk Factors
  - Chronic malnutrition, anorexia nervosa, morbid obesity with massive weight loss, patients not fed for 7-10 days with evidence of stress and depletion
- Clinical
  - Low serum Phos, Mg, and K levels, acute respiratory and circulatory collapse
- Treatment
  - Start with providing 50-75% estimated energy needs or give current intake.
  - Increase kcals by 10-20% daily until goal reached; monitor labs, vital signs, fluids.
  - Provide adequate protein.

Fuentebella et al. *Pediatr Clin North Am.* 2009;56(5):1201-10.

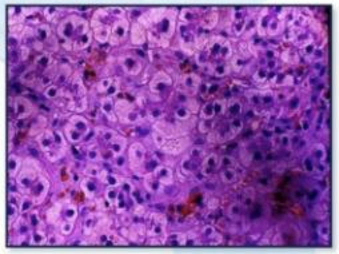
Parenteral Nutrition - Liver Disease I

- Well described complication of PN
- Develops in 40 – 60% of neonates; ~15% in children
- Variable degree of injury
  - Mild: mild cholestasis, gall stones, hepatic steatosis
  - Severe: can result in cirrhosis and liver failure
- Pathogenesis:
  - Multifactorial
  - Prolonged duration of PN
  - Lack of enteral feeding
  - Prematurity and low birth weight
  - Early and recurrent sepsis
  - Length of bowel remnant
  - Reduced enterohepatic circulation
  - Deficiency or toxicity of components of PN solutions (excess glucose, excess energy, AA content, Mn, Cu, and fat emulsions)

Normal Liver



Cholestasis



Ovchinsky N. *J Parent & Enteral Nutr.* 2010;34(5):472-73.

Parenteral Nutrition - Liver Disease II

Treatment

- Provide maximal tolerated EN
- Provide cyclical PN as soon as possible
- Consider and treat small bowel bacterial overgrowth
- Consider reducing intravenous lipids to 1g/kg per day, if conjugated bilirubin rises with no other explanation
  - Consider fish-oil based lipids, if the above strategy fails
- If transaminases, alkaline phosphatase or conjugated bilirubin continue to increase, consider commencing ursodeoxycholic acid

Gura et al. *Pediatrics* 2008;121(3):e678-86.
Koletzko et al. *J Pediatr Gastroenterol Nutr.* 2005;41(Suppl 2):S1-87.

Special Article

Guidelines for the Provision and Assessment of Nutrition Support Therapy in the Pediatric Critically Ill Patient: Society of Critical Care Medicine and American Society for Parenteral and Enteral Nutrition

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and clinical practice parameters for the critical care practitioner. New guidelines and practice parameters are continually developed, and current ones are systematically reviewed and revised.

These guidelines are being copublished by the American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) in the Journal of Parenteral and Enteral Nutrition (JPEN), 2017; 41:706–742.

Q2C. What is the target energy intake in critically ill children?	Quality of evidence: low
R2C. Based on observational cohort studies, we suggest achieving delivery of at least two thirds of the prescribed daily energy requirement by the end of the first week in the PICU. Cumulative energy deficits during the first week of critical illness may be associated with poor clinical and nutritional outcomes. Based on expert consensus, we suggest attentiveness to individualized energy requirements, timely initiation and attainment of energy targets, and energy balance to prevent unintended cumulative caloric deficit or excesses.	GRADE recommendation: weak

Q3A. What is the minimum recommended protein requirement for critically ill children?	Quality of evidence: moderate
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.	GRADE recommendation: strong
Q3B. What is the optimal protein delivery strategy in the PICU?	Quality of evidence: moderate
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.	GRADE recommendation: weak

Q2B. How should energy requirement be determined in the absence of IC?	Quality of evidence: very low
R2B. If IC measurement of resting energy expenditure (REE) is not feasible, we suggest that the Schofield or Food Agriculture Organization/World Health Organization/United Nations University equations may be used "without" the addition of stress factors to estimate energy expenditure. Multiple cohort studies have demonstrated that most published predictive equations are inaccurate and lead to unintended overfeeding or underfeeding. The Harris-Benedict equations and the RDAs, which are suggested by the Dietary Reference Intakes, should not be used to determine energy requirements in critically ill children.	GRADE recommendation: weak

