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MALNUTRITION IN CHILDREN

Methodical recommendations

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CONTENT

ABBREVIATIONS

CBC complete blood count
CNS central nervous system
h - hour
Hb haemoglobin
ICD 10 the 10th revision of the International Statistical Classification of Diseases and Related Health Problems
IM intramuscular
IMCI Integrated Management of Childhood Illness
IV intravenous
NG nasogastric
PEM protein-energy malnutrition
ReSoMal Rehydration Solution for Malnutrition
SD standard deviation
UNICEF United Nations Children's Fund
WHO World Health Organization

INTRODUCTION

A well-balanced diet is vitally essential for normal physical and mental development of the children and the maintenance high resistance to infections and adverse environmental effects.

Inadequate nutrition is very common among children. In 2017, globally there were 151 million children under 5 year of age were stunted, 51 million wasted and 38 million overweight.

Childhood undernutrition is a major global health problem, contributing to childhood morbidity, mortality, impaired intellectual development, suboptimal adult work capacity, and increased risk of diseases in adulthood. Protein-energy malnutrition is one of the most serious medical problems in the world. Severe acute malnutrition affects nearly 20 million preschool-age children, mostly from African Region and South-East Asia Region. Malnutrition is a significant factor in approximately one third of the nearly 8 million deaths in children who are under 5 years of age worldwide.

For this reason, education of health care workers and parents of prevention malnutrition, and the improved management of severe acute malnutrition is an integral part of the WHO/UNICEF strategy of Integrated Management of Childhood Illness (IMCI), to improve child survival and to reduce the global burden of disease.

1. TYPES OF NUTRITIONAL DISORDERS IN CHILDREN

The World Health Organization (WHO) defines malnutrition as *"the cellular imbalance between supply of nutrients and energy and the body's demand for them to ensure growth, maintenance, and specific functions."*

Malnutrition is a category of diseases that includes: *undernutrition (*underweight, stunting, wasting), *overweight* and *obesity*, and *micronutrient deficiency* among others.

However, the term 'malnutrition' is frequently used to denote either the lack of adequate nutrition or inadequate supply/amount of calories, as the synonym of 'undernutrition'.

In Russian-speaking medical literature the term "*dystrophy"* is usually used to mean children's chronic disorders of nutrition. It corresponds to the English term '*malnutrition*'.

Dystrophy (from Greek *dis* – frustration, *trophy* – a nutrition) is a group of diseases which are accompanied by multiorganic insufficiency, endogenous intoxication, infringements in weight, growth and development. It is diagnosed more often for children of first three years of life. The following types of the dystrophy are distinguished: *hypotrophy, hypostature, paratrophy,* and *obesity.*

Hypostature is the dystrophy which is characterized by approximately uniform reduction of body weight and growth of the child beside satisfactory state of nourishment and turgor of tissue.

Paratrophy, and *obesity* are the conditions which are characterized by the superfluous body weight of the child. The diagnosis *paratrophy* is specified to breastfed and early age children with the superfluous body weight which is no more then 10-20 % of norm and characterized by increased hydrolability of tissue. The term *obesity* is used for elder children.

Hypotrophy (=undernutrition, malnutrition) is the chronic disturbance of nutrition and digestion, characterized by lag of growth and weight and accompanied by disorders of metabolic and trophic processes, decrease of immunity and development of micronutrient deficiency.

The term *severe malnutrition* is often used to refer specifically to ***protein-energy malnutrition (PEM).***

PEM, first described in the 1920s, is observed most frequently in developing countries but has been described with increasing frequency in hospitalized and chronically ill children in the United States.

The term PEM applies to a group of related disorders that include *marasmus*, *kwashiorkor.* Some children have signs of both kwashiorkor and marasmus. It is *marasmus-kwashiorkor.*

The term ***marasmus*** is derived from the Greek word MARASMOS, which means withering or wasting ("to waste away"). Marasmus results from the 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", "reddish boy", or from the West African word for "displaced child". Kwashiorkor is a nutritional deficiency disease caused when infants and very young children are weaned from their mother's milk and placed on a diet consisting of maize flour, cassava, or low-protein cereals. That diet is generally high in calories and carbohydrates, but low in protein.

2. ETIOLOGY OF MALNUTRITION

The malnutrition can be distinguished according to its origin:

- prenatal or congenital hypotrophy (malnutrition) or intrauterine growth retardation;
- postnatal hypotrophy (malnutrition);
- mixed.

Prenatal causative factors of malnutrition

- an inappropriate nutrition of pregnant women;
- acute and chronic diseases of pregnant women;
- intrauterine toxin exposure (professional factors, unfavorable environmental factors, bad habits – smoking, alcohol and\or drugs abuse);
- fetal intra-uterine infections;
- chromosomal aberrations of fetus;
- prematurity.

Postnatal causative factors of malnutrition

1. Alimentary factors (starvation, inadequate or unbalanced diet);
2. Defective assimilation (problems with digestion or absorption):

- syndromes of malabsorption (chronic diarrhea for whatever reason (from allergies, immune deficiencies to chronic diseases), celiac disease;
- hereditary anomalies of metabolism (lactose intolerance, galactosemia, leycinosis, fructosemia, fenilketonuria, and others);
- malformations of gastrointestinal tract (hypoplasia of the low jaw, short frenulum, pylorostenosis, etc.);
- syndrome of "short bowel" after extensive intestinal resections;
- infectious diseases (all acute severe and\or prolonged infections).

