Protein-energy malnutrition

Last updated: 07/19/2022 13:29:42

Summary

Malnutrition is a significant cause of morbidity and mortality worldwide, leading to ~ 45% of all deaths in children under the age of five. Approximately 52 million children have wasting with one-third (17 million) suffering from severe acute malnutrition. Even more children (~ 154.8 million) have stunted growth, indicating widespread chronic malnutrition. In severe cases, primary protein-energy malnutrition (PEM) can develop, which has two major clinical forms: kwashiorkor and marasmus. Kwashiorkor is characterized by muscle atrophy, pitting edema, and distended abdomen with an enlarged fatty liver. It is caused by a deficiency of dietary protein despite sufficient calorie intake (e.g., from carbohydrates). Marasmus is the diffuse loss of muscle and fat tissue (without edema or distended abdomen) due to a severe state of total calorie deficiency of all macronutrients. Secondary PEM occurs due to illnesses affecting appetite, digestion, absorption, metabolism, and/or increased energy/protein demand. In addition to muscle atrophy, it is possible for patients to have clinical features of either marasmus or kwashiorkor. All forms of PEM are primarily clinical diagnoses; for primary PEM, WHO diagnostic criteria involve a child's weight-for-length/height and mid-upper arm circumference. Thorough laboratory testing should also be conducted to evaluate for severity and complications. Treatment involves managing complications, rehydration, and careful nutritional rehabilitation to avoid refeeding syndrome. In the case of secondary PEM, underlying conditions should also be treated, as well.

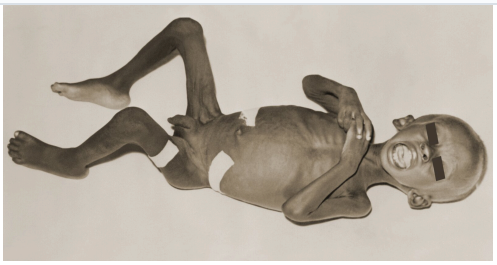
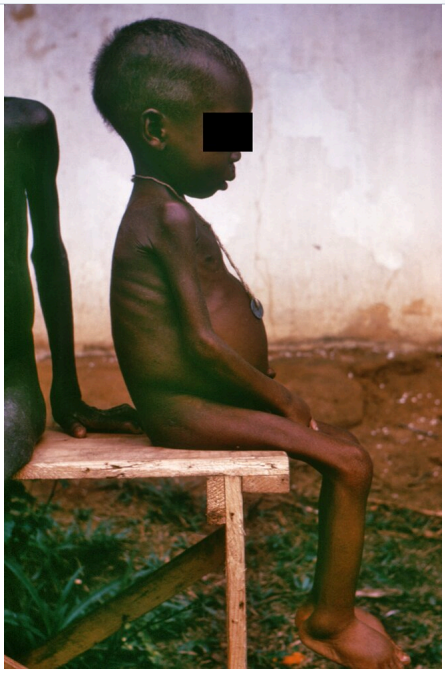
Overview

- Protein-energy malnutrition (PEM) describes pathological conditions resulting from a deficiency of dietary protein and/or total calories.
- Primary PEM: due to inadequate macronutrient intake
  - Marasmus: due to deficiency of all macronutrients and total calories
  - Kwashiorkor: due to protein deficiency
  - Marasmic kwashiorkor: a severe form with features of both marasmus and kwashiorkor
- Secondary PEM: due to chronic illnesses or drugs disrupting appetite, digestion, absorption, metabolism, and/or increased energy/protein demand

Primary protein-energy malnutrition

Main types of PEM		
	Marasmus	**Kwashiorkor**
Deficiency	• **All major** nutrients	• **Primarily protein,** e.g., due to: ◦ Premature cessation of breastfeeding ◦ Chronic GI infection