Q7A. What is the indication for and optimal timing of PN in critically ill children?	Quality of evidence: moderate
R7A. Based on a single RCT, we do not recommend the initiation of PN within 24 hr of PICU admission.	GRADE recommendation: strong

Q7B. What is the role of PN as a supplement to inadequate EN?	Quality of evidence: low
R7B. In children tolerating EN, we suggest stepwise advancement of nutrient delivery via the enteral route and delaying commencement of PN. Based on current evidence, the role of supplemental PN to reach a specific goal for energy delivery is not known. The time when PN should be initiated to supplement insufficient EN is also unknown. The threshold for and timing of PN initiation should be individualized.	GRADE recommendation: weak
Based on a single RCT, supplemental PN should be delayed until 1 wk after PICU admission in patients with normal baseline nutritional state and low risk of nutritional deterioration. Based on expert consensus, we suggest PN supplementation in children who are unable to receive any EN during the first week in the PICU. In patients who are severely malnourished or at risk of nutritional deterioration, PN may be supplemented in the first week if they are unable to advance past low volumes of EN.	

Enteral nutrition remains the preferred route for nutrient delivery.

Several strategies to optimize enteral nutrition during critical illness have emerged.

The role of supplemental parenteral nutrition has been highlighted, and a delayed approach appears to be beneficial.

Immunonutrition cannot be currently recommended.

Overall, the pediatric critical care population is heterogeneous, and a nuanced approach to individualizing nutrition support with the aim of improving clinical outcomes is necessary.

(Mehta et al. *Pediatr Crit Care Med* 2017; 18:675–715)

Study Case

Tabela 1. Equações para o cálculo do Gasto Energético Basal (GEB).

Referência	Sexo	Idade	Equação para o GEB
(FAO/OMS, 1985)	Masculino	0 a 2 anos	60,9 x P – 54
	Feminino	0 a 2 anos	61 x P – 51
(Schofield, 1985)	Masculino	0 a 2 anos	(0,167 x P) + (15,174 x E) – 617,6
	Feminino	0 a 2 anos	(16,252) x P + (10,232 x E) – 413,5
(Schofield, 1985)	Masculino	0 a 2 anos	59,48 x P – 30,33
	Feminino	0 a 2 anos	58,29 x P – 31,05

P=peso (kg); I=idade (anos); E=estatura (centímetros).

- RAM, male, 2 years old was diagnosed with small bowel syndrome due to congenital bowel disease (removed big ileus portion and illeocecal valve). Physical examination: weight 9kg (<p3; p50 = 12kg) height 81cm (< p3; p50 = 88cm; WHO 2006; biological age = 1 year and 4 months). Lab results: Hg 10g/dl; Ht 31%; Ferritin 5ng/ml; Fe 40mcg/dl; transferrin 400mg/dl; glycemia 120mg/dl; albumin 3,1g/dl; CRP 1,0mg/dl; Na 128mEq/l; K 3,2mEq/l; Ca 0.9mmol/l; Mg 1,1mEq/l; P 3mEq/l. BMR requirement: Shofield – 613 kcal/day

Element	Reference
Sodium	≤1 year=≥129≤143mEq/L >1 year=≥132≤145mEq/L;
Potassium	>4 months – 1 year=≥3.6≤5.8mEq/L >1 year=≥3.5≤5.1mEq/L
Ionic calcium	≥1.15 ≤1.29 mmol/L
Magnesium	≤6 years=≥1.4≤1.88mEq/L 6-12 years=≥1.4≤1.72mEq/L ≥12 years=≥1.4≤1.8mEq/L
Chloride	≥96≤107mEq/L
Phosphorus	1 month- 1 year=M=≥3.5≤6.6mEq/L and F=≥3.7≤6.5mEq/L 4-6 years=M ≥3.3≤5.6mEq/L and F ≥3.2≤5.5mEq/L 7-9 years=M ≥3≤5.4mEq/L and F ≥3.1≤5.5mEq/L 10-12 years=M ≥3.2≤5.7mEq/L and F ≥3.3≤5.3 mEq/L 13-15 years=M ≥2.9≤5.1mEq/L and F ≥2.8≤4.8mEq/L

Tabela 6. Valores de referência para ferro sérico, capacidade de ligação do ferro, transferrina e ferritina segundo a faixa etária.

