R.F. Tepaev[1,2], A.E. Aleksandrov[1,2], I.V. Kirgizov[1,2]
[1] Scientific Center of Children's Health, RAMS, Moscow
[2] Sechenov First Moscow State Medical University

Parenteral nutrition in pediatrics and pediatric surgery

Contact Information:

RAMS, Scientific Center of Children's Health, Department of Anesthesiology-Resuscitation - Chief Scientific Officer.
First Moscow State Medical Academy, Department of Pediatrics - Professor.
Address: 119991, Moscow, Lomonosov avenue, 2/62
tel.: (499) 783-27-91 (499) 783-27-91
e-mail: rtepaev@inbox.ru

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Nutrition plays a key role in the growth and development of children. Modern balanced parenteral nutrition can adequately supply the child's body with amino acids, carbohydrates, fats, and energy needed to maintain a basic energy level, physical activity, growth, correction of previous nutritional deficiency. The child's body needs a sufficient amount of electrolytes, minerals, trace elements and vitamins. Protein-energy homeostasis is the basis of life of the organism, which determines the activity of the inflammatory response, the adequacy of the immune status, duration and severity of the disease. The paper presents current data on the conduct of parenteral nutrition in children of different age groups.

Keywords*: malnutrition, correction, Protein and energy homeostasis, parenteral nutrition, and children.*

A balanced, nutritious food is the basis of harmonious growth and development of children. In contrast to adults children need adequate nutrition, not only to sustain the body, but also to grow, which is especially important for children of the early age group and teenagers. It is known that these periods are characterized by extremely rapid growth, which explains the special sensitivity to energy starvation due to the high level of basal and anabolic requirements. It is important to note the exceptional sensitivity to nutritional deficiency in infants and neonates: for example, premature babies weighing up to 1 kg contain only 1% fat, 8% protein and have a non-protein energy reserve of 110 kcal / kg of body weight. As the baby is accumulating fat and protein mass slowly, by the end of the first year of life the non-protein energy reserve reaches 220 kcal / kg body weight. The accession of a disease in preterm infants may lead to a dramatic increase in the demand for energy substrates with the development of life-threatening conditions in 2 days [1,

2]. Obviously, this category of patients is at a considerable disadvantage compared to older children and older patients, which requires early administration of parenteral nutrition (PN). Nutritional deficiency, caused by dysfunction of the gastrointestinal tract (GIT) that captures digests and reabsorbs nutrients is the reason for the PN. The following are the major causes of nutritional deficiency:
• congenital or acquired anomalies of the gastrointestinal tract (gastroschisis, intestinal fistulae, intestinal obstruction, intestinal atresia, short bowel syndrome);
• syndrome of chronic diarrhea (malabsorption syndrome, inflammatory diseases of the gastrointestinal tract, including Crohn's disease, ulcerative colitis, necrotizing enter colitis, etc.);
• premature infants;
• symptoms of malnutrition (including diseases where enteral feeding does not provide adequate energy needs: cystic fibrosis, oncology, conditions after radiation and cytostatic therapy, psychogenic anorexia, hyper metabolic states, such as patients with burns);
• Children with temporary restrictions on enteral nutrition (including after surgery).
PN means conducting infusion therapy, which aims at the introduction of water, macro-and micronutrients to meet the needs of the body. There are full, partial and additional PPs.
Partial or mixed PN - a parenteral administration of nutrients with limited opportunities for enteral way of their introduction.
Additional PN - the introduction of certain nutrients with increasing demand for them (for example, addition of amino acids for activation of repair processes).
Depending on the type of venous access two types of total parenteral nutrition are distinguished:
• Peripheral (no more than 2 weeks using solutions containing no more than 10% glucose);
• Central (subject to the constraints of access and duration of peripheral PN for more than 2 weeks using a solution containing 10% glucose).
The initiation of PN suggests a preliminary correction of fluid, electrolyte disturbances and acid-base status. Water is the most important carrier of nutrients and metabolites in the body, therefore providing an adequate amount of fluids and electrolytes is one of the most important tasks for the PP.
Total water requirements (TW) consist of three components: daily maintenance fluid requirement (DMF), replacement of water deficits (WD), and replacement of ongoing losses (OL):
TW = DMF + WD + OL.
DMF are 1500 ml/m2 body surface. This formula is used for children weighing over 10 kg. The need for fluid, depending on body weight is defined as follows [3, 4]:
• up to 2.5 kg - 120 ml / kg per day;
• 2.5 to 10 kg - 100-120 ml / kg per day;
• 10 to 20 kg - 1000 ml + 50 ml per kg of body weight over 10 kg;
• more than 20 kg - 1500 ml + 20 ml per kg of body weight over 20 kg.
DMF is satisfied in the form of uniform infusions during the day.