3. Chronic illnesses:

- cystic fibrosis;
- chronic renal failure;
- childhood malignancies;
- congenital heart disease;
- central nervous system (CNS) disorders: cerebral palsy, neuro-muscular diseases;
- chronic inflammatory bowel diseases (Crohn disease and ulcerative colitis);
- hereditary primary immune deficiencies;
- endocrine disease (adrenogenital syndrome, pituitary nanism, etc);
- multiple food allergies;
- infections.

In addition, PEM divided into primary and secondary malnutrition.

Causes of primary (non-organic) PEM are social or economic factors leading to lack of food.

Secondary PEM results from conditions or drugs that interfere with the child's ability to absorb ingested protein.

Causes of secondary (organic):

- increase caloric requirements (infection, trauma, cancer);
- increase caloric loss (malabsorbtion);
- reduce caloric intake (anorexia, cancer, oral intake restriction, social factors);
- combination of these factors.

3. PATHOPHYSIOLOGY OF MALNUTRITION

Malnutrition in children typically develops during the period from 6 to 18 months of age, when growth velocity and brain development are especially high. Young children are particularly susceptible to malnutrition if complementary foods are of low nutrient density and have low bioavailability of micronutrients. In addition, children's nutritional status will be further compromised if complementary foods are introduced too early or too late, or are contaminated.

Three phases are identified in the pathogenesis of malnutrition:

Phase 1 – "hungry excitement", when reserve carbohydrates are spent for the energy needs. Blood glucose level is reducing, the processes of amino acids metabolism in the liver are suppressing and nitrogen excretion is decreasing.

Phase 2 - fatty tissue is consumed for energy needs. The basic metabolism and protein metabolism are reduces, less nitrogen excreted,

the synthesis of vital proteins occur from the catabolism of other proteins in the body.

Phase 3 - Endogenous proteins are spent on energy needs. There are structural changes in mitochondria, regulatory mechanisms are violated.

Malnutrition leads to physiological and metabolic changes, which affect every cell, organ, and system. Disorders of all types of metabolism (protein, carbohydrate and fat) take place when children become malnourished.

The most common disorder is the one of protein metabolism. Total plasma proteins, including albumin, are decreased, but gamma globulins are often increased by the associated infections.

Carbohydrate metabolism is disturbed too; especially it occurs in patient safer from severe malnutrition. The glucose level is often initially low, and the glycogen stores are depleted. Patients with severe PEM have high risk of fatal hypoglycemia.

Fat metabolism: blood lipid levels are usually low, and serious dysregulation of lipid metabolism can occur, mainly during kwashiorkor and rarely during marasmus.

Furthermore, children with severe acute malnutrition have profound disturbances of electrolyte imbalances and altered fluid distribution. Children with bilateral pitting edema typically have high intracellular sodium and are therefore inclined to retain fluids. By comparison, intracellular potassium is lost to the extracellular space and total body potassium is often very low.

These changes at cellular level are part of the overall adaptive responses to repeated infections and damage to cell membranes by free radicals. Children with severe wasting but without edema also have depleted intracellular and total body potassium and similarly experience adaptive physiological changes such as reduced renal and cardiac output. As a result, they are prone to fluid retention and susceptible to fluid changes and, in particular, have reduced tolerance to rapid changes in circulating blood volume.

Early studies of malnourished children showed changes in the brain developing, including, a slow rate of growth of the brain, lower brain weight, thinner cerebral cortex, decreased number of neurons, insufficient myelinization, and changes in the dendritic spines.

In addition to the impairment of physical growth and cognitive and other physiologic functions, immune response changes occur early in the course of significant malnutrition in a child.

The immune changes predispose children to severe and chronic infections, most commonly, infectious diarrhea, which further compro-

mises nutrition causing anorexia, decreased nutrient absorption, increased metabolic needs, and direct nutrient losses.

Other important pathologic changes include fatty degeneration of the liver and heart, atrophy of the small bowel, and decreased intravascular volume leading to secondary hyperaldosteronism.

Children with severe acute malnutrition have profoundly disturbed physiology and metabolism, such that if intensive refeeding is initiated before metabolic and electrolyte imbalances have been corrected, mortality rates are high.

4. CLINICAL MANIFESTATIONS OF MALNUTRITION

The diagnostics of malnutrition (hypotrophy) is based on a complete physical examination, the clinical signs, and the calculation of height-for-age or weight-for-height measurements.

Practical nutritional assessment

1. Complete history, including a detailed dietary history;
2. Growth measurements, including weight and length/height;
3. Complete physical examination.

Main clinical signs and symptoms of malnutrition

- *Poor weight gain and deficit of weight;*
- *Slowing of linear growth and lag of growth;*
- *Syndrome of trophic disorders:*
  - decrease of subcutaneous tissue and tissue turgor;
  - changes of skin, and hair;
  - wasted, thinned and flabby muscles;
  - signs of deficiencies of micronutrients (multihypovitaminoses).
- *Syndrome of gastrointestinal disorders (digestive disorders):*
  - anorexia,
  - signs of maldigestion,
  - instability of stool with tendency to constipation, commonly diarrhea;
  - usually loss of appetite (however, children with marasmus may sometimes have voracious appetite)
- *Syndrome of CNS dysfunctions:*
  - behavioral changes - irritability, anxiety, apathy, lethargy in severe forms;
  - developmental delay - delayed motor skills and/or psychomotor retardations (a child stops sitting, standing, walking), delayed mental development, and sometimes permanent cognitive deficits.