Grupo etário	Ferro (µmol/dL)	TIBC (µmol/dL)	TRF SAT	Ferritina (µg/L)
1 -5 anos	4 -25	48-79	0,07-0,44	6- 24
6 -9 anos	7-25	43-91	0,17-0,42	10-55
Masculino				
10-14 anos	5-24	54-91	0,11-0,36	23-70
14-19 anos	6-29	52-102	0,06- 0,33	23-70
Feminino				
10 -14	8 -26	57 -103	0,02 – 0,40	6,40
15-19	5-33	52- 102	0,06 -0,33	6,40

Adaptado de (Lockitch et al., 1988). TIBC = Total Iron Biding Capacity/ Capacidade total de ligação do ferro. TRF SAT= Cálculo de saturação da transferrina = Ferro sérico/TIBC x 100.

Tabela 7. Valores de referência de normalidade para ferro sérico.

Faixa etária	Concentração de ferro (µg/dL)			
	Pesce, 2009	Adriolo & Rotondi[a], 2005	CALIPER Study **	HCFMRP/USP
Todas as idades	22 -184	40 a 180 22 a 184*		M: 65 a 175 F: 50 a 170
0 a < 14 anos			16 a 128	
14 a < 19 anos			F: 20 a162 M: 31 a 168	

***Variações nos níveis de ferro sérico durante a infância. **Colantonio et al., 2012.**

Tabela 8. Valores de referência para a capacidade latente de fixação do ferro U.I.B.C.

	Capacidade latente de fixação do ferro U.I.B.C (µg/dL)	
Faixa etária	Pesce, 2009	HCFMRP/USP
Bebê	100-400	
Após esta fase	250-400	
Todas as idades		140 a 280

T.I.B.C(µg/dL) = U.I.B.C (µg/dL) + ferro sérico (µg/dL).

Tabela 4. Valores de referência do hemograma adotados pelo Hospital das Clínicas – FMRP/USP.

	1 a 7 dias	8-14d	15d < 2m	≥ 2 < 6m	≥6 <12m	≥1< 3a	≥3 < 6ª	≥6 <12a	≥12< 16a	≥ 16a
Hb (g/dL)	13,5-22,0	12,5-21,0	10,0-20,0	10,0-14,0	10,0-14,0	10,5-13,5	M: 10,5-13,5 F: 11,8-14,7	M: 12,0-14,0 F: 12,0-14,5	M: 12,8-16,0 F: 12,2-14,8	M: 13,5-17,5 F: 12,0-15,5
Ht (%)	42,0-60,0	39,0-60,0	31,0-55,0	28,0-42,0	28,0-42,0	33,0-40,0	M: 33,0-43,0 F: 35,0-44,0	M: 36,0-42,0 F: 36,0-43,0	M: 37,0-47,0 F: 36,0-43,0	M: 39,0-50,0 F: 35,0-45,0
HCM (pg)	28,0-40,0	28,0-40,0	28,0-40,0	26,0-34,0	25,0-35,0	27,0-35,0	M: 24,0-32,0 F: 25,0-32,0	M: 25,0-33,0 F: 27,0-33,0	25,0-35,0	26,0-34,0
VCM (fl)	88,0-120,0	86,0-120,0	85,0-110,0	77,0-110,0	74,0-89,0	74,0-89,0	74,0-89,0	M: 77,0-91,0 F: 79,0-90,0	M: 81,0-92,0 F: 80,0-92,0	M: 81,0-95,0 F: 82,0-98,0
CHCM (g/dL)	28,0-38,0	28,0-38,0	29,0-37,0	29,0-37,0	30,0-36,0	33,0-36,0	32,0-36,0	M: 31,0-36,0 F: 32,0-36,0	31,0-36,0	31,0-36,0
RDW (%)	12,0-14,5	12,0-14,5	12,0-14,5	12,0-14,5	12,0-14,5	12,0-14,5	12,0-14,0	M: 11,6-13,4 F: 12,0-14,0	M: 11,6-13,8 F: 11,2-13,5	M: 11,8-15,6 F: 11,9-15,5
Linf (10*6/µ)	2,0-17,0	2,0-17,0	2,5-16,5	4,0-13,5	4,0-10,5	1,5-7,0	1,5-7,0	1,5-6,5	1,2-5,2	0,9-2,9
Neut (10*6/µ)	1,5-10,0	1,0-9,5	1,0-9,0	1,0-8,5	1,5-8,5	1,5-8,5	1,5-8,5	1,5-8,5	1,8-8,0	1,7-8,0