The volume WD depends on the degree of dehydration, as determined by clinical and laboratory parameters (Table 1).
Calculation of WD can also lead to hematocrit:
LRD ml / kg = (Htb - Ht n)/Ht n × M (kg) × K
where Htb - hematocrit patient Htn - hematocrit is normal, M - mass of the child in kilograms, K - coefficient of the extracellular fluid, expressed as a percentage (45 - to prematures, 40 - for babies, 30 - for infants, 25 - younger age, 20 - older age).
Table 2 presents the recommendations for the volume of WD in children of different ages.
In the case of stable hemodynamic parameters the calculated volume of WD can be divided into two equal parts, the first part must be injected in up to 8, the second - in up to 16 hours
The volume of OL is calculated as follows:
• for each degree of temperature above 37 C for at least 8 hours - 10 ml / kg;
• for every 20 breaths higher than the age norm - 15 ml / kg;
• vomiting - 20 ml / kg (in 1 liter of gastric juice there is 50-100 mmol. sodium, 10-20 mmol. of potassium and 100 mmol of chloride);
• For an increased stool - 20-30 ml / kg after each defecation (approximately 40 mmol of sodium, potassium, chloride in 1 liter of intestinal losses);
• second degree paresis of the intestine - 20 ml / kg, third degree - 40 ml / kg;
• during the neonatal phototherapy - 20 ml / kg per day.
OL are compensated directly at the time of their registration.
The volume of fluid therapy should be limited in the case of following conditions:
• swollen brain;
• heart failure;
• swelling;
• acute renal failure;
• respiratory failure due to acute lung injury, respiratory distress syndrome, pneumonia.
Limitations of FT can be calculated as 2/3-3/4 of the DMF, or intangible losses due to perspiration - 300-400 ml/m2 + urine output for the previous day, depending on the severity of the patient.

Electrolytes and minerals
Daily demand in the electrolytes and minerals, depending on age is presented in Table 3[4].
Sodium is the major cat ion of the extracellular fluid, which modulates the intravascular and interstitial fluid volume. Severe hyponatremia is associated with cerebral edema, convulsions, loss of consciousness, coma [5]. The most common causes of hyponatremia are: excessive loss of sodium in diseases of the digestive tract surgery (drainage, fistulas), non-surgical profile (gastroenteritis), and kidney disease.
Daily requirement of sodium is composed of physiological needs and shortages which are caused by the pathological process. Calculation of sodium deficit is as

follows:
Deficiency of Na (mmol) = (Na desired - Na true) × M (kg) × K
where K - the coefficient of the extracellular fluid, which is 0.45 for prematures, for newborns - 0.4, babies - 0.3, young children - 0.25, school-age children - 0.2, on average - 0.3. 1 ml of 10% sodium chloride contains 1.7 mmol of sodium.
Injection speed: Optimal growth in the level of sodium in the blood serum in the case of hyponatremia should not exceed 0.5 mmol / L per hour (preferably no more than 6-8 mmol / day), given the possibility of development of the osmotic demyelination syndrome [6].
Potassium is the main intracellular cation. There is a direct relationship between a negative energy balance and hypokalemia. Clinical signs usually occur with a decrease in serum potassium levels below 2.5 mmol / l. These include muscular hypotonic conditions, seizures and paresis of the intestine.