Main types of PEM		
	Marasmus	**Kwashiorkor**
		◦ Protein-deficient diet: inadequate intake of staple foods without the necessary amounts of proteins (e.g., sweet potatoes, cassava)
Calorie intake	• **Deficient**	• Variable (can be normal or even high)
Pathophysiology	• Severe energy deficiency leads to a catabolic state → breakdown of adipose tissue, muscle, and, ultimately, organ tissue for energy	• The lack of protein leads to: ◦ Muscle atrophy ◦ ↓ Plasma protein (especially albumin) → ↓ plasma oncotic pressure → edema ◦ ↓ Apolipoprotein synthesis → ↓ secretion of hepatic triglycerides → enlarged fatty liver • Increased oxidative damage to cellular protein synthesis [1] • Impaired development of the intestinal microbiome may be a risk factor. [2]
Epidemiology [3] [4]	• Widespread in children living in resource-limited countries in Sub-Saharan Africa, South-East Asia, and Central America. • Marasmus is more common than kwashiorkor. • ~ 45% of children's deaths < 5 years of age are associated with undernutrition [5] • Growth stunting affects 144 million children < 5 years of age worldwide.	
Key clinical features	• **Profound muscle wasting** (broomstick extremities) • **Loss of subcutaneous fat** • Pronounced chest bone, ribs, and facial bones • Failure to thrive: Low weight for height • Thin, dry skin • Thin, sparse hair • Irritable affect • **No edema**	• **Bilateral pitting edema**, anasarca in severe cases • **Distended abdomen** (due to hepatomegaly, intestinal distention, and weakened abdominal muscles) • **Hepatomegaly** • Skin changes: thin, dry, peeling skin with areas of hyperpigmentation and hyperkeratosis (flaky skin) • Hair changes: dry, hypopigmented hair that falls out easily • Rounded cheeks (moon face) • Muscle atrophy • Variable weight for height • Apathetic affect

Main types of PEM		
	Marasmus	**Kwashiorkor**
		
	• Susceptibility to infections • **Growth stunting** as a sign of chronic malnutrition • In severe cases: bradycardia, hypotension, pancreatic insufficiency, and hypothermia	
Marasmic kwashiorkor	• A severe form with features of both marasmus and kwashiorkor	

Protein-deficient **KW**ick **MEALS** lead to **Kw**ashiorkor: **M**alnutrition, **E**dema, **A**nemia, fatty **L**iver, **S**kin lesions.

Marasmus causes **M**uscle wasting but no edema.

Secondary protein-energy malnutrition

- **Description**: A form of PEM caused by illnesses affecting appetite, digestion, absorption, metabolism, and/or increased energy/protein demand rather than a lack of calorie intake.
- Epidemiology: usually observed in
  - Chronically ill, hospitalized patients
  - Elderly
  - Chronic alcoholics
- **Etiology**: decreased appetite/food intake, increased energy and protein demand, and/or malabsorption due to illnesses and medications
  - Cachexia/wasting syndrome: a form of secondary PEM caused by an underlying illness that causes chronic muscle breakdown despite nutritional supplementation

        - Neoplasm (cancer cachexia)
        - AIDS (HIV wasting syndrome)
        - Chronic renal failure
        - Congestive heart failure
        - COPD
        - Less common
            - Neuromuscular disorders
            - Cystic fibrosis
            - Crohn disease
    - Gastrointestinal dysfunction
        - Chronic liver disease
        - Pancreatic insufficiency
        - Enteropathy (e.g., celiac disease, HIV enteropathy)
        - Retroperitoneal fibrosis
    - Increased metabolic demands
        - Chronic infection
        - Endocrine disorders (hyperthyroidism, pheochromocytoma)
        - Trauma, surgery, or burns
- **Clinical features**
    - Depleted subcutaneous fat and skeletal muscle (as seen in marasmus)
    - Lower extremity edema
    - Bradycardia, hypotension, and hypothermia
    - Delayed wound healing, increased risk of decubitus
    - Susceptibility to infections

Diagnostics

PEM is primarily a clinical diagnosis. Laboratory testing should be conducted to assess the severity and complications. Additional testing may be required to determine the underlying condition for secondary PEM.