Idade	1d < 6m	≥6m
PLQ(10*3/µ)	150,0-350,0	150,0-450,0

Hb=Hemoglobina. Ht=hematócrito. HCM=Hemoglobina corpuscular média. VCM=Volume corpuscular médio. CHCM=Concentração de hemoglobina corpuscular média. RDW=Red blood cell distribution width. Linf=linfócitos. Neut=Neutrófilos. PLQ=plaquetas. M=masculino. F=Feminino. d=dias. m=meses. a=anos.

Tabela 9. Valores de referência para ferritina.

	Concentração de ferritina (ng/mL)		
Valor de referência por faixa etária	Pesce, 2009	*CALIPER Study	HCFMRP/USP
Recém-nascidos	25,0 a 200,0		
1 mês	200,0 a 600,0		
2 a 5 meses	50,0 a 200,0		
6 meses a 15 anos	7 – 140		
4 a 14 dias		99,6 a 717,0	
15 dias a < 6 meses		14,0 a 647,2	
6 meses a < 1 ano		8,4 a 181,9	
1 a < 5 anos		5,3 a 99,9	
5 a < 14 anos		13,7 a 78,8	
14 a < 19 anos		F: 5,5 a 67,4	
14 a < 16 anos		M: 12,7 a 82,8	
16 a < 19 anos		M: 11,1 a 171,9	
Todas as idades			M: 28,0 a 397,0 F: 6,0 a 159,0

***Bailey et al., 2013. M=masculino. F=feminino.**

4.2 Valores de referência

Tabela 10. Valores de referência para transferrina.

	Transferrina (mg/dL)
Faixa etária	CALIPER study*
0 a < 9 semanas	104 a 224
9 semanas a < 1 ano	107 a 324
1 a < 19 anos	220 a 337

