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Malnutrition: A Hidden Problem in Hospitalized Children

Troy Gibbons, MBBS, and George J. Fuchs, MD

Introduction

Childhood undernutrition remains one of the greatest causes of morbidity and mortality. The World Health Organization (WHO) estimates that malnutrition contributes to 55% of childhood mortality worldwide.[1] Children with severe malnutrition, also known as protein energy malnutrition (PEM), typically are also deficient in various micronutrients, including zinc, copper, selenium, iron, vitamin A, vitamin C, and vitamin E, which can result in immune dysfunction and increased risk of infection, particularly persistent diarrheal disease and lower respiratory tract infection. The vicious cycle of pediatric malnutrition, immunodeficiency, and infection has long been recognized as a major cause of childhood morbidity and mortality.

Malnutrition can be categorized as primary or secondary malnutrition. In primary malnutrition, the main underlying cause is food insecurity, and this is the predominant form of malnutrition in developing countries. Although less common in economically developed nations, primary malnutrition occurs but usually in circumstances of extreme social neglect or poor nutritional intake arising from ignorance of proper infant feeding practices. In developed countries, the great majority of malnutrition is secondary and in association with an underlying disease process or disorder that predisposes the child to undernourishment. Survey data indicate the presence of severe malnutrition in a variety of settings, including the newborn and pediatric intensive care units and subspecialty wards of tertiary hospital centers, and is associated with adverse outcomes of morbidity, length of hospital stay, and mortality.[2,3] Indeed, as advances in medicine have contributed to the extended life span of chronically ill children, systematic nutrition surveillance and appropriate management to ensure adequate protein, energy, and micronutrient intakes have taken on an added importance. Unfortunately, this is often underappreciated, with subsequent development and underrecognition of malnutrition.

Classification of Malnutrition

The initial step in the management of malnutrition is recognition and diagnosis by anthropometry. The most commonly used indices are those of weight for age, height for age, and in particular, weight for length or height. Additional information can be obtained by other body composition indices, including mid–upper arm circumference and skinfold thickness.

Clinically, PEM broadly falls under one of two extremes, the severe loss of body weight that is marasmus or the edematous malnutrition of kwashiorkor. Conceptualization of PEM in this way has some disadvantages in its simplicity but also has practical significance and reflects differences in epidemiology, pathophysiology, treatment, and presumably etiology. Severe wasting is thought to be because of the slow and cumulative effect of the lack of an adequate intake in both energy and protein. A variety of potential insults have been proposed as a principal cause of kwashiorkor, including dietary protein deficiency, oxidative stress, aflatoxins, and depressed visceral protein synthesis reinforced by infection, among others.[4-6]

The severity of malnutrition is typically defined by the extent of negative deviation of the individual's anthropometric measurement from the average or median of a normal population and is expressed

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Table 1. Classification of Protein Energy Malnutrition, Children Less Than 10 Years of Age

	Moderate Malnutrition	Severe Malnutrition
Symmetric edema	No	Yes, Kwashiorkor
Weight for age		
SD score	−2 to −3	<−3
Percentage median	70-79	<70
Length for age		
SD score	−2 to −3	<−3
Percentage median	85-95	<85

Note: SD = standard deviation.
Source: adapted from Murray et al.[7]

as the percentage of median (percentage median) or standard deviation (SD) from the median (*z* score), with the latter considered a bit more precise (Table 1).[7] The presence of edema, regardless of the weight, indicates severe malnutrition.

Primary severe malnutrition is most common in preschool-aged children and is comparatively rare in adolescence apart from situations of food insecurity that occur in famine or civil unrest. In developed countries, severe malnutrition in adolescents is usually secondary and associated with chronic illness, including anorexia nervosa. The significant normal changes in body morphology and composition that occur with puberty present a challenge in anthropometric classification of malnutrition. The BMI (body mass index), which gives an indication of the degree of thinness, is often recommended to categorize the nutritional status of adolescents and adults, with a BMI less than the fifth percentile indicative of moderate to severe malnutrition.[8]