- *Disorders of thermoregulation:* tendency to hypothermia.
- *Syndrome of immunological disorders:*
  - frequent severe and chronic infections (recurrent episodes of respiratory and skin infections, diarrhea and other),
  - tendency to asymptomatic and atypical course of infection diseases.

Note: In severe malnutrition usual signs of infection, such as fever, are often absent.

Manifestation of the clinical signs and their expression depends on degree of malnutrition (hypotrophy).

Physical findings associated with malnutrition

Decreased subcutaneous tissue: the most affected areas are legs, arms, buttocks, and face. The thickness of the adipose layer is the main diagnostic criterion of hypotrophy and its degree. The subcutaneous fatty layer is thinned on the abdomen in mild malnutrition, it is decreased from the body and the extremities in moderate malnutrition, the subcutaneous fat is absolutely absent in the severe PEM, only buccal fat pads (*clots of Bichaut*) may be preserved.

In marasmus, the child appears emaciated. Monkey faces are characteristic of this disorder due to a loss of buccal fat pads. The decrease of tissues turgor is observed, muscles are wasting, flabby, thinned.

Skin changes: skin is pale, flabby; in severe PEM it is xerotic, wrinkled, and loose.

Kwashiorkor typically presents with dry peeling skin with raw exposed areas, hyper pigmented plaques over areas of trauma. The skin becomes dark, dry, and then splits open when stretched, revealing pale areas between the cracks (i.e., crazy pavement dermatosis, enamel paint skin). This feature is seen especially over pressure areas, so called the classic *"mosaic skin"* and *"flaky paint"* dermatosis. In contrast to pellagra, these changes seldom occur on sun-exposed skin.

Hair changes: Hair is dry, lusterless, thin, sparse, and brittle. It easily pulls out, sometimes may result in alopecia.

In kwashiorkor the hair depigmentation occur. It causes hair to be reddish yellow or white. Curly hair becomes straightened. If periods of poor nutrition are interspersed with good nutrition, alternating bands of pale and dark hair, respectively, called the flag sign, may occur.

Edema of the distal extremities (the most affected); anasarca (generalized edema). Kwashiorkor typically presents edema, moon faces, a swollen abdomen (potbelly).

Note: Edema is characteristic of kwashiorkor but it is absent in marasmus.

Abdominal findings: abdominal distension due to poor abdominal musculature; hepatomegaly because of fatty infiltration. A swollen "potbelly" is one of the most common manifestations of kwashiorkor.

Deficiencies of micronutrients, including vitamins, minerals, and trace elements have been studied well. The most common and clinically significant deficiencies include the following:

- **Iron** - fatigue, anemia, decreased cognitive function, headache, glossitis, and nail changes;
- **Iodine** - goiter, developmental delay, and mental retardation;
- **Vitamin D** - poor growth, rickets, and hypocalcemia;
- **Vitamin A** - night blindness, xerophthalmia, poor growth, and hair changes;
- **Vitamin C -** hemorrhages, petechiae, gingival bleeding, and splinter hemorrhages;
- **Folate** - glossitis, anemia (megaloblastic), and neural tube defects (in fetuses of women without folate supplementation);
- **Zinc** - anemia, dwarfism, hepatosplenomegaly, hyperpigmentation and hypogonadism, acrodermatitis enteropathica, diminished immune response, poor wound healing.

5. CLASSIFICATION OF MALNUTRITION

Several classifications of malnutrition are suggested.

Primary and secondary malnutrition, organic and non-organic, prenatal and postnatal were discussed above (*see Etiology*).

Classification of malnutrition in ICD-10

IV. Endocrine, nutritional and metabolic diseases.

Malnutrition (E40-E46)

E40 Kwashiorkor - Severe malnutrition with nutritional
- Edema with dyspigmentation of skin and hair.

E41 Nutritional marasmus - Severe malnutrition with marasmus

E42 Marasmic kwashiorkor - Severe protein-energy malnutrition [as in E43]: intermediate form, with signs of both kwashiorkor and marasmus

E43 Unspecified severe protein-energy malnutrition

E44 Protein-energy malnutrition of moderate and mild degree

E44.0 Moderate protein-energy malnutrition

E44.1 Mild protein-energy malnutrition

E45 Retarded development following protein-energy malnutrition. Short stature; stunting

E46 Unspecified protein-energy malnutrition

Assessment of severity of malnutrition may based on detection of deficit of the body weight (*Tab. 1*).

Table 1

Severity of malnutrition (hypothrophy)

Degrees of hypothrophy	I (mild)	II (moderate)	III (severe or complicated)
The deficiency of the body weight	10-20 %	21-30 %	31 % and more

In 2006, WHO released new growth standards for children aged 0–5 years. These represent the standards on which all WHO definitions and estimates of malnutrition, including moderate and severe acute malnutrition, and obesity are now based.

In children who are 6–59 months of age, severe acute malnutrition is defined as weight-for-height less than –3 Z-score of the median of the WHO growth standards, or a mid-upper arm circumference less than 115 mm, or presence clinical signs of bilateral edema of nutritional origin (*Tab. 2*).