Neurological and psychiatric disorders are observed such as numbness of the skin, par aesthesia, irritability, apathy, and lethargy. The most dangerous complications are the increased excitability of the myocardium (cardiac arrhythmias as ventricular arrhythmia, ventricular fibrillation) and metabolic alkalosis. Among the most important causes of hypokalemia there are such conditions as the loss of potassium via the gastrointestinal tract (gastroenteritis, intestinal obstruction, intestinal paresis, peritoneal drainage, rarely lasting effusions of pleural fluid and CSF) [7].
Calculation of extracellular potassium deficiency can be made concerning the formula for sodium, but it is important to understand that potassium is predominantly an intracellular electrolyte, and the elimination of extracellular deficit is not accompanied by his true correction. In recent years, due to the complexity of the process, method of intracellular potassium is determination is rarely used.
Rate of introduction of the electrolyte should not exceed 0.5 mmol / kg per hour. The concentration of potassium in the fluid medium is not more than 0.75%. 1 ml of 7.5% potassium chloride contains 1 mmol of potassium.
Magnesium: 1 ml of 25% magnesium sulfate solution contains 1 mM of magnesium.
Calcium: 1 ml of 10% calcium gluconate solution contains 0.25 mmol of calcium.
Microelements
Daily requirement for trace elements (iron, chromium, copper, magnese, selenium, iodine, fluorine) (Table 4) is provided by adding into the mixture of amino acids or glucose solutions of the drug Addamel N at rate of 0.1 ml / kg per day (for children with weighing from 15 to 40 kg). For patients weighing 40 kg and more the appropriate dose is of 10 ml.
Sources of Energy
The major objective of PP is to ensure adequate energy needs of a child (basic metabolic rate, physical activity, growth, malnutrition, previous nutritional deficiency). [8] On the one hand, the excessive energy can be accompanied by hyperglycemia, excessive deposition of fat, fatty liver, liver disease associated with

parenteral nutrition (parenteral nutrition-associated liver disease - PNALD) [9, 10]; on the other hand, the lack of supply of energy is usually associated with development of malnutrition, and hypo statue and immunological failure.
The daily energy requirement is determined by age (kcal / kg per day) [4]:
• Up to 1 year - 90-120;
• from 1 to 7 years - 75-90;
• 7 to 12 years - 60-75;
• over 12 years - 30-60.
In some states, the daily caloric needs should be increased (Table 5).
It should be emphasized that children of the first year of life with nutritional deficiency may require up to 150-170 kcal / kg per day to meet the needs of the organism for growth.
Below there are energy sources needed to conduct a full parenteral support of the patient.
Carbohydrates (glucose 1 g - 4.1 kcal) are the main source of energy, usually up to 60% of daily caloric needs. Home glucose concentration during the infusion therapy is 5-10%. There are exceptions such as premature and newborn babies whose saturation of the solution should not exceed 5%. Rate of daily increasing concentrations of glucose for newborns, infants is 2.5%, for younger and older age - 2.5-5%. European Society for Clinical Nutrition and Metabolism (ESPEN) recommends the following calculation of the starting rate of glucose introduction for children of different age groups (in mg / kg per min) [4]:
• premature infants - 4-8 mg / kg per min, increased - by 1.2 mg / kg per minute every day;
• full-term and children under 2 years - 7-8 mg / kg per min, higher - 2-4 mg / kg per minute every day;
• Children older than 2 years - 6-9 mg / kg per min;
• Children in critical conditions: no more than 5 mg / kg per min (7.2 g / kg per day).
Table 6 shows the need of glucose for children (in g / kg per day) depending on the duration spent the PP.
The target (maximum) concentration of glucose can not be more than 12.5% during peripheral PP and 20-25% - in the central PP. Higher concentrations (30-35%) can be used with caution in older patients, as well as in the case of hard limiting the amount of ongoing infusion.
In order to increase the utilization of glucose insulin is used in a dose of 1 IU to 4-5 g dry weight of glucose (hyperglycemia with more than 8 mmol / l). In the case of hypoglycemia (less than 2.8 mmol / L in children) intravenous infiltration of 20 or 40% glucose at the rate of 0.25 g / kg body weight is recommended, followed by intravenous drip infusion - 5 mg / kg per min, or 0 3 g / kg per hour. In case of severe hyperglycemia it is necessary to begin a continuous infusion of insulin of 0.1 U / kg per hour to control blood glucose levels every 2-3 hours.
Lipids (1 g - 9 kcal) are appointed as isosmotic sources of energy, providing up to 40% of daily needs, as well as for prevention of deficiency of essential fatty acids. Duration of fat emulsions infiltrations is 20-24 h (Table 7).

There are four generations of fat emulsion:
1st generation - long-chain fatty emulsion (LCT): Lipofundin S, Intralipid, Lipovenoz;
2nd generation - the fat emulsion - triglycerides with medium chain length (LCT / MCT): Lipofundin LCT / MCT;
The emulsions of second generation LCT / MCT (Lipofundin LCT / MCT) have the following advantages:
• More efficient source of energy;
• High protein-saving effect;
• Increased rate of utilization of triglycerides;
• No immune system suppression;
• Reduction of the production of pro inflammatory cytokines [11].

