Protein-Energy Malnutrition

OVERVIEW

Background

The World Health Organization (WHO) defines malnutrition as "the cellular imbalance between the supply of nutrients and energy and the body’s demand for them to ensure growth, maintenance, and specific functions." The term protein-energy malnutrition (PEM) applies to a group of related disorders that include marasmus, kwashiorkor (see the images below), and intermediate states of marasmus-kwashiorkor. The term marasmus is derived from the Greek word *marasmos*, which means withering or wasting. Marasmus involves inadequate intake of protein and calories and is characterized by emaciation. The term kwashiorkor is taken from the Ga language of Ghana and means "the sickness of the weaning." Williams first used the term in 1933, and it refers to an inadequate protein intake with reasonable caloric (energy) intake. Edema is characteristic of kwashiorkor but is absent in marasmus.

![Image of children and a nurse attendant at a Nigerian orphanage in the late 1960s. Notice four of the children with gray-blond hair, a symptom of the protein-deficiency disease kwashiorkor.](Image courtesy of Dr. Lyle Conrad and the CDC Public Health Image Library.)

Although protein-energy malnutrition affects virtually every organ system, this article primarily focuses on its cutaneous manifestations.
Patients with protein-energy malnutrition may also have deficiencies of vitamins, essential fatty acids, and trace elements, all of which may contribute to their dermatosis.

Pathophysiology

In general, marasmus is an insufficient energy intake to match the body’s requirements. As a result, the body draws on its own stores, resulting in emaciation. In kwashiorkor, adequate carbohydrate consumption and decreased protein intake lead to decreased synthesis of visceral proteins. The resulting hypoalbuminemia contributes to extravascular fluid accumulation. Impaired synthesis of B-lipoprotein produces a fatty liver.

Protein-energy malnutrition also involves an inadequate intake of many essential nutrients. Low serum levels of zinc have been implicated as the cause of skin ulceration in many patients. In a 1979 study of 42 children with marasmus, investigators found that only those children with low serum levels of zinc developed skin ulceration. Serum levels of zinc correlated closely with the presence of edema, stunting of growth, and severe wasting. The classic "mosaic skin" and "flaky paint" dermatosis of kwashiorkor bears considerable resemblance to the skin changes of acrodermatitis enteropathica, the dermatosis of zinc deficiency.

In 2007, Lin et al [2] stated that "a prospective assessment of food and nutrient intake in a population of Malawian children at risk for kwashiorkor" found "no association between the development of kwashiorkor and the consumption of any food or nutrient."

Marasmus and kwashiorkor can both be associated with impaired glucose clearance that relates to dysfunction of pancreatic beta-cells. [3] In utero, plastic mechanisms appear to operate, adjusting metabolic physiology and adapting postnatal undernutrition and malnutrition to define whether marasmus and kwashiorkor will develop. [4]

In 2012, a report from Texas noted an 18-month-old infant with type 1 glutaric acidemia who had extensive desquamative plaques, generalized nonpitting edema, and red-tinged sparse hair, with low levels of zinc, alkaline phosphatase, albumin, and iron. This patient has a variation on kwashiorkor, and the authors suggest that it be termed acrodermatitis dysmetabolica. [5] On the same note, a boy aged 18 months with type 1 glutaric academia suffered from zinc deficiency and acquired protein energy malnutrition. [6]

For complex reasons, sickle cell anemia can predispose sufferers to protein malnutrition. [7]

Protein energy malnutrition ramps up arginase activity in macrophages and monocytes. [8]

Epidemiology

Frequency

United States

Protein-energy malnutrition is the most common form of nutritional deficiency among patients who are hospitalized in the United States. As many as half of all patients admitted to the hospital have malnutrition to some degree. In a recent survey in a large children's hospital, the prevalence of acute and chronic protein-energy malnutrition was more than one half. This is very much a disease that occurs in 21st century America, and a case in an 8-month-old child in suburban Detroit, Mich, was reported in 2010. [9] Additional cases of kwashiorkor have been noted to occur in the United States. An interesting report of a baby with a clinical picture imitating Stevens-Johnson syndrome but who in fact had kwashiorkor has been noted. [10] Babies solely fed on rice milk can develop kwashiorkor even in the United States.