Clinical diagnosis [6]

Primary PEM

- **H&P**: Take a thorough history and physical exam, focusing on nutrition/potential child maltreatment and typical clinical features.
- **Anthropometrics**: to assess the degree of malnutrition
    - Height/length

- Weight
- Weight-for-length/height (WFL/H) represented as a Z-score or a percentile
- Height/length-for-age (HFA) represented as a Z-score or a percentile
- Mid-upper arm circumference (MUAC)
- BMI

- **WHO diagnostic criteria:** for primary PEM in children aged 6–60 months [7]
  - Marasmus
    - WFL/H z-score < -3 OR
    - MUAC < 11.5 cm
  - Kwashiorkor
    - WFL/H z-score < -2 OR
    - MUAC < 12.5 cm WITH
    - Bilateral pitting edema

Secondary PEM

- Clinical diagnosis based on history, body composition (e.g., low BMI), and underlying condition
- If etiology is unclear, determine the cause, e.g.:
  - HIV testing
  - Cytokine excess: measure cytokines
  - Hyperthyroidism: measure thyroid function tests

Laboratory tests

- Thorough laboratory testing (CBC, electrolyte panel, inflammatory markers, organ function tests) should be conducted to evaluate for severity and any complications.
- Typical findings
  - **Anemia**
  - ↓ Total lymphocyte count, ↓ CD4+ count
  - **Electrolyte abnormalities**, especially:
    - Hypokalemia
    - Hyponatremia
    - Hypophosphatemia
    - Also: hypocalcemia, hypomagnesemia
  - ↓ **Serum albumin** and transferrin (especially in Kwashiorkor)
  - ↓ Blood glucose
  - ↓ BUN and creatinine (unless concurrent renal failure)
  - ↑ CRP if associated with an inflammatory condition

- Test for ova and parasites in stool culture.

Treatment

- **Hydration** (typically oral)
- **Nutritional rehabilitation**: must occur slowly to prevent refeeding syndrome
  - Should be initiated slowly at ~ 20% above the child's recent intake.
  - Slowly increase calorie intake while monitoring lab values daily.
  - For kwashiorkor, protein should slowly be introduced into the diet to avoid acute liver injury.
- Treat complications (e.g., infection)
- For secondary PEM
  - Treat the underlying condition
  - Nutritional counseling
  - In anorexia-cachexia syndrome: consider corticosteroids (e.g., prednisolone) and cannabinoids (e.g., dronabinol)

Refeeding syndrome is a frequent complication if nutritional rehabilitation occurs too rapidly (sudden shift from a catabolic to an anabolic state): It is characterized by fluid retention, hypophosphatemia, hypomagnesemia, and hypokalemia.

10 steps of recovery for severely undernourished children

- Approx. 50 million children < 5 years of age are malnourished. The fatality rate of severely malnourished children brought to the hospital still is 30–50%. With the right management, this rate can be reduced to approx. 5%. The following 10 steps (conditions to treat) are an attempt to drastically reduce the fatality rate. [8]
- The first 9 steps usually take at least 1–3 weeks depending on the child's general status and recovery. [9]

10 steps for inpatient management of severely undernourished children [8][10]

Condition to treat	Phase	Management	Maintenance
1. Hypoglycemia	• Stabilization: initiate immediately and continue for up to 2 days	• Blood glucose and body temperature should be managed simultaneously • Blood glucose ◦ When unable to test blood glucose levels, treat as if the child were hypoglycemic. ◦ Test blood glucose levels. ◦ Administer glucose (oral liquid glucose if child is conscious; IV glucose infusion if child is unconscious). • Body temperature	• Feed every 2 hours, also during the night

