

Chapter 35

Emergency Nutrition for Sick or Injured Infants and Children

Introduction

The goal of nutritional therapy in a critically ill infant or child is to provide sufficient calories and protein to spare mobilization of body reserves, prevent catabolism, promote wound healing, and protect from infection (Tables 35-1–35-3). In the initial phase of trauma or illness, metabolic rate decreases and the body becomes catabolic. As the patient becomes more stable, exogenous calories and protein can be used to promote anabolism. It is important to avoid both underfeeding, which can compromise healing, and overfeeding, which can lead to refeeding syndrome (see page 447).

Table 35-1. Average Weights and Heights for Age and Gender

Age	Males		Females	
	Length/Height (cm)	Weight (kg)	Length/Height (cm)	Weight (kg)
2–6 mo	62	6	62	6
7–12 mo	71	9	71	9
1–3 y	86	12	86	12
4–8 y	115	20	115	20
9–13 y	144	36	144	37
14–18 y	174	61	163	54
19–30 y	177	70	163	57

Table 35-2. Enteral and Oral Nutritional Needs (Nonspecific Range) in Infants and Children

Age (y)	Calories (per kg)	Protein (g/kg)	Distribution of kcals		
			Fat	Protein	Carbohydrate
0–1	80–120	2.5–3.5	35%–45%	8%–15%	45%–65%
1–10	60–90	2.0–2.5	30%–35%	10%–25%	45%–65%
11–18	30–75	1.5–2.0	25%–30%	12%–25%	45%–65%

Table 35-3. Parenteral Nutritional Needs (Nonspecific Range) of Infants and Children

Age (y)	Calories (per kg)	Protein (g/kg)	Distribution of kcals		
			Fat	Protein	Carbohydrate
0-1	80-120	2.0-2.5	35%-45%	8%-15%	45%-65%
1-10	60-90	1.7-2.0	30%-35%	10%-25%	45%-65%
11-18	30-75	1.0-1.5	25%-30%	12%-25%	45%-65%

Calories and Protein Needs

- Calorie needs are generally lower in extremely ill children than in healthy ones because of their lack of activity and catabolic state, which inhibits use of calories for growth; calorie needs will increase as the infant or child becomes stable
- Protein needs are elevated in sick infants and children, particularly those with open wounds, burns, or losses such as in diarrhea or ostomy output (Tables 35-4 and 35-5)

Table 35-4. World Health Organization’s Equations for Estimating Resting Energy Expenditures*

Age (y)	Resting Energy Expenditure (kcal/day)	
	Males	Females
0-3	$(60.9 \times \text{weight [kg]} - 54)$	$(61.0 \times \text{weight [kg]} - 51)$
3-10	$(22.7 \times \text{weight [kg]} + 495)$	$(22.5 \times \text{weight [kg]} + 499)$
10-18	$(17.5 \times \text{weight [kg]} + 651)$	$(12.2 \times \text{weight [kg]} + 746)$

*Use in combination with an activity factor and stress factor to determine total energy expenditure.

Data source: World Health Organization. *Energy and Protein Requirements: Report of a Joint FAO/WHO/UNU Consultation*. Geneva, Switzerland: WHO; 1985. Technical Report 724.

- Calorie and protein needs are best calculated using the child’s weight
 - If actual weight is not available, use the average weight for the child’s age, or measure the patient’s length and use the corresponding average weight (see Table 35-1)
 - ▶ **Note:** using average or ideal weights when calculating energy needs in severely malnourished patients can lead to serious metabolic intolerance (see Refeeding Syndrome and Overfeeding)

Table 35-5. Effects of Activity Factors and Stress Factors on Energy Requirements in Children

Type of Activity Factor	Multiply REE by
Nonambulatory, intubated, sedated	0.8–0.9
Bed rest	1.0–1.15
Mildly ambulatory	1.2–1.3
Type of Stress Factor	Multiply REE by
Starvation	0.70–0.9
Surgery	1.1–1.5
Sepsis	1.2–1.6
Closed head injury	1.3
Trauma	1.1–1.8
Growth failure	1.5–2.0
Burns	1.5–2.5
Cardiac failure	1.2–1.3