***Colantonio et al., 2012.**

	Recém-nascido	Pré-escolar	Escolar	Adolescente
Água:		50-120ml/kg/d até 2 anos ou: 1000ml + 50ml/kg para cada kg acima 10kg 120 x 9kg = 1080 ml/day	1500ml + 20ml/kg para cada kg acima 20kg	20ml – 40ml/kg/d
RNT	60ml/kg/dia			
RNPT	80ml/kg/dia			
Final da 1ª sem	120-160ml/kg/d			
Calorias:				
< 1 ano 1 – 3 anos 4 – 6 anos 7 – 10 anos 11 – 18 anos	RFA: 55 – 45kcal/kg Recuperação: 120 – 95kcal/kg Cardiopatas: 120 – 180kcal/kg RFA: 55 – 40kcal/kg Recuperação: 100 – 95kcal/kg	RFA: 50 – 40kcal/kg Recuperação:100kcal/kg 100 kcal x 9 kg = 900 kcal/d BMR = 613 kcal/d	RFA: 40 – 35kcal/kg Recuperação: 90 – 60kcal/kg	RFA: 35 – 25 kcal/kg Recuperação: 60 – 45 kcal/kg
RNPT	Basal: 70kcal/kg/dia Até 160kcal/kg/d (reserva 100kcal/kg; RNT 150kcal/kg)			
Relcalnptn/gN	150 - 200/1	150 - 200/1	150 - 200/1	150 - 200/1
Proteína:	1,4 – 2,5g/kg/d	3 anos: 1,2 – 2,2 4 – 6 anos: 1,2 – 2,0 1,5 g x 9 = 13,5g/day OR 2,5g x 9 = 22,5g/day	7 – 10 anos: 1,0 – 2,0	11 – 18 anos: 1,0 – 2,0
Lipídios:	0,5 – 3,5g/kg/dia	3-4g/kg/d 3 g x 9 = 27 g/day OR 2,5 g x 9 = 22,5 g/day	3-4g/kg/d	2-3g/kg/d
Sódio (mEq/kg/d):	2 - 5	2 – 3	2 - 3	1 – 3
Potássio (mEq/kg/d):	2 - 3	2 – 3	2 - 3	0,7 – 2,5
Cálcio:	Lactente: 210 - 270mg/d RNPT: 200mg/kg/d RNMBP: 240mg/kg/d	500 – 800mg/d ou 20 – 120mg/kg	1300mg/d	1300mg/d
Fósforo:	Lactente: 100 – 275mg/d RNPT: 120mg/kg/d RNMBP: 140mg/kg/d	460 – 500mg/d	1250mg/d	1250mg/d
Magnésio:	0,9 – 3 mEq/kg ou 30 – 75mg/d	0,9 – 1,5 mEq/kg ou 80 – 130mg/d	0,9 – 1,5 mEq/kg ou 240mg/d	0,9 – 1,5mEq/kg ou 240 - 410mg/d

Recomendações de eletrólitos para nutrição parenteral pediátrica

	DAVID(2001)				RIBEIRO JUNIOR(s.d)			Marchini et al (1998)		
Eletrólito	Neonato	Lactente/criança	Adolescente	TELES JUNIOR (1994)	Prematuro	Neonato	Criança/Adolescente	Pré-Termo/Neonatos	Lactentes/Crianças	Adolescentes
Cálcio**	3 a 4 mEq/kg	1 a 2,5 mEq/kg	10 a 20 mEq/dia	0,5 a 2,5 mEq/dia 10 a 50 mg/kg/dia	1 a 2 mEq/kg	4-5,2 mEq/kg ou 2 a 2,6 mmol/kg	0,3 a 2 mEq/kg 0,15 a 1 mmol/kg	3-4 mEq/kg	1-2,5 mEq/kg	10-20 mEq/dia
Magnésio máximo de 24 mEq/dia	0,3 a 0,5 mEq/kg	0,3 a 0,5 mEq/kg	10 a 30 mEq/dia	0,6 a 1 mEq/kg ou 7 a 10 mg/kg/dia	0,2 a 0,5 mEq/kg	0,3-0,65 mEq/kg	0,25 a 1 mEq/kg	0,3-0,5 mEq/kg	0,3-0,5 mg	10-30 mg
Fósforo máximo de 50 mmol/dia	1 a 2 mmol/kg	0,5 a 1 mmol/kg	10 a 40 mEq/dia	1 a 2 mmol/kg/dia ou 20 a 62 mg/kg/dia	0,5 a 2,0 mmol/kg	2-2,6 mmo/kg	0,65 a 2 mmol/kg	1-2 mEq/kg	0,5-1 mmo/kg	10-40 mEq/dia
Sódio Máximo de 150 mEq/dia	2 a 5 mEq/kg	2 a 6 mEq/kg		3 a 4 mEq/kg/dia	2 a 3 mEq/kg	2-6 mEq/kg	3 a 5 mEq/kg	2-5 mEq/kg	2-6 mEq/kg	50-80 mEq/dia
Potássio Máximo de 6 mEq/100 mL	1 a 4 mEq/Kg	2 a 3 mEq/kg		2 a 3 mEq/kg/dia	2 a 3 mEq/kg	2 a 3 mEq/kg	1 a 2 mEq/Kg	1-4 mEq/Kg	2-3 mEq/Kg	40-60 mEq/kg
Ferro	-	-	-	1 a 1,5 mEq/kg/dia	-	-	-	-	-	-
Cloro	-	-	-	-	-	-	-	1-5 mEq/kg	2-5 mEq/kg	-