Management of Primary Malnutrition

Severe malnutrition, once identified, is considered a medical emergency. Case fatality among children in developing countries hospitalized with severe malnutrition has been disappointingly high during the last 5 decades and is attributed to faulty case management and lack of emphasis in medical and other health professional education curricula and programs.[9] The WHO published guidelines in 1999 for the management of severe malnutrition in the developing country hospital setting.[10] Implementation of these guidelines has resulted in a dramatic reduction in case fatality rates in centers across the world where

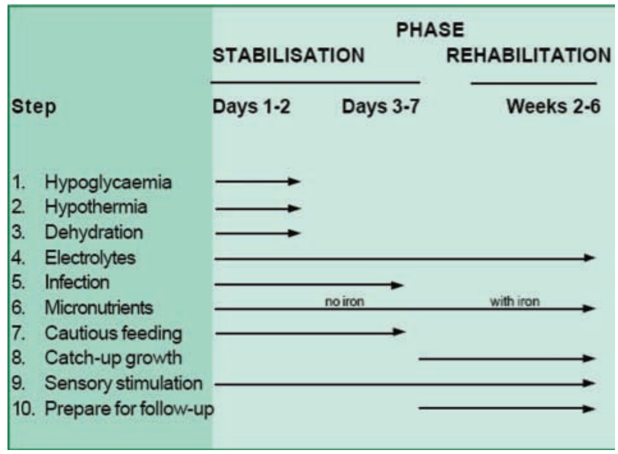

Figure 1. Stabilization and rehabilitation phases for managing severe undernutrition.
Source: Printed with permission from the World Health Organization.[10] Originally published in *Child Health Dialogue*. 1996;(3-4):10-12.

appropriately applied. These guidelines are based on 10 essential steps divided into 3 phases of management: stabilization, rehabilitation, and eventual follow-up (Figure 1).[10] The initial phase focuses on the stabilization of metabolic imbalances, electrolyte imbalances, and acute infections, including treatment of any associated medical emergencies such as shock, anemia, and associated illnesses. The rehabilitation phase is clinically identified by return of appetite, progressive weight gain, reduction of apathy, and increasing social interaction. Emphasis in this stage is on intensive refeeding to attain catch-up growth and restoration of social and emotional interactions, all of which are considered part of the recovery process. This phase is successfully completed when the child reaches −1 SD (90%) of the median weight for length. A major reason for the success of the WHO guidelines is that by being prescriptive in nature, they allow the use of validated guidelines by all health care workers who manage malnutrition and reduce the risk of adverse outcome based on invalidated discretionary management. Furthermore, they advocate only a few select laboratory tests and instead largely address complications, commonly referred to as refeeding syndrome in developed countries, in a preventive rather than reactive way. We recommend routine monitoring of blood phosphorous, magnesium, calcium, potassium, urea, nitrogen, and creatinine for the first 4 days of hospitalization and rehabilitation, after which blood tests are done only as indicated.

Secondary Malnutrition

Surveys of hospitalized children in developed countries conducted primarily in the 1980s attest to a high prevalence of malnutrition; approximately 30% of hospitalized children were malnourished.[11-15] The only institution that repeated a survey of hospitalized children[12] while using approximately the same method to assess nutritional status showed a decreased prevalence of acute malnutrition from one third of all hospitalized children to 24.5% from 1979 to 1995. During the same period, chronic malnutrition in hospitalized children decreased from 55% to 27.2%. Although the prevalence in malnutrition significantly declined by the second survey, the rate remains high from a clinical perspective.

Serious consequences of malnutrition in hospitalized adult patients were recognized as early as 1936.[16] More recently, Naber et al[17] showed that adult patients malnourished on admission developed more complications during their hospital stay than well-nourished patients. Information is comparatively scarce about the impact of malnutrition in hospitalized children in developed countries on the type and frequency of complications, length of hospital stay, or other adverse outcomes. Hospitalized malnourished children acutely or chronically ill, injured, or who have recently undergone a surgical procedure are more likely to experience increased risk for adverse outcomes compared with children who are not malnourished. The costs that can be directly or indirectly ascribed to malnutrition in hospitalized children are unknown. However, studies on adult hospitalized patients[18,19] show an increased length of stay and increased hospital charges for patients who are malnourished or at risk of becoming malnourished.