REE: resting energy expenditure

- Total Energy Expenditure (TEE) = Resting Energy Expenditure (REE) × Activity Factor (AF) × Stress Factor (SF) (see Tables 35-4 and 35-5)
 - ▶ **Example:** 4-year-old male who is paralyzed, has a closed head injury, and weighs 15.9 kg

$$\text{REE} = (22.7 \times 15.9) + 495 = 855 \text{ kcal}$$

$$\text{REE} \times 0.8 \text{ AF} \times 1.3 \text{ SF} = 889 \text{ kcal}$$

Refeeding Syndrome

- Refeeding syndrome occurs when a malnourished patient is rapidly refeed
 - Catabolism of fat and muscle leads to loss of lean muscle mass, water, and minerals, with total-body depletion of phosphorus (serum levels may remain normal)
 - When carbohydrates are given, insulin is released, enhancing uptake of glucose and phosphorus and increasing protein synthesis
 - This leads to a deficiency in phosphorus-containing compounds, which results in cardiac and neuromuscular dysfunction, anemia, and acute ventilatory failure
 - Potassium and magnesium stores may also become depleted; replace electrolytes as needed

- If laboratory data are not available, physical signs include muscle weakness, labored breathing, seizures, diarrhea, retching, and volume overload (Table 35-6)

Table 35-6. Metabolic Disturbances and Symptoms Associated With Refeeding Syndrome

Metabolic Disturbance	Symptoms
Hyperglycemia	Polyuria, polydipsia, polyphagia, weight loss, weakness, fatigue, blurred vision
Hypoglycemia	Decreased consciousness, sweating, anxiety, shakiness, palpitations, weakness, hunger, faintness, headaches, tremor, tachycardia
Hypophosphatemia	Respiratory failure, pyorrhea, fatigue, nervous disorders
Hypokalemia	Cardiac arrhythmia, muscle weakness, nocturia, elevated blood pressure or hypotension, atonia, paraesthesia, hyporeflexia
Hypomagnesemia	Seizure, muscle cramps, tetany, tremor, weakness, vertigo, dysphagia, confusion, hypocalcemia

- Treatment
 - Prevent by recognizing patients at risk
 - Slowly increase rate and concentration of carbohydrate delivery, maintain hydration, and measure electrolytes and blood glucose frequently; correct abnormalities
 - When beginning total parenteral nutrition (TPN) or tube feeding (TF), slowly increase the number of goal calories given per day
 - ▶ Give 50% of the patient's goal calories on day 1 of TPN or TF
 - ▶ Give 75% of goal calories on day 2 of TPN or TF
 - ▶ Give 100% of goal calories on day 3 of TPN or TF
 - With TPN patients, maintain a favorable distribution of calories from protein, carbohydrates, and fats

Overfeeding

Overfeeding can occur in any patient who is being fed more calories than needed. Overfeeding can cause metabolic and respiratory stress leading to hyperglycemia, diarrhea, tachypnea, carbon dioxide retention, and failure to wean off ventilation.

Because calculations for estimating energy needs are not exact, signs of overfeeding should always be considered whenever a patient is on nutrition support.

Tube Feedings

- Use an age-appropriate TF product, if available
 - Standard adult formulas are acceptable in children > 1 year old and can be used if they are the only type available
 - ▶ Protein content will be 1½–2-fold that of pediatric products
 - ▶ Avoid exceeding 4 g of protein per kilogram (higher protein concentrations will stress the kidneys; be sure fluid intake is adequate)
 - Minimum calories can usually be met, even while giving the maximum amount of protein
 - Additional calories can be given using vegetable oil (100 kcal/15 mL) and sugar (48 calories per 15 mL) or intravenous (IV) dextrose
- Goal rate for enteral feedings depends on caloric and fluid needs (Table 35-7)
 - If the patient is on IV fluids, adjust volume
 - Enteral feeds are advanced so calculated fluid requirements are not exceeded

Table 35-7. Guidelines for Initiating and Advancing Continuous Enteral Feeding

Age (y)	Initial Infusion	Incremental Advances
0–1	1–2 mL/kg/h	10–20 mL/kg/day
1–6	1 mL/kg/h	1 mL/kg q 2–8 h
> 7	10–25 mL/h	20–25 mL q 2–8 h

*Hourly infusion increases incrementally until goal calories are achieved.

Breast-Feeding

- Whenever possible, give breast milk (orally or enterally) rather than commercial formulas, particularly if powdered formulas need to be reconstituted with potentially contaminated water
- Breast milk can routinely be given to children up to age 2 or older and occasionally to children as old as 5 or 6
- If clean equipment is available to obtain pumped breast milk,

additional calories and protein can be added to expressed milk if the volume of the milk or the child's volume tolerance is limited

- If formula is necessary, the standard powdered infant type is recommended
 - One scoop (8–9 g) of infant formula powder added to 8 ounces of pumped breast milk will yield 24 calories per ounce
 - If necessary, add a carbohydrate from a clean source, such as granulated sugar (2 teaspoons per 8 oz breast milk will yield 24 calories per ounce)