10 steps for inpatient management of severely undernourished children [8][10]			
Condition to treat	**Phase**	**Management**	**Maintenance**
2. Hypothermia		◦ When unable to take the temperature, treat as if the child had hypothermia. ◦ Take axillary (hypothermia: < 35.0 °C) or rectal (hypothermia: < 35.5 °C) temperature ◦ Rewarm the child, especially the head (with e.g., clothes, blankets, heating lamp, skin to skin with the mother). • Monitor blood glucose level, temperature, and consciousness.	• Keep the child warm; also during the night (e.g., by avoiding bathing and drafts). • Keep the child dry (e.g., change wet diapers). • Feed every 2 hours, also during the night
3. Dehydration		• When unable to assess dehydration in a malnourished child treat as if the child is dehydrated • Rehydrate orally (intravenous rehydration might lead to circulatory overload and thus to heart failure). • Use the WHO standard oral rehydration solution as it contains less sodium and more potassium than normal saline or lactated Ringer's solution (see also step 6, micronutrient deficiencies). [8] • Monitor heart rate, respiratory rate, and frequency of urine, stool, and vomit. • Monitor skin turgor, lacrimation, and	• Orally replace lost fluids (e.g., due to diarrhea). • Continue breastfeeding if child is breastfed.

10 steps for inpatient management of severely undernourished children [8][10]			
Condition to treat	**Phase**	**Management**	**Maintenance**
		fontanelle depth	
4. Electrolyte imbalance	• Stabilization and rehabilitation: initiate immediately and continue for up to 6 weeks	• Test serum electrolyte levels. • Rehydrate with low sodium fluid. • Give low sodium food. • Administer potassium and magnesium. • Monitor serum electrolyte levels.	• Continuously administer potassium and magnesium (e.g., by adding them to the solid food).
5. Infections	• Stabilization: initiate immediately and continue for up to 7 days	• Identify source of infection if possible. • Administer prophylactic broad-spectrum antibiotics (e.g., cotrimoxazole, ampicillin). • Administer measles vaccine in unimmunized children > 6 months of age. • Monitor general condition of the child.	• Reassess general condition of the child and adjust antibiotics if necessary.
6. Micronutrient deficiencies	• Stabilization and rehabilitation: initiate immediately and continue for up to 6 weeks	• Administer multivitamin supplements first (especially vitamin A, unless it has been given within the past 4 weeks). • Administer folic acid. • Administer trace elements: zinc, copper, iron.	• Reassess general condition of the child and adjust supplements if necessary.
7. Cautious feeding	• Stabilization: initiate immediately and continue for up to 7 days	• Feed orally (if oral feeding is not possible, feed enterally via nasogastric tube). • Feed low-osmolarity and low-lactose foods as soon as possible (e.g., milk-based formulas). • Feed small portions every 2–4 hours. • Gradually increase feeding volume and decrease frequency (over the course of 1 week	• Compensate food loss after vomiting; if oral feeding is refused, administer via nasogastric tube.

10 steps for inpatient management of severely undernourished children [8][10]			
Condition to treat	**Phase**	**Management**	**Maintenance**
		depending on the child's general status). • Monitor vomiting frequency and the child's weight.	
8. Catch-up growth	• Rehabilitation: initiate after day 7 and continue for up to 6 weeks	• Replace milk-based formula with higher caloric food (e.g., porridge). • Increase portion size slowly to prevent heart failure. • Monitor heart rate and respiratory rate. • Monitor the child's weight gain daily.	• If child fails to respond to treatment, reassess 1 to 7 and adjust management if necessary. • If child is breastfed, continue feeding higher caloric food AND breastfeeding (breastmilk does not contain enough sufficient calories and/or protein for rapid rehabilitation).
9. Sensory stimulation and emotional support	• Stabilization and rehabilitation: initiate immediately and continue throughout childhood	• Create an emotionally stable environment. • Provide stimulation through playtime. • Restart physical activity once the child is well enough. • Involve parents as much as possible.	
10. Prepare for follow-up after recovery	• Rehabilitation: initiate after day 7 and continue for up to 6 weeks	• Educate parents about correct feeding practices and playtime for the child at home. • Recommend regular follow-up checks to parents.	

Complications

- Infections (e.g., pneumonia, gastroenteritis, urinary tract infection, sepsis)
- Delayed wound healing
- Growth retardation
- Micronutrient deficiencies (e.g., vitamin deficiencies, iron deficiency, zinc deficiency)
- Dehydration
- Multiorgan failure and death if left untreated

We list the most important complications. The selection is not exhaustive.