3rd generation - emulsions containing soybean oil, MCT, fish oil: Lipoplus.
4th generation - SMOFLipid ,a four-fat emulsion consisting of soybean oil, olive oil, MCT, and fish oil. The creators have used all the advantages of the used fat emulsion components and developed a balanced composition, taking into account current knowledge on fats metabolism.
• Soybean oil is a source of essential fatty acids.
• Olive oil is a source of monounsaturated fatty acids, addition of which reduces the proportion of polyunsaturated fatty acids reduce the activity of lipid peroxidation.
• Fish oil has the omega-3 fatty acids, which help to reduce the severity of the inflammatory response and have immunomodulation effects.
• Positive effects of MST are provided above. Their share of the fat emulsion SMOFLipid is 30%, which eliminates the risk of increased thermogenesis and ketone acidosis associated with their introduction to the excess.
In addition, there is a separate product based on the fat emulsion of fish oil ,- "Omegaven." It is used along with parenteral nutrition, in which the content of omega-3 fatty acids is not enough.
It is important to keep in mind that young children have decreased lipoprotein lipase activity, which may cause hyper lipid emic syndrome. In this regard, there is a recommendation to use heparin, at the rate of 3-4 units per 1 ml of fat emulsion for stimulation of endothelial lipoprotein lipase. However, according to J. Peterson et al. [12], heparin injection leads to increased blood concentrations of free fatty acids, thus exceeding the possibilities of fixation of lipolysis products and reducing the ability to bind endothelial lipoprotein lipase to the endothelium. That's why ESPEN / ESPGHAN do not recommend routine use of heparin during the PP in children [4].
Lipids are prescribed with caution to patients with hyper bilirubinemia (bilirubin glucoronization depression) and severe respiratory failure (deterioration of the alveolar capillary diffusion and subsequent decrease in p02).
To assess the tolerance of fat emulsions (lack of tolerance is associated with the development of cholestasis hepatitis and poor prognosis), it is advisable to determine the serum levels of triglycerides. ESPEN recommends maintaining the

level of triglycerides in the background of PP not higher than 2.8 mmol / L for neonates and premature infants and 3, 3-4, 5 mmol / l - for older patients [4].

Sources of nitrogen

Currently sources of nitrogen are the solutions of crystalline amino acids. The creation of these solutions is necessary because inadequacy of enzymes involved in protein metabolism of newborn and young children. In addition to the indispensable amino acids of the adults (isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine), for infants the following amino acids are especially essential: cysteine, taurine, tyrosine, histidine. For parenteral nutrition of infants and children under 2 years it's now allowed to use the drug Aminoven Infant - 6, and 10%. For children older than 2 years it may be possible to use a balanced content of essential and nonessential amino acids Aminoven 5, 10, 15% CI 10% Aminosteril; Infezol, Vamin 18, Vamin EF, Polyamine, Haymiks [13].

The daily need for protein is presented in Table 8.

The starting rate of introduction of amino acid mixtures is:

• Baby - 0.5-1 g / kg per day with a daily capacity dose of 0.5 g / kg per day,

• For older children - 1 g / kg per day with a daily capacity dose of 0.5-1 g / kg per day.

The speed of amino acids intake is 0.1-0.15 g / kg per hour. In order to increase the anabolic direction PP, ratio of energy in kilocalories to nitrogen, expressed in grams, should be 250-300:1, which ensures adequate utilization of amino acids. It should be noted: 1 g protein / 6.25 = nitrogen content of 1 g Calories Protein - 4 kcal / g, when calculating the total calorie value of PP, this is not considered. Pharmacy nutrients are the nutrients that have specific pharmacological properties contributing to regeneration of damaged cells (enterocytes, lymphocytes, macrophages), improving metabolic processes and the immune system in critical conditions, etc. These include glutamine, arginine, nucleotides, omega-3 fatty acid, carnitine and tocopherol. Effects of glutamine and omega-3 fatty acid are the most deeply investigated. Artificial nutrition with nutrients, or so-called pharmacological nutrition, is appointed to improve the efficiency of clinical nutrition in specific states and pathological processes.