Table 2

WHO Classification of Malnutrition

Evidence of Malnutrition	Moderate	Severe (type)
Symmetric edema	No	Yes (edema PEM)*
Weight for height†	Standard deviation (SD)‡ score -3 SD score <-2 (70-90 %)§	SD score <-3 (ie, severe wasting)‖ (< 70 %)
Height for age	SD score- 3 SD score <-2 (85-89 %)	SD score <-3 (ie, severe stunting) (< 85 %)

* This includes kwashiorkor (KW) and kwashiorkor marasmus (presence of edema always indicates serious PEM).

† Standing height should be measured in children taller than 85 cm, and supine length should be measured in children shorter than 85 cm or in children who are too sick to stand. Generally, the supine length is considered to be 0.5 cm longer than the standing height; therefore, 0.5 cm should be deducted from the supine length measured in children taller than 85 cm who are too sick to stand.

‡ Below the median National Center for Health Statistics (NCHS)/WHO reference: The SD score is defined as the deviation of the value for an individual from the median value of the reference population divided by the standard deviation of the reference population (ie, SD score = [observed value – median reference value]/standard deviation of reference population).

§ This is the percentage of the median NCHS/WHO reference.

‖ This corresponds to marasmus (without edema) in the Wellcome clinical classification and to grade III malnutrition in the Gomez system. However, to avoid confusion, the term severe wasting is preferred.

6. LABORATORY TESTS FOR DIAGNOSIS

Malnutrition is clinical diagnosis that based on clinical and physical symptoms and signs. However, laboratory tests are necessary for detection causes of malnutrition and chronic illnesses, also for monitoring during treatment (*Tab. 3*).

Table 3

Tests	Finding
Obligatory tests	
Blood glucose	Hypoglycemia (blood glucose is < 3mmol/l)
CBC (complete blood count)	Decrease of Hb (hemoglobin) - *anemia* from nutritional deficiencies such as iron, folate, and vitamin B-12 deficiencies; leukocytosis; increased level of ESR (erythrocyte sedimentation rate); and neutrophils (infections or sepsis)
Urine examination	Pyuria (urinary tract infection), ketonuria (catabolism)
Urine culture	Bacteriuria (urinary tract infection or sepsis)
Stool examination by microscopy	Ova and parasites (helminthiasis)
Serum protein and albumin	Hypoproteinemia and\or hypoalbuminemia (less then 30 g/L),
HIV test	HIV infection (*This test must be accompanied by counseling of the child's parents, and strict confidentiality should be maintained*).
Serum electrolytes	Increased level of potassium (hyperkalemia) and magnesium. Hyponatremia (decrease of sodium).
Additional diagnostic tests	
Transferrin level	Decreased
Serum creatinine	Normal or increased (catabolism)
Plasma cortisol and growth hormone levels	Increased
Insulin secretion and insulin-like growth factor levels	Decreased
Blood lipids (lipoprotein, cholesterol)	Decreased
Immunology examination	Lowering of indices of specific (immunoglo-bulins A, M, antibody titer) and unspecific immunity (phagocytosis, lysozyme)
Thoracic radiography	Possible pulmonary infection (despite lack of clinical signs), a primary tuberculosis lesion, cardiomegaly, or signs of rickets.

Differential diagnosis of malnutrition

Firstly, diagnosis of genetic diseases, congenital abnormalities and varies chronic illnesses are important (see Etiology).

The most common disease that present with underweight are following: cystic fibrosis, cardiovascular diseases, chronic kidney diseases, oncologic diseases, CNS disorders and endocrine pathology.

7. TREATMENT OF MALNUTRITION

In mild-to-moderate cases of malnutrition, initial assessment and nutritional intervention may be done in the outpatient setting. A patient with malnutrition may require hospitalization based on the severity and instability of the clinical situation. Hospitalization of patients with suspected malnutrition because of neglect allows observation of the interactions between parent/caregiver and child and documentation of actual intake and feeding difficulties.

Managem ent of malnutrition

Management of malnourished children should include:

1. Detection of causes and their elimination or correction
2. Diet therapy
3. Special medical care, hygienic educations of parents
4. Diagnosis and treatment of infections, complications and accompanying diseases
5. Vitamin-therapy and symptomatic therapy.

Nutrition for children with PEM

Diet – is the most important part of therapy. Typically, treatment will include a feeding program with a specially planned diet, and possibly some additional nutritional supplements.

Therapeutic nutrition of infants with undernutrition includes three stages.

Stage I: period of tolerance estimating (discharging and minimal nutrition):

- volume of feeding is 2/3-1/2 of the full volume,
- the rest of volume is given to the patient with liquids.
- Number of feedings on this stage is usual or plus 1-2 feedings (in severe malnutrition – 10-12 time/day).
- Duration of stage I is from 1-2 to 8-10 days.

Stage II: increasing nutritional loading (the transition period)

Increasing of the feeding volume and decreasing of frequency.

Breast milk is optimal base food. If there is lack of breast milk, special hydrolyzed formulas or easily digestible formulas with high quantities of protein and calories can be used.

Stage III – optimal nutrition.