	GARÓFOLO (2005) (mEq/kg/dia)				Mirtallo et al (2004)			FEFERBAUM (2005)		
Eletrólito	Pré-termo	Termo	1 a 10 anos	>10 anos	Pré-termo	Lactentes/Crianças	Adolescentes ou crianças > 50 kg	Dias de vida	Recém-nascido pré-termo	Recém-nascido a termo
Cálcio**	3-4,5	3 - 4	0,7 - 1,4	0,7-1,4	2 -4 mEq/kg	0,5-4 mEq/kg	10-20 mEq	-	1,5 mEq/kg/dia	1,5 mEq/kg/dia
Magnésio máximo de 24 mEq/dia	0,35-0,6	0,3-0,5	0,3-0,5	10 - 30	0,3 - 0,5 mEq/kg	0,3-0,5 mEq/kg	10-30 mEq	-	0,5 mmol/kg/dia	0,25 mmol/kg/dia
Fósforo máximo de 50 mmol/dia	2,7-4	1,5-3	0,7-1,4	0,7-1,4	1-2 mmol/kg	0,5- 2 mmol/kg	10-40 mmol	-	1,8 mmol/kg/dia	1,8 mmol/kg/dia
Sódio								1°dia de vida	0	0
Máximo de 150 mEq/dia								1° - 3° dia de vida	2 mEq/kg/dia	2 mEq/kg/dia
								3°- 5°dia de vida	3 mEq/kg/dia	4 mEq/kg/dia
	2,0 -3,0	2,0-5,0	2,0 -3,0	2,0 -3,0	2-5 mEq/kg	2-5mEq/kg	1-2mEq/kg	>7° dia de vida	3-5 mEq/kg/dia	3 mEq/kg/dia
Potássio								1°dia de vida	0	0
Máximo de 6 mEq/100 mL								1° - 3° dia de vida	0	0
								3°- 5°dia de vida	2,5 mEq/kg/dia	2,5 mEq/kg/dia
	2,0-3,0	1,0-4,0	2,0-5,0	2,0-3,0	2-4 mEq/kg	2-4 mEq/kg	1-2mEq/kg	>7° dia de vida	2,5 mEq/kg/dia	3-5 mEq/kg/dia
Ferro	-	-	-	-	-	-	-	-	-	-
Flúor	-	-	-	-	-	-	-	-	-	-

Fósforo: utilizado na forma de HPO4-2   1 mmol = 2 mEq(HPO4 -2) = 31mg
Cálcio: 1 mEq= 20 mg = 0,5 mmol
Potássio: 1 mEq = 1mmol = 39g
Sódio: 23 mg = 1 mEq = 1mmol
Magnésio: 1 mEq= 0,5 mmol = 12 mg
* 1mmol = 1 mEq/valência

NEONATO = 30 DIAS

LACTENTE = 12 MESES /24 MESES

	RECOMENDAÇÕES mEq
CÁLCIO	2,5 mEq/kg = 22,5mEq/d
MAGNÉSIO	0,5 mEq/kg = 4,5mEq/d
SÓDIO	4 mEq/kg = 36mEq/d
POTÁSSIO	2,5mEq/kg = 22,5mEq/d
FOSFATO	1 mmol/kg = 9mmol/d
FERRO	
CLORO	
FLÚOR	