Glutamine (**Dipeptiven**)

The introduction of glutamine for parenteral nutrition reduces bacterial translocation by preventing mucosal atrophy and having a stimulating effect on the immune function of the gastrointestinal tract; it normalizes production of secretory immunoglobulin A; improves endocrine, metabolic and barrier functions, the preservation of which is necessary to prevent multiple organ failure caused by translocation of bacteria and toxins in the blood in critical conditions. A number of studies showed that inclusion of glutamine in a comprehensive therapy reduces mortality, length of hospitalization, and health care costs [14, 15]. Intravenous glutamine dipeptide makes up for deficits that occur with patients having pathology of the gastrointestinal tract and with patients in critical conditions [14, 15]. The recommended dose of Dipeptiven is - 1.5-2.0 ml / kg body weight per day. It is appropriate to add the drug into solutions of amino acids.

Omega-3 fatty acids (Omegaven)

Parenteral infiltration of omega-3 fatty acids (eicosapentaenoic acid - C20: 5 omega-3 and docosahexaenoic acid - C22: 6 omega 3) allows to make up the deficit and restore the balance of omega-6 and omega-3 fatty acids. Due to its modulatory and anti-inflammatory immune properties, omega-3 fatty acids, included into composition of parenteral nutrition, are particularly effective for patients in critical conditions due to sepsis.

It is important to note that Omegaven is not recommended for use for children, but there is evidence of successful use of the drug for the treatment of the first year infants with short bowel syndrome. In Gura K.M. et al. there was mentioned a regression of cholestasis hepatitis (Parenteral Nutrition-Associated Liver Disease - PNALD) during long-term parenteral nutrition with Omegaven as a source of fat and energy [10].

Vitamins

Cernevit (water-and fat-soluble vitamins) is used in a daily dose of 5 ml / day for children older than 11 years. Infilitarion: by slow intravenous injection or as continuous infusion.

Vitalipid H children (fat-soluble vitamins) can be added to Intralipid 10 or 20% emulsion but no earlier than 1 hour prior to the start of infusion at a dose of 10 ml / day for children up to age 11. Premature babies are prescribed with a daily dose rate of 4 mL / kg per day.

Soluvit H (water-soluble vitamins) is added to one of the following solutions: H Vitalipid children, Intralipid (10 or 20%), glucose solutions (5, 10, and 20%) or in the system for parenteral nutrition, "three in one" (Kabiven central and peripheral) in a dose of 10 ml / day for children over 1 year. For newborns and infants it’s infused at a rate of 1 ml / kg per day.

The formula "three in one"

Among the drugs registered in Russia there are Kabiven central, Kabiven peripheral and Oliklinomel. Table 9 shows the characteristics of the drugs.

It is important to mention the obvious ease of use of these formulas in the older age group; during parenteral nutrition of young children it is advisable to use single component products.

The advantages of using "three in one" technology before infiltrating the solutions of the isolated amino acids, fat emulsion and glucose solution, are the following:

1. High technology, user-friendliness and easy use. While applying the drug "three in one" there is no need to calculate the dose; infusion rate is separately calculated for amino acids, fat emulsion and glucose.

2. Optimally balanced composition. There is no need to specially calculate the ratio of the input amino acid / energy ratio glucose / fat. Kabiven contains electrolytes in balanced proportions. For patients with hyper catabolism supplementation of glutamine dipeptides is required. Three-chambered package has a special port for adding Dipeptivena, vitamins and trace elements, and if necessary, additional infusions - electrolytes.

3. Reducing the risk of infectious complications. Using a three-chamber package reduces the number of manipulations required to conduct a full parenteral nutrition,

minimizes the risk of microbial contamination: three-chamber package is a closed system, requiring only one infusion line; one package fully covers daily needs of the patient in amino acids and energy.
4. It is a less costly technology in economic terms. Application Kabiven can facilitate and expedite the work of medical personnel, reduce the amount of supplies and equipment (systems, infusion pumps, etc.), reduce the incidence of metabolic and infectious complications requiring expensive treatment.