Table 4

Diet therapy of PEM

	I	II	III
Duration of clearing-up of food tolerance	1-3 days	6-7 days	10-14 days
Food	Breast milk or formula feeding		
Daily amount of food	complete	2/3 or ½ of proper amount	½ or 1/3 of proper amount
Number of feeding	6-7 every 3-3.5 hour	8 every 2.5 hour	10 every 2 hou
Permissible daily addition of food	Complete amount without correction	100-150 ml every day	100-150 ml two day
Criteria of changing of feeding number	No changing	On reaching of food amount to carry out 7 feeding every 3 hour	On reaching of ½ food amount to feed 8 times every 2.5 hour

The diet must include adequate amounts of protein and other macronutrients.

Children with chronic malnutrition may require caloric intakes more than 120-150 kcal/kg/d to achieve appropriate weight gain.

The formula for determining adequate caloric intake is:

kcal/kg = (RDA* for age X ideal weight)/actual weight

*RDA - recommended daily (or dietary) allowance

Adequacy of intake is determined by monitoring weight gain.

The main instructions of medical care for malnourished children

1. Keep the malnourished child dry, change wet nappies, clothes and bedding, keep covered and away from draughts. Avoid exposure (e.g. bathing, prolonged medical examinations). Let the child sleep with the mother for warmth at night, use a kangaroo position if possible at day.

2. Monitor the axillaries temperature, weight gain, ensure the child is covered at all times, especially at night, feel for warmth.

3. Check for hypoglycemia whenever hypothermia is found.

4. Control pulse rate, respiratory rate, urine frequency and stool/ vomit frequency, especially if patient has rehydration therapy.

5. Each week calculate and record weight gain as g/kg/d.

Treatment of severe malnutrition

Children who are identified as having severe acute malnutrition should first be assessed with a full clinical examination to confirm whether

they have medical complications and whether they have an appetite. Children who have appetite and are clinically well and alert should be treated as outpatients. Children who have medical complications, severe edema, or poor appetite or present with one or more IMCI danger signs should be treated as inpatients.

Danger signs: unable to drink or breastfeed; vomits everything; has had convulsions (more than one or prolonged >15 min); lethargic or unconscious; convulsing now.

General principles for routine care (the '10 Steps')

1. Treat/prevent hypoglycaemia
2. Treat/prevent hypothermia
3. Treat/prevent dehydration
4. Correct electrolyte imbalance
5. Treat/prevent infection
6. Correct micronutrient deficiencies
7. Start cautious feeding
8. Achieve catch-up growth
9. Provide sensory stimulation and emotional support
10. Prepare for follow-up after recovery

These steps are accomplished in two phases: an initial stabilization phase where the acute medical conditions are managed; and a longer rehabilitation phase.

Standard inpatient management of severe acute malnutrition involves two phases:

1) initial stabilization when life-threatening complications are treated
2) nutritional rehabilitation when catch-up growth occurs.

Note: treatment procedures are similar for marasmus and kwashiorkor.

1. Treat/prevent hypoglycaemia

Hypoglycaemia and hypothermia usually occur together and are signs of infection. Check for hypoglycaemia whenever hypothermia (axillary $<35.0^0$C; rectal$<35.5^0$C) is found. Frequent feeding is important in preventing both conditions.

Treatment:

If the child is conscious and dextrostix shows <3mmol/l or 54 mg/dl give:

• 50 ml bolus of 10% glucose or 10% sucrose solution, orally or by nasogastric (NG) tube. Then feed starter F-75 (see step 7) every 30 min for two hours (giving one quarter of the two-hourly feed each time)

• antibiotics (see step 5)

• two-hourly feeds, day and night (see step 7)

If the child is unconscious, lethargic or convulsing give:

• IV sterile 10% glucose (5ml/kg), followed by 50 ml of 10% glucose or sucrose by Ng tube. Then give starter F-75 as above

• antibiotics

• two-hourly feeds, day and night

Monitor:

• blood glucose: if this was low, repeat dextrostix after two hours. Once treated, most children stabilize within 30 min. If blood glucose falls to <3 mmol/l give a further 50 ml bolus of 10% glucose or sucrose solution, and continue feeding every 30 min until stable

• rectal temperature: if this falls to <35.5^{0}C, repeat dextrostix

• level of consciousness: if this deteriorates, repeat dextrostix

Prevention: feed two-hourly, start straightaway (see step 7) or if necessary, rehydrate first. Always give feeds throughout the night.

Note: If you are unable to test the blood glucose level, assume all severely malnourished children are hypoglycaemic and treat accordingly.

2. Treat/prevent hypothermia

Treatment

If the axillary temperature is <35.0 0C, take the rectal temperature using a low reading thermometer. If the rectal temperature is <35.50C (<95.90F):

• feed straightaway (or start rehydration if needed)

• rewarm the child: either clothe the child (including head), cover with a warmed blanket and place a heater or lamp nearby (do not use a hot water bottle), or put the child on the mother's bare chest (skin to skin) and cover them

• give antibiotics (see step 5)

Monitor:

• body temperature: during rewarming take rectal temperature two hourly until it rises to >36.5oC (take half-hourly if heater is used)

• ensure the child is covered at all times, especially at night

• feel for warmth

• blood glucose level: check for hypoglycaemia whenever hypothermia is found

Prevention:

• feed two-hourly, start straightaway (see step 7)

• always give feeds throughout the day and night

• keep covered and away from draughts

• keep the child dry, change wet nappies, clothes and bedding

• avoid exposure (e.g. bathing, prolonged medical examinations)

• let child sleep with mother/carer at night for warmth

Note: If a low reading thermometer is unavailable and the child's temperature is too low to register on an ordinary thermometer, assume the child has hypothermia.