In a survey focusing on low-income areas of the United States, 22-35% of children aged 2-6 years were below the 15th percentile for weight. Another survey showed that 11% of children in low-income areas had height-for-age measurements below the 5th percentile. Poor growth is seen in 10% of children in rural populations.

In hospitalized elderly persons, up to 55% are undernourished. Up to 85% of institutionalized elderly persons are undernourished. Studies have shown that up to 50% have vitamin and mineral intake that is less than the recommended dietary allowance and up to 30% of elderly persons have below-normal levels of vitamins and minerals.

International

In 2000, the WHO [11] estimated that malnourished children numbered 181.9 million (32%) in developing countries. In addition, an estimated 149.6 million children younger than 5 years are malnourished when measured in terms of weight for age. In south central Asia and eastern Africa, about half the children have growth retardation due to protein-energy malnutrition. This figure is 5 times the prevalence in the western world.

A cross-sectional study of Palestinian adolescents found that 55.66% of boys and 64.81% of girls had inadequate energy intake, with inadequate protein intake in 15.07% of boys and 43.08% of girls. The recommended daily allowance for micronutrients was met by less than 80% of the study subjects. [12]

Mortality/Morbidity

Approximately 50% of the 10 million deaths each year in developing countries occur because of malnutrition in children younger than 5 years. In kwashiorkor, mortality tends to decrease as the age of onset increases.

Race
Dermatologic findings appear more significant and occur more frequently among darker-skinned peoples. This finding is likely explained by the greater prevalence and the increased severity of protein-energy malnutrition in developing countries and not to a difference in racial susceptibility.

**Age**

Marasmus most commonly occurs in children younger than 5 years. This period is characterized by increased energy requirements and increased susceptibility to viral and bacterial infections. Weaning (the deprivation of breast milk and the commencement of nourishment with other food) occurs during this high-risk period. Weaning is often complicated by geography, economy, hygiene, public health, culture, and dietetics. It can be ineffective when the foods introduced provide inadequate nutrients, when the food and water are contaminated, when the access to health care is inadequate, and/or when the patient cannot access or purchase proper nourishment.

In some studies, the protein-energy malnutrition prevalence among elderly persons is estimated to be as high as 4% for those living in the community, 50% for those hospitalized in acute care units or geriatric rehabilitation units, and 30-40% for those in long-term care facilities. Protein-energy malnutrition has also been found to be a primary factor of poor prognosis in elderly persons.

**Prognosis**

The extent of growth failure and the severity of hypoproteinemia, hypoalbuminemia, and electrolyte imbalances are predictors of a poorer prognosis. Additionally, underlying HIV infection is associated with a poor prognosis.

**Clinical Presentation**

**References**


17. Sander CS, Hertecant J, Abdurrazzaq YM, Berger TG. Severe exfoliative erythema of malnutrition in a child with coexisting coeliac and


Media Gallery
- This photograph shows children and a nurse attendant at a Nigerian orphanage in the late 1960s. Notice four of the children with gray-blond hair, a symptom of the protein-deficiency disease kwashiorkor. Image courtesy of Dr. Lyle Conrad and the CDC Public Health Image Library.
- This late 1960s photograph shows a seated, listless child who was among many kwashiorkor cases found in Nigerian relief camps during the Nigerian-Biafran war. Kwashiorkor is a disease brought on due to a severe dietary protein deficiency, and this child, whose diet fit such a deficiency profile, presented with symptoms including edema of legs and feet, light-colored, thinning hair, anemia, a pot-belly, and shiny skin. Image courtesy of Dr. Lyle Conrad and the CDC Public Health Image Library.
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