Complications during parenteral nutrition:

1. Infections: Bacteremia, fungi in blood, sepsis, and catheter tunnel infection.
2. Complications associated with catheter and / or venous catheter: venous thrombosis, catheter occlusion of Ca-P crystals, cardiac arrhythmias, myocardial perforation, pneumatic-, hydraulic-, hem thorax, air embolism.
3. Metabolic disorders: fluid overload, dehydration, electrolyte, vitamin disorders, deficiency of essential fatty acids, ammonia in blood, hyperlipidemia, acidosis, hypo-, hyperglycemia.
4. Other: bone demineralization, cholestasis, liver failure, fibrosis and cirrhosis.

The control parameters during parenteral nutrition

Table 10 provides data to be analyzed during the PN for the timely correction of metabolic disorders. It should be noted that the multiplicity of biochemical research depends on the severity of patient's condition, i.e. metabolic monitoring of children in critical condition differs significantly from that of children with chronic gastrointestinal diseases. In addition, it is necessary to assess the patient's physical development: body weight, height, head circumference of children aged 3 years, the estimated ideal weight, skin fold thickness, ratio of weight to height, etc. Ultimately, the purpose of parenteral nutrition is to maintain the nutritional status (in the absence of prior nutritional deficiency). For example, if the child's anthropometric data corresponds to the 75 centile, it's necessary to ensure that the indicators of physical development remained within these limits in the course of introducing the PCB.

Algorithm of parenteral nutrition program

• Calculation of the daily fluid volume using the formula:
Vit = AF + + ZHVO +ZHTPP.
• Addressing the need for transfusion therapy and its volume (mass of erythrocytes, platelet, plasma, intravenous immunoglobulin).
• Calculation of amino acid infusion rate (starting dose of 0.5-1 g / kg per day with a daily capacity dose of 0.5-1 g / kg per day, with full PP - 24 h, maximum speed 0.1 - 0.15 g / kg per hour).
• Calculation of the amount of fat emulsion infusion rate with full 24-hour PP (starting dose of 0.5-1 g / kg per day with daily doses of 0.5-1 buildup g / kg per day).
• Calculation of the volume of electrolyte solutions, based on the physiological needs and deficits, taking into account the jet injection drugs.
• Calculation of glucose infusion rate during the full 24-hour PP (starting concentration - 10% with a daily capacity of concentration 2.5-5%).
• Check and correcting (if necessary) the ratio Energy (kcal): Nitrogen (r) = 1:250-

300. In case of insufficient power supply for the rate of 1 g of amino acids the dose of amino acids should be reduced.

Sample preparation of parenteral nutrition program

Child of 3 years old weighing 16 kg, the second day after surgery, excluding enteral nutrition.

• DMF: V = 1000 ml + 50 ml × 6 kg = 1300 ml.
• The added transfusion therapy is not needed.
• Amino acids intake: V = 16 kg × 1, 5 g = 24 g, 10% Aminoven Infant -240.0, 32.0 Dipeptiven.
• The volume of fat emulsion: V = 16 kg × 1, 5 g = 24 g, 20% -120.0 Lipofundin.
• Electrolyte:
- Potassium intake is V = 16 kg × 2 mmol = 32 mg = S.KCl 4% -64.0.
- Sodium V = 16 kg × 2 mmol = 32 mg = S.NaCl 10% -37.0.
- Magnesium V = 16 kg × 0,1 mg = 1.6 mmol 25% = S.MgSO4 -1.6.
- Calcium V = 16 kg × 0,2 mg = 3.2 mmol = 10% S.Sa gluconici -13.0.
There is no need in correction of the electrolyte deficits for this child.
• The volume of 10% glucose: V = 1300 ml - 272.0 (Aminoven+ Dipeptiven) - 120.0 (Lipofundin) - 104.0 (electrolytes) - 26.0 (jet injection) = 778.0 ~ 800.0.
• The ratio of nitrogen: energy. Nitrogen - Aminoven 10% - 240.0 = 3.5 g, energy: 20% Lipofundin -120.0 kcal = 216 + 10% glucose = 320 -800.0 kcal. Total = 536 calories. Nitrogen Ratio: Energy = 153, which requires reducing the amount of amino acids up to 160 ml (a ratio of 225).

Appointments:

• 10% glucose -800.0 (speed of - 37 ml / h);
• Potassium chloride, 4% -64.0;
• sodium chloride, 10% -37.0;
• Magnesium sulfate, 25% -1.6;
• Calcium gluconate 10% -13.0;
• Lipofundin 20% -120.0 (speed of - 5.8 ml / h);
Aminoven Infant 10% -160 (speed of - 6.7 ml / h);
• Dipeptiven 32.0;
• In case of prolonged (more than 7-14 days) PN, therapy vitamins and minerals are added: Soluvit H 10.0 for children, 10.0 Vitalipid H for children; Addamel H 1.6.