3. Treat/prevent dehydration

Note: Low blood volume can coexist with edema. Do not use the IV route for rehydration except in cases of shock and then do so with care, infusing slowly to avoid flooding the circulation and overloading the heart.

Treatment

The standard oral rehydration salts solution (90 mmol sodium/L) contains too much sodium and too little potassium for severely malnourished children. Instead give special **R**ehydration **S**olution for **Mal**nutrition (ReSoMal).

Children with severe acute malnutrition who present with some dehydration or severe dehydration but who are not shocked should be rehydrated slowly, either orally or by nasogastric tube, using oral rehydration solution for malnourished children (5–10 mL/kg/h up to a maximum of 12 h).

During treatment, rapid respiration and pulse rates should slow down and the child should begin to pass urine.

It is difficult to estimate dehydration status in a severely malnourished child using clinical signs alone. So assume all children with watery diarrhea may have dehydration and give: ReSoMal 5 ml/kg every 30 min for two hours, orally or by nasogastric tube, then 5-10 ml/kg/h for next 4-10 hours: the exact amount to be given should be determined by how much the child wants, and stool loss and vomiting. Replace the ReSoMal doses at 4, 6, 8 and 10 hours with F-75 if rehydration is continuing at these times, then continue feeding starter F-75 (see step 7)

Monitor progress of rehydration: Observe half-hourly for two hours, then hourly for the next 6-12 hours, recording pulse rate, respiratory rate, urine frequency, stool/vomit frequency.

Return of tears, moist mouth, eyes and fontanelle appearing less sunken, and improved skin turgor, are also signs that rehydration is proceeding.

It should be noted that many severely malnourished children will not show these changes even when fully rehydrated. Continuing rapid breathing and pulse during rehydration suggest coexisting infection or overhydration. Signs of excess fluid (overhydration) are increasing respiratory rate and pulse rate, increasing edema and puffy eyelids. If these signs occur, stop fluids immediately and reassess after one hour.

The only indication for IV infusion in a child with severe acute malnutrition is circulatory collapse caused by severe dehydration or septic

shock when the child is lethargic or unconscious (excluding cardiogenic shock). In this cases IV rehydration should begin immediately, using 15 mL/kg/h of one of the recommended fluids.

Following fluids are recommended for therapy: half-strength Darrow's solution with 5 % dextrose or Ringer's lactate solution with 5 % dextrose. If neither is available, 0.45 % saline + 5 % dextrose should be used.

It is important that the child is carefully monitored every 5–10 min for signs of overhydration and signs of congestive heart failure. If signs of overhydration and congestive heart failure develop, intravenous therapy should be stopped immediately. If a child with severe acute malnutrition presenting with shock does not improve after 1 h of IV therapy, a blood transfusion (10 mL/kg slowly over at least 3 h) should be given.

Prevention:

To prevent dehydration when a child has continuing watery diarrhea: keep feeding with starter F-75 (see step 7). Replace approximate volume of stool losses with ReSoMal. As a guide give 50-100 ml after each watery stool. (Note: it is common for malnourished children to pass many small unformed stools: these should not be confused with profuse watery stools and do not require fluid replacement). If the child is breastfed, encourage to continue.

4. Correct electrolyte imbalance

All severely malnourished children have excess body sodium even though plasma sodium may be low (giving high sodium loads will kill). Deficiencies of potassium and magnesium are also present and may take at least two weeks to correct. Edema is partly due to these imbalances. Do NOT treat edema with a diuretic!

Give:

- extra potassium 3-4 mmol/kg/d
- extra magnesium 0.4-0.6 mmol/kg/d
- when rehydrating, give low sodium rehydration fluid (e.g. ReSoMal)
- prepare food without salt

5. Treat/prevent infection

In severe malnutrition the usual signs of infection, such as fever, are often absent, and infections are often hidden.

Children admitted with severe acute malnutrition and complications such as septic shock, hypoglycaemia, hypothermia, skin infections, or respiratory or urinary tract infections, or who appear lethargic or sickly, should be given parenteral (IM or IV) antibiotics.

Children admitted with severe acute malnutrition and with no apparent signs of infection and no complications should be given an oral antibiotic.

Children with uncomplicated severe acute malnutrition, not requiring to be admitted and who are managed as outpatients, should be given a course of oral antibiotic such as amoxicillin.

Children who are undernourished but who do not have severe acute malnutrition should not routinely receive antibiotics unless they show signs of clinical infection. Where specific infections are identified, add specific antibiotics if appropriate, antimalarial treatment if the child has a positive blood film for malaria parasites.

6. Correct micronutrient deficiencies

All severely malnourished children have vitamin and mineral deficiencies. Although anaemia is common, do NOT give iron initially but wait until the child has a good appetite and starts gaining weight (usually by the second week), as giving iron can make infections worse.

Children with severe acute malnutrition should receive the daily recommended nutrient intake of vitamin A throughout the treatment period. Children with severe acute malnutrition should be provided with about 5000 IU vitamin A daily, either as an integral part of therapeutic foods or as part of a multi-micronutrient formulation.