Nutrient Needs in Specific Conditions

- Burns, open wounds, gunshot wounds, and fragment injuries
 - Give the mid- to upper range of calories (see Table 35-5)
 - Give the high value of protein
 - Supplement with vitamin C and zinc if available (otherwise use a standard multivitamin-mineral supplement)
- Ventilated, sedated, or paralyzed patients
 - Use lower-end calorie values (see Table 35-5)
 - Give goal protein value
- Sepsis
 - Give the midrange calorie value and goal protein
 - If the patient is febrile, use the upper-range calorie value and goal protein (see Table 35-5)
- Amputation

Table 35-8. Parenteral Electrolyte Needs

Electrolyte	Infants/Toddlers (Birth–2 y)	Children (2–11 y)	Adolescents (≥ 12 y)
Sodium	2–5 mEq/kg/day	3–5 mEq/kg/day	60–150 mEq/day
Potassium	1–4 mEq/kg/day	2–4 mEq/kg/day	70–180 mEq/day
Chloride	2–3 mEq/kg/day	3–5 mEq/kg/day	60–150 mEq/day
Calcium	0.5–4.0 mEq/kg/ day	0.5–3.0 mEq/kg/day	10–40 mEq/day
Magnesium	0.15–1.0 mEq/kg/ day	0.25–1.0 mEq/kg/day	8–32 mEq/day
Phosphorus	0.5–2.0 mmol/kg/ day	0.5–2.0 mmol/kg/day	9–30 mmol/day

Table 35-9. Signs of Specific Nutrient Deficiencies

Nutrient	Deficiency Symptoms
Protein	Kwashiorkor, weakness, lethargy, edema, ascites, fatty liver, dermatitis, depigmented hair, alopecia, decubitus ulcers, moon face, muscle wasting, growth failure, hypotension, cheilosis, stomatitis, delayed wound healing
Protein/ energy	Marasmus; dry, dull hair; drawn-in cheeks; carious teeth; ascites; diarrhea; weakness; irritability; increased appetite; muscle wasting; growth failure; other vitamin deficiencies
Fat/EFAs	Xerosis; flaking; scaly skin; dermatitis; follicular hyperkeratosis; dry, dull hair
Vitamin A	Eggshell nails, night blindness, dermatitis, taste changes, xerosis, keratomalacia
Vitamin C	Decubitus ulcers, perifolliculitis, petechiae, bleeding gums, swollen gums, stomatitis, bone pain, dry or rough pigmented skin, poor wound healing, anemia
Vitamin D	Rickets, bowed legs, prone to fractures, restlessness, frequent crying, sweating, muscular atony, weakness, scoliosis, back pain, bone pain, spinal changes
Calcium	Weight loss, muscle weakness, bone pain, skeletal deformities
Vitamin B ₁₂	Megaloblastic anemia, scarlet tongue, fatigue, weight loss, jaundice, oral mucosa ulcerations, dementia, sensory loss, yellow skin pallor, hypertrophy, gait sensory ataxia
Iron	Fatigue, weight loss, glossitis, stomatitis, tachycardia, tachypnea, thin or spoon-shaped nails
Zinc	Delayed wound healing, alopecia, night blindness, taste changes, decubitus ulcers, delayed wound healing, dermatitis, erythema, xerosis
Iodine	Goiter, outer third of eyebrow missing
Thiamine	Edema, weakness, irritability, burning feet, pruritus, nausea, vomiting, anorexia, muscle wasting, muscle tenderness and cramps, beriberi, photophobia, confusion
Niacin	Pellagra, dermatitis, diarrhea, dementia, red / scarlet tongue, erythema, depression, irritability, stomatitis, glossitis, cheilosis, hyperpigmentation
Folic acid	Megaloblastic anemia, skin pallor, stomatitis, scarlet tongue, glossitis, sensory loss, oral mucosa ulcerations
Riboflavin	Flaking, scaly dermatitis, conjunctivitis, magenta tongue, stomatitis, glossitis, cheilosis, hypertrophy

EFAs: essential fatty acids

- If no actual weight is available, estimate needs and ideal body weight based on metabolically active tissue

Total Parenteral Nutrition

- Premixed adult TPN solutions are higher in protein and some electrolytes, such as potassium (Table 35-8)
- Calculate the maximum volume of premixed adult TPN solution to avoid excessive intakes in a pediatric patient, then titrate in additional dextrose 50% to meet estimated calorie needs
- Maintain a balanced distribution of calories from protein, carbohydrate, and fat (see Table 35-3) to maintain nutrient efficiency and to minimize hepatic damage from TPN
- Watch for signs of specific nutrient deficiencies (Table 35-9)