References

1. Koletzko B., Akerblom H., Dodds P., Ashwell M. Early nutrition and its later consequences: new opportunities. Perinatal programming of adult health — EC supported research series. *Advances in Experimental Medicine and Biology.* 2005; 569: 1–237.

2. Tsang R., Koletzko B., Uauy R., Zlotkin S. Nutrition of the preterm infant. Scientific basis and practical application. *Cincinnati: Digital Educational Publishing*. 2005.
3. Weil W.B., Bailie M.D. Fluid and electrolyte metabolism in infants and children. A unified approach. *New York: Grune Stratton*.1977.
4. ESPEN/ESPGHAN Guidelines on paediatric parenteral nutrition. *Clinical Nutrition*. 2006; 25: 177–360.
5. Jannon M., Thompson C.J. Hyponatremia — current treatment strategies and perspectives for the future. *Nephrology*. 2011; 6 (1): 35–39.
6. Douglas I. Hyponatremia: why it matters, how it presents, how we can manage it. *Cleve. Clin. J. Med.* 2006; 73 (Suppl. 3): 4–12.
7. Verive M.J. Pediatric hypokalemia clinical presentation. 2011. URL: http://www.emedicine.medscape.com/article/907757-clinical
8. Elia M. Changing concepts of nutrient requirements in disease: implications for artificial nutritional support. *Lancet.* 1995; 345: 1279–1284.
9. Sheldon G.F., Peterson S.R., Sanders R. Hepatic dysfunction during hyperalimentation. *Arch. Surg*. 1978; 113: 504–508.
10. Gura K.M. et al. Reversal of Parenteral nutrition–associated liver disease in two infants with short bowel syndrome using parenteral fish oil: Implications for future management. *Pediatrics.* 2006; 118: 197–201.
11. Adolph M. Lipid emulsions in total parenteral nutrition. *Clnical Nutrition*. 2001; 20 (Suppl. 4): 11–14.
12. Peterson J., Bihain B.E., Bengtsson-Olivecrona G. et al. Fatty acid control of lipoprotein lipase: a link between energy metabolism and lipid transport. *Proc. Natl. Acad. Sci. USA.* 1990; 87: 909–913.
13. Lazarev V.V., Tsypin L.E., Korsun, A.A., E. N. Baibarina . Current approaches to parenteral nutrition for children. Children's Hospital2007; 2: 36–47.
14. Novak F., Heyland D.K., Avenell A. et al. Glutamine supplementation in serious illness: a systematic review of the evidence. *Critical Care Medicine*. 2002; 30: 2022–2029.
15. Newsholme P., Curi R. et al. Glutamine metabolism by lymphocytes, macrophages, and neutrophils: its importance in health and disease. *Journal of Nutritional Biochemistry.* 1999; 10: 316–324.

Table 1 The evaluation of dehydration severity among children

Sign	**The degree of dehydration (% weight loss)**		
	I (4–5%)	**II (6–9%)**	**III (10% and more)**
Stool	Liquid, 4–6 times per day	Liquid, up to 10 times per day	Watery, > 10 times per day
Vomiting	1–2 times	Repeated	Multiple
Thirst	Moderate	Sharply expressed	Weak desire to drink
Appearance	The child is excited and anxious	Restlessness or lethargy	Drowsiness, a child can be unconscious
Skin elasticity	Saved	Decreased (skin fold	Dramatically reduced

		crashes slowly)	(skin folding crashes in 2 sec)
Eyes	Normal	Sunken	Sunken sharply
Tears	Yes	No	No
Large fontanel	Normal	Sinks	Sharply drawn
Mucous	Moisturized or a little bit dry	Dry	Dry sharply reddish
Heart tones	Loud	Soft	Deaf
Tachycardia	Absence	Moderate	Severe
Radial pulse	Normal or slightly speeded	Fast and weak	Thread-like, sometimes not detectible
Cyanosis	Absence	Moderate	Pronounced
Breath	Normal	Moderate shortness of breath	Deep, rapid, dyspnea
Voice	Saved	Weakened	Aphonic
Urine output	Normal	Lowered	Absent for 6-8 hours
Body temperature	Normal or increased	Often increased	Lower than normal

Table 2 The volume of infusion therapy for replacement of water deficits in children of different ages, ml / kg per day

Dehydration degree	**Up to 1 year old**	**1–5 years old**	**Older than 5 years old**
I	170	100–125	75–100
II	200	130–150	110
III	220	150–170	120

Table 3 Electrolytes and minerals daily intake.