Children with severe acute malnutrition do not require a high dose of vitamin A as a supplement if they are receiving F-75, F-1001 or ready-to-use therapeutic food that comply with WHO specifications (and therefore already contain sufficient vitamin A), or vitamin A is part of other daily supplements.

Children with severe acute malnutrition should be given a high dose of vitamin A (50 000 IU, 100 000 IU or 200 000 IU, depending on age) on admission, only if they are given therapeutic foods that are not fortified as recommended in WHO specifications and vitamin A is not part of other daily supplements.

Give daily for at least 2 weeks:

- Multivitamin supplement
- Folic acid 1 mg/d (give 5 mg on Day 1)
- Zinc 2 mg/kg/d
- Copper 0.3 mg/kg/d
- Iron 3 mg/kg/d but only when gaining weight

7. Start cautious feeding

In the stabilization phase a cautious approach is required because of the child's fragile physiological state and reduced homeostatic capacity. Feeding should be started as soon as possible after admission and should be designed to provide just sufficient energy and protein to maintain basic physiological processes.

The essential features of feeding in the stabilization phase are:

- small, frequent feeds of low osmolarity and low lactose

• oral or NG feeds (never parenteral preparations)
• 100 kcal/kg/d
• 1-1.5 g protein/kg/d
• 130 ml/kg/d of fluid (100 ml/kg/d if the child has severe oedema)
• if the child is breastfed, encourage to continue breastfeeding but give the prescribed amounts of starter formula to make sure the child's needs are met.

Milk-based formulas such as starter F-75 containing 75 kcal/100 ml and 0.9 g protein/100 ml will be satisfactory for most children.

F-75, a low-protein milk-based formula diet, is given as the therapeutic food in the stabilization phase, while F-100, a milk formula with higher protein and energy content, is recommended as the therapeutic food in the rehabilitation phase.

Give from a cup. Very weak children may be fed by spoon, dropper or syringe.

Table 5

Recommended schedule for feeding frequency and volume

Days	Frequency	Vol/kg/feed	Vol/kg/d
1-2	2-hourly	11 ml	130 ml
3-5	3-hourly	16 ml	130 ml
6-7+	4-hourly	22 ml	130 ml

For children with a good appetite and no edema, this schedule can be completed in 2-3 days (e.g. 24 hours at each level).

Use the Day 1 weight to calculate how much to give, even if the child loses or gains weight in this phase. If, after allowing for any vomiting, intake does not reach 80 kcal/kg/d (105 ml starter formula/kg) despite frequent feeds, coaxing and re-offering, give the remaining feed by NG tube for intake volumes below which NG feeding should be given). Do not exceed 100 kcal/kg/d in this phase.

Monitor and note: amounts offered and left over, vomiting, frequency of watery stool, daily body weight.

During the stabilization phase, diarrhea should gradually diminish and edematous children should lose weight. If diarrhea continues unchecked despite cautious refeeding, or worsens substantially.

8. Achieve catch-up growth

In the rehabilitation phase a vigorous approach to feeding is required to achieve very high intakes and rapid weight gain of >10 g gain/kg/d. The recommended milk-based F-100 contains 100 kcal and 2.9 g protein/100 ml. Modified porridges or modified family foods can be used provided they have comparable energy and protein concentrations.

WHO recommends changing from F-75 to F-100 once sepsis and metabolic abnormalities are managed effectively, usually indicated by a return of appetite, usually about one week after admission.

The transition to F-100 in the rehabilitation phase should be gradual, with F-75 replaced with an equal volume of F-100 over about 2 days, before increasing the amount of therapeutic food offered to the child.

A gradual transition is recommended to avoid the risk of heart failure which can occur if children suddenly consume huge amounts.

Monitor during the transition for signs of heart failure: respiratory rate, pulse rate. If respirations increase by 5 or more breaths/min and pulse by 25 or more beats/min for two successive 4-hourly readings, reduce the volume per feed.

After the transition give:

• frequent feeds (at least 4-hourly) of unlimited amounts of a catchup formula

• 150-220 kcal/kg/d

• 4-6 g protein/kg/d

• if the child is breastfed, encourage to continue (Note: breast milk does not have sufficient energy and protein to support rapid catch-up growth).

Monitor progress after the transition by assessing the rate of weight gain: weigh child each morning before feeding. Plot weight, each week calculate and record weight gain as g/kg/d.

If weight gain is:

• poor (<5 g/kg/d), child requires full reassessment

• moderate (5-10 g/kg/d), check whether intake targets are being met, or if infection has been overlooked

• good (>10 g/kg/d), continue to praise staff and mothers

The recommended energy intake during this period is 100–135 kcal/kg/day.

Let the child drink water freely.

Children who have been admitted with complicated severe acute malnutrition and are achieving rapid weight gain on F-100 should be changed to ready-to-use therapeutic food and observed that they accept the diet before being transferred to an outpatient programme.

9. Provide sensory stimulation and emotional support

In severe malnutrition there is delayed mental and behavioral development. Provide:

• tender loving care

• a cheerful, stimulating environment

• structured play therapy 15-30 min/d

• physical activity as soon as the child is well enough

• maternal involvement when possible (e.g. comforting, feeding, bathing, play)

10. Prepare for follow-up after recovery

A child who is 90% weight-for-length (equivalent to -1SD) can be considered to have recovered. The child is still likely to have a low weight-for-age because of stunting. Good feeding practices and sensory stimulation should be continued at home. Show parent or carer how to feed frequently with ener-gy- and nutrient-dense foods, give structured play therapy.