A wide variety of illnesses and risk factors are associated with undernutrition (Table 2). Anorexia may accompany a variety of medical or surgical illnesses. Abdominal pain or nausea on eating may be directly disease related, such as in inflammatory bowel disease, or may be a complication of specific therapies directed at the underlying disease, such as cancer chemotherapy. In many circumstances, iatrogenic causes precipitate or aggravate undernutrition, including the failure of systematic nutrition surveillance or early recognition of the child at risk for malnutrition. Extensive or prolonged diagnostic and therapeutic procedures often require *nil per os* status and result in inadequate intake. Children with significant neurodevelopment disorders dependent on their caregiver for nutrient provision are particularly vulnerable to inadequate intake because of ignorance, difficulties in chewing and swallowing, or gastroesophageal reflux.

Recognizing the importance of nutritional status on admission to hospital and the risk presented by chronic diseases, the Joint Commission on the Accreditation of Healthcare Organizations requires a focus on the timely assessment of the nutritional status of patients initially admitted to the hospital and continuous monitoring of the patient's response to nutritional care.[27]

Management of Secondary Malnutrition

The best approach to managing secondary undernutrition is to determine the point of failure in the process of nutrition. This can broadly be defined as problems associated with reduced nutritional intake, energy/nutritient malabsorption, or increased expenditure of energy, acting independently or in concert with one another (Table 2).

In secondary undernutrition, the specific disease etiology must also be addressed. The underlying disease may inherently imply the need for a greater intake than the "recommended daily caloric requirement for age" to sustain normal growth. Increased needs can result from increased catabolism resulting from chronic inflammatory processes (inflammatory bowel disease, cystic fibrosis), increased energy expenditure such as with respiratory work (chronic lung disease, congenital cardiac disease, cystic fibrosis) or muscular contractions of spasticity, and rapid growth rates (prematurity). Other pathological states are associated with known greater requirements for specific micronutrients and vitamins, such as malabsorption syndromes and chronic pancreatic and liver disease. Although much is known about the nutrition requirements of certain chronic illnesses, validated guidelines are often lacking or incomplete for the management of secondary undernutrition in many of these illnesses.

As with primary undernutrition, definition of the severity of undernutrition is an important initial starting point that determines the nutritional therapeutic plan. If severe undernutrition is identified,

Table 2. Diseases Associated With Undernutrition, Causes of Nutrition Inadequacy, and Special Concerns

Disease or Risk Factor	Cause of Inadequacy	Special Concerns
Preterm birth	• Increased energy expenditure for growth • Malabsorption as a result of secondary gut injury	• Immaturity of gut may require parenteral nutrition initially • At risk for severe gut injury (NEC), recurrent infections, chronic lung disease, sepsis
Short bowel syndrome	• Nutrient loss from malabsorption	• Varying micronutrient deficiency depending on region of intestine affected
Cystic fibrosis	• Nutrient loss from malabsorption caused by pancreatic insufficiency • Increased energy expenditure from chronic lung disease • Decreased oral intake as a result of recurrent respiratory infections, altered taste	• Adequate nutrition, no restriction on fat intake shown to improve pulmonary function[20] • Oral enzymes to maximize absorption • Difficult to attain high caloric goals by mouth • Long-term tube feeding should be considered[21] • Fat-soluble vitamin deficiency • Essential fatty acid deficiency • Sodium chloride depletion resulting from losses in sweat
Inflammatory bowel disease	• Increased energy expenditure from chronic inflammatory process/cachexia • Nutrient loss from malabsorption • Decreased oral intake as a result of abdominal pain, diarrhea and cachexia	• Medical control of underlying pathology • Undernutrition more significant in Crohn's disease compared with ulcerative colitis • Long-term growth significantly affected[22]
Chronic liver disease	• Nutrient loss from malabsorption • Inappropriate substrate use • Increased metabolic needs • Decreased oral intake as a result of abdominal pain, altered taste, cachexia (if prominent inflammatory component)	• Calorie intake 130% to 150% estimated requirement[23] • Provide adequate protein rich in BCAA (32%) • Micronutrient deficiency especially fat-soluble vitamins
Chronic renal disease	• Decreased oral intake as a result of altered taste, nausea, cachexia if underlying inflammatory component • Altered energy expenditure resulting from metabolic disturbances (uremia, acidosis)	• Nutrient requirements vary with age and severity of renal dysfunction[24] • Long-term growth significantly affected
Heart disease	• Decreased oral intake caused by fatigue and shortness of breath • Increased nutrient loss from malabsorption (intestinal loss from primary or secondary PLE)	• Genetic/congenital syndromes may play a role in inherent growth failure[25] • Infants may require up to 180 kcal/kg/d[26] • Hypoxia plays a role in growth failure, particularly if associated with lactic acidosis
Cancer	• Increased energy expenditure from cachexia • Decreased oral intake as a result of gut mucosal injury, altered taste, and cachexia • Nutrient loss from malabsorption caused by gut mucosal injury	• Periods of severe gut injury may require gut rest and temporary parenteral nutrition