Age	**Na mmol/kg**	**K mmol/kg**	**Cl mmol/kg**	**Mg* Mgr/kg (mmol/kg)**	**Ca* mgr/kg (mmol/kg)**	**P* Mgr/kgr (mmol/kg)**
Newborns	2–3	1,5–3	2–3	5 (0,2) < 6 мес	32 (0,8) < 6 мес	14 (0,5)
Up to 1 years old	2–3	2–3	2–4	4,2 (0,2) > 6 мес	20 (0,5) > 6 мес	14 (0,5)
Young children	2–3	1–2	2–3	2,4 (0,1)	11 (0,2) до 13 лет	6 (0,2)
Pupils	1–3	1–2	2	2,4 (0,1)	7 (0,2) 14–18 лет	0,2
Notice: Here and in Table 4 asterisk is entered with 2 weeks of parenteral nutrition						

Table 4 Daily intake of microelements in children [4]

Age	**Fe* Mkg/kg**	**Cr* Mkg/kg**	**Se** Mkg/kg**	**J Mkg/day**	**Cu** Mkg/kg**	**Zn** Mkg/kg**	**Mn** Mkg/kg (mkmol/kg)**
Newborns	50–100	0,2	2–3	1,0	20	250 <3 мес	1,0 (0,018)
Up to 1 years old	50–100	0,2	2–3	1,0	20	100	1,0 (0,018)
Young children	50–100	0,2	2–3	1,0	20	50	1,0 (0,018)
Pupils	50–100	0,2	2–3	1,0	20	50	1,0 (0,018)
Notice. ** — injected from the 4th week of parenteral nutrition							

Table 5 Factors incresing needs in energy.

Factor	**Additional need in energy, %**
Fever	10–12 — for every degree >37° C
Heart failure	15–25
Surgeries	20–30
Burns	Before 100
Severe sepsis	40–50
Wasting	50–100

Table 6 The need for children to carbohydrates (g / kg per day) depending on the time spent parenteral nutrition

Body mass, kg	**1st day**	**2nd day**	**3rd day**	**4th day**
Up to 3	10	14	16	18
3–10	8	12	14	16–18
10–15	6	8	10	12–14
15–20	4	6	8	10–12
20–30	4	6	8	<12
>30	3	5	8	<10

Table 7. Dosing of fat emulsions, depending on age

Doses	**Premature**	**Infants**	**Old children**
Start dose, gr/kg per day	0,5	1	1
Increasing the dose rate, gr/kg per day	0,25	0,5	0,5
Maximum dose, gr/kg per day	3	3–4	2–3

Table 8 The need for children in the protein, depending on age

Age group	**Protein requirements for parenteral nutrition gr/kg per day**
Preterm, neonates, infants	2,5–3
Over 1 year old	1,5–2
Older children	1–1,5

Table 9 Characteristics of drugs "Three in one"

Indicator	**Kabiven (central)**	**Oliklinomel (7-1000)**
Nitrogen/non protein calories	1/148	1/158
Glucose/Lipids (kkal)	55/45%	62/38%
Percentage of essential amino acids	45%	40,5%
Leucine/Isoleucine	1/1,45	1/1,2
Essential fatty acids	62%	20%
The ratio of fatty acids ω-3/ω-6	1/7	1/9
Glucose concentration	19%	40%

Table 10. The control parameters during parenteral nutrition

Daily	Body mass
	Blood glucose 1–4 times
	Urine glucose 2–4 times
	Urine density 2 times
	Diuresis
	Clinical condition
Weekly	Serum electrolytes 2–3 times
	Acid-based status 2–3 times
	Calcium, phosphorus, magnesium 1–2 times
	Total protein 1–2 times
	Albumin 1–2 times

	Immunoglobulin 1 time
	Total blood test 2 times
	Creatinin 1–2 times
	Triglycerides 2–3 times
	Transaminases 1 time
	Bilirubin 1 time
	Lipase 1 time
	Osmolality 2–3 times