Advise parent or carer to:

- bring child back for regular follow-up checks,
- ensure booster immunizations are given,
- ensure vitamin A is given every six months.

Criteria for discharging children from treatment

Children with severe acute malnutrition should only be discharged from treatment when their:

– weight-for-height/length is ≥–2 Z-score and they have had no edema for at least 2 weeks, or

– mid-upper-arm circumference is ≥125 mm and they have had no edema for at least 2 weeks.

Percentage weight gain should not be used as a discharge criterion.

Discharge before recovery is complete

A child may be considered to have recovered and be ready for discharge when she/he reaches 90% weight-for-length. For some children, earlier discharge may be considered if effective alternative supervision is available.

Domiciliary care or home-based treatment should be considered only if the following criteria are met:

The child

• is aged >12 months

• has completed antibiotic treatment

• has good appetite and good weight gain

• has taken potassium/magnesium/mineral/vitamin supplement for 2 weeks (or continuing supplementation at home is possible)

The mother/carer

• is not employed outside the home

• is specifically trained to give appropriate feeding (type, amount and frequency)

• has the financial resources to feed the child

• lives within easy reach of the hospital for urgent readmission if the child becomes ill

• can be visited weekly
• is trained to give structured play therapy
• is motivated to follow the advice given

Local health workers

• are trained to support home care
• are specifically trained to examine the child clinically at home, to decide when to refer him/her back to hospital, to weigh the child, and give appropriate advice
• are motivated

When children are being rehabilitated at home, it is essential to give frequent meals with a high energy and protein content. Aim at achieving at least 150 kcal/kg/d and adequate protein intake (at least 4 g/kg/d).

Children with severe acute malnutrition who are discharged from treatment programmes should be periodically monitored to avoid a relapse.

8. PREVENTION OF MALNUTRITION

There are five main components for prevention of malnutrition which focus on:

1) close observations and monitoring of pregnant women,
2) encourage of breastfeeding,
3) improving of vaccination and immunization,
4) adequate complimentary feeding,
5) water supply, sanitation, and hygiene

Training of health care workers for monitoring of child`s weight and growth and parent's education also are important.

9. PROGNOSIS

Even if medical treatment is sought immediately, children and adults with severe malnutrition may never fully recover. In fact, the long-term effects of severe malnutrition often include a chronic ability to absorb nutrients and mental impairment. Patients presenting with persistent diarrhea, jaundice, low sodium levels and loss of consciousness at the time of treatment typically have a poorer prognosis than other malnourished patients.

10. QUESTIONS FOR SELF-CONTROL

1. Anatomical and physiological features of the skin and subcutaneous layer in children.
2. Anatomical and physiological features of digestive system in children.
3. Definition of main nutritional disorders in children.

4. Etiology and pathogenesis of protein-energy malnutrition in children.
5. Classification of protein-energy malnutrition.
6. Clinical manifestations of malnutrition in children
7. Physical examination of children with protein-energy malnutrition.
8. Obligatory and additional laboratory tests for diagnosis of malnutrition.
9. Differential diagnostics of severity of protein-energy insufficiency.
10. Management of malnutrition in children.
11. Diet therapy of different degree of protein-energy malnutrition.
12. Medical care for malnourished children.
13. General principles for treatment of severe malnutrition.
14. Prevention of malnutrition in children.

11. TESTS FOR SELF-CONTROL

1. A 12 months old child has progressive weight loss, constipation, muscular atrophy, loss of skin turgor, hypothermia, and edema. Select the dietary deficiency that is likely to be responsible.

A. Fat deficiency
B. Caloric deficiency
C. Riboflavin deficiency
D. Vitamin D deficiency
E. Vitamin C deficiency

2. The criterion of effectiveness of diet therapy in case of hypotrophy is:

A. Normalization of Hb and serum protein
B. Normal serum protein and glucose
C. Normal level of sodium in blood
D. Increase of body weight by 25-30 g every day
E. Normal temperature of body

3. An 8 months old child is exclusively breastfed. Physical examination reveals pallor of skin and mucous membrane, decrease of turgor, and absent of subcutaneous fat on his trunk and extremities. Lack of body mass is 28 %. Heart sounds are rhythmic and muffled. Abdomen is swollen. Make the diagnosis.

A. Pylorostenosis
B. Hypotrophy (malnutrition) of the 1 degree.
C. Congenital myocarditis
D. Hypostature
E. Hypotrophy of the II degree

4. The inpatient pediatric team is discussing the causes of failure to thrive (FTT) as they evaluate a 9-month-old infant with weight and length

below the 5th percentile. Which of the following should be included in the differential diagnosis of infant who is not thriving?

A. Small atrial septal defect
B. Acute bacterial meningitis
C. Cystic fibrosis
D. Recurrent otitis media
E. Mild intermittent asthma

5. The main target of the first period of diet therapy in case of malnutrition is:

A. Achievement of normal body weight
B. Increase of protein loading
C. Increase of fat loading
D. Increase of carbohydrate loading
E. Estimation of food tolerance

Key answer:

1. B;
2. D;
3. E;
4. C;
5. A.

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