Note: NEC = necrotizing enterocolitis; BCAA = branch chain amino acid; PLE = protein-losing enteropathy.

Table 3. The World Health Organization Equation Estimations of Resting Energy Expenditure (REE)

Age Range (years)	REE (kcal/d)
Boys	
0-3	60.9W − 54
3-10	22.7W + 495
10-18	17.5W + 651
Girls	
0-3	61.0W − 51
3-10	22.5W + 499
10-18	22.2W + 746

Note: W = weight (kg).
Source: adapted from reference 28.

Table 4. Schofield Equations for Estimation of Resting Energy Expenditure (REE)

Age Range (years)	REE (kcal/d)
Males	
0-3	0.167 W + 15.174 H − 617.6
3-10	19.59 W + 1.303 H + 414.9
10-18	16.25 W + 1.372 H + 515.5
Females	
0-3	16.252 W + 10.232 H − 413.5
3-10	16.969 W + 1.618 H + 371.2
10-18	8.365 W + 4.65 H + 200

Note: W = weight (kg); H = height (cm).
Source: adapted from Schofield.[29]

the conceptual framework of the WHO guidelines[10] for management of severe malnutrition is relevant and applicable to severe secondary malnutrition.

The type and means of nutritional rehabilitation may need to be modified depending on the child's underlying condition, such as renal insufficiency, heart failure, or short bowel syndrome. Various methods can be used to estimate the nutritional needs of children. These include dietary reference intakes (DRIs), the WHO[28] and Schofield[29] prediction equations for estimation of resting energy expenditure (REE), and direct measurement of REE.

DRIs are commonly used in North America and provide estimates for both macronutrients and micronutrients. DRIs are based on an estimation of the nutritional need of healthy individuals and do not address the requirements of acutely/chronically ill or malnourished children. The best way to determine the REE and daily energy requirements for any given individual is by indirect calorimetry; however, this is not routinely available in many clinical settings.

The WHO equations calculate REE based on age, gender, and weight groups (Table 3),[28] whereas the Schofield equations additionally use height to derive an estimated REE (Table 4).[29] Both WHO and Schofield calculations can then be adjusted by a fixed factor based on the underlying illness and physical activity (Table 5).[30]

Regardless of the method used, it must be emphasized that these are only estimates. Adjustments should be made based on objective measurements such as weight gain and laboratory data and, when needed, within the context of the underlying medical condition.

Table 5. Factors Used to Calculate Total Energy Needs Based on Selected Stress Conditions and Activity

Factor	
Activity	
Bedridden	1.20
Ambulatory	1.30
Fever	
Per degree Fahrenheit deviation	1.07
Injury	
Starvation	0.70
Minor surgery	1.00-1.20
Peritonitis	1.20-1.50
Soft tissue trauma	1.14-1.37
Skeletal trauma	1.35
Major sepsis	1.40-1.60
Thermal injury	2.00

Source: adapted from Long et al.[30]

Summary

Undernutrition remains a major cause of morbidity and mortality both in the developed and the developing world. Management of severe undernutrition is complex and multifactorial in nature. WHO guidelines for management of severe undernutrition should be considered as the standard approach, which can be modified depending on the clinical environment. As there are few validated protocols for management of secondary undernutrition in chronic illness, nutritional plans must be flexible and adjusted depending on close monitoring of these plans.

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