Na 128mEq/l; K 3,2mEq/l; Ca 0.9mmol/l; Mg 1,1mEq/l; P 3mEq/l

A	B	C	D	E

CONCENTRAÇÕES DE ALGUMAS SOLUÇÕES USADAS EM NPT

SOLUÇÕES	QUANTIDADE EM mEq/mL	QUANTIDADE EM mg/mL
Acetato de sódio 10 %	1,2 mEq/mL	28 mg/mL de Na
Acetato de sódio 2 mEq/mL	2 mEq/mL de Na	46 mg/mL de N
Acetato de zinco 0,5 mEq/mL	0,5 mEq/mL de Zn	16,3 mg/mL de Zn
Bicarbonato de sódio 10%	1,2 mEq/mL de Na	27,4 mg/mL de Na
Cloreto de sódio 20 %	3,4 mEq/mL de Na	78,6 mg/mL de Na
Cloreto de potássio 19,1%	2,6 mEq/mL de K	100,1 mg/mL de K
Fosfato de potássio 2 mEq/mL	2 mEq/mL de k / 2 mEq/mL de P	79 mg/mL de K / 35 mg/mL de P
Gluconato de Cálcio 10%	0,5 mEq/mL de Ca	8,9 mg/mL de Ca
Sulfato de magnésio 10%	0,8 mEq/mL de Mg	9,9 mg/mL de Mg
Fosfato orgânico 12,54% 0,66 mEq/kg	0,66 mEq/mL de P;0,66 mEq/mL de Na	31,66 mg/mL de P

	RECOMENDAÇÕES mEq	FORNECIMENTO mEq	FONTE	mL
CÁLCIO	2,5 mEq/kg = 22,5mEq/d		Gluc Ca 10%	45 ml
MAGNÉSIO	0,5 mEq/kg = 4,5mEq/d		Sulf Mg 10%	5,6 ml
SÓDIO	4 mEq/kg = 36mEq/d		NaCl 20%	10,5 ml
POTÁSSIO	2,5mEq/kg = 22,5mEq/d	22,5 – 18mEq = 4,5mEq	KCl 19,1%	1,7 ml
FOSFATO	1 mmol/kg = 9mmol/d = 18 mEq/d	1 mmol = 2mEq	Fosf K 2mEq/ml	9 ml
FERRO	0			
CLORO	0			
FLÚOR	0			

Recém-Nascido > 3 kg

Polivit A = 1 ampola (10 mL/dia)

Polivit B = 1 ampola (5 mL/dia)

Complexo Vitamínico (mL)= According to availability and requirements

Recém-Nascido < 3 kg

Polivit A = 2/3 de ampola (6,5 mL/dia)

Polivit B = 2/3 de ampola (3,2 mL/dia_

Kanakion (vit K) = 0,5 mg 1xsem,i.m.

Remember Vit B12 IV and Vit K IM according to reccommendation

Multivitamin Requirements with Examples of some Multivitamin Products

	Preterm (per kg) +	Term infants & children > 1 yr ++	MVI Ped® (5ml) +++	MVI 12® (5 ml) ++++
Vitamin A, IU	700-1500	2300	2300	3300
Vitamin E, IU	3.5	7	7	10
Vitamin D, IU	40-160	400	400	200
Vitamin K, mg	0.1	0.2	0.2	0
Thiamine, mg	0.2-0.35	1.2	1.2	6
Riboflavin, mg	0.15-0.2	1.4	1.4	3.6
Vitamin B6, mg	0.15-0.2	1	1	6
Niacin, mg	4-6.8	17	17	40
Biotin, mcg	8	20	20	60
Pantothenic acid, mg	1-2	5	5	15
Folate, mcg	56	140	140	600
Vitamin B12, mcg	0.3	1	1	5
Vitamin C, mg	15-25	80	80	200

+Tsang RC et al. *Scientific Basis and Practical Guidelines*, 2ndEd 2005; pp.415-16.
++ Greene et al. *Am J Clin Nutr.* 1988;48:1324-42.

Dosing Recommendations for Pediatric Parenteral Multiple Vitamins *

Manufacturer Recommendations		NAG-AMA Recommendations◊	
Weight (kg)	Dose (mL)	Weight (kg)	Dose (mL)
< 1	1.5	< 2.5	2 mL/kg
1-3	3.25	> 2.5	5 mL
> 3	5		

* MVI-Pediatric®; assumes normal organ function

◊ Nutrition Advisory Group-American Medical Association

Nutrition Advisory Group AMA. *J Parenter and Enter Nutr.* 1979;3(4):258-262.
Shulman et al. *Pediatric Nutrition Support.*. 2007;p273-85.

Recomendações de oligoelementos para nutrição parenteral pediátrica										
Elementos traços	Marchini et al (1998)									
	Pré-termo Neonatos	A termo Neonatos	<1,5 kg	< 5 anos (mcg/kg)	Crianças	Adolescentes	Pré-termo < 3 kg (mcg/kg/dia)	A termo 3-10 kg (mcg/kg/dia)	Crianças 10-40 (mcg/kg/dia)	Adolescentes > 40 kg (mcg/dia)
Manganês	1 mcg/kg	1 mcg/kg	-	2-10 mcg/kg	50-150 mcg	50-150 mcg	1	1	1	40-100
Cobre	20mcg/kg	20 mcg/kg	-	20 mcg/kg	200-500 mcg	200-500 mcg	20	20	5 - 20	200-500
Cromo	0,2 mcg/kg	0,2 mcg/kg	-	0,14-0,2 mcg/kg	5-15 mcg	5-15 mcg	0,05-0,2	0,2	0,14-0,2	mai/15
Zinco	400 mcg/kg	300 mcg/kg	-	100 mcg/kg	2-5 mg	2-5 mg	400	50-250	50-125	2 - 5
Molibdênio	-	-	-	-	-	-	-	-	-	-
Selênio	-	-	-	-	-	-	1,5-2	2	1 - 2	40-60
Iodo	-	-	-	-	-	-	-	-	-	-

ELEMENTO	COMPOSIÇÃO DE PRODUTOS PEDIÁTRICOS mcg/mL			
	Zinc Vita	Neozinc	Oligoped 4	Ped Element
Zn	1000	200	100	500
Cu			20	100
Mn			6	10
Cr			0,17	1

Mineral	Multitrace®-4 (per mL)	Multitrace®-4 (per mL)	Multitrace®-5 Concentrate (per mL)
	Neonatal	Pediatric	(Adolescent/Adult)
Zinc (as Sulfate)	1.5 mg	1 mg	5 mg
Chromium (as Chloride)	0.85 mcg	1 mcg	10 mcg
Selenium (as Selenious Acid)	none	none	60 mcg
Copper (as Sulfate)	0.1 mg	0.1 mg	1 mg
Manganese (as Sulfate)	25 mcg	25 mcg	0.5 mg

TPN order

Recommendation	Order Day 1 (50%)	Goal Order	
Glucose 8 to 28g/kg 7 to 13mg/kg/min 40 to 60% calories	Glucose 50% - 160ml	Glucose 50% - 320ml	(160g = 544kcal = 18g/kg = 12,3mg/kg/min)
Protein 1,5 (13,5g) to 2,5g/kg (22,5g)	Aa 10% - 112,5ml	Aa 10% - 225ml	(22,4g = 90kcal)
Lipids 1 to 3g/kg Max. 50-60%cal	Lipid emulsion 20% - 50,5ml	Lipid emulsion 20% - 101ml	(2,5g/kg = 22,5g/day – 202kcal)
Na: 36mEq/day	NaCl 20% -10,5ml	According to exam	
P: 18mEq/day	Phosphate Potassium 2mEq/ml– 9ml	According to exam	
Mg: 4,5mEq/day	Magnesium sulfate 10% - 5,6ml	According to exam	
K: 22,5mEq/day	KCl 19,1% - 1,7ml	According to exam	
Ca: 22,5mEq/day (separately)	Gluc Ca 10% - 45ml	According to exam	
Oligoelements 1 ampoule (4ml)	1 ampoule (4ml)	1 ampoule (4ml)	
MVI 1 ampoule (5ml)	1 ampoule (5ml)	1 ampoule (5ml)	

THANK YOU…