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OPTIMIZATION OF PARENTERAL NUTRITION AS A FACTOR IN REDUCING COMPLICATIONS IN NECROTIZING ENTEROCOLITIS IN NEWBORNS

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Abstract:

Necrotizing enterocolitis (NEC) is one of the most severe diseases of the neonatal period, characterized by high mortality and a significant risk of long-term complications. In conditions where enteral feeding is limited in newborns with NEC, adequate nutritional support becomes especially important. The aim of this review is to analyze current data on the role of optimizing parenteral nutrition in the prevention of metabolic disorders, infectious complications, and in improving clinical outcomes in newborns with necrotizing enterocolitis. The review discusses the features of providing requirements in proteins, lipids, carbohydrates, trace elements, and vitamins, as well as modern strategies for individualizing nutritional support. Data on the impact of balanced parenteral nutrition on reducing the incidence of sepsis, cholestasis, growth retardation, and short bowel syndrome are presented.

Некротизирующий энтероколит (НЭК) является одним из наиболее тяжёлых заболеваний неонатального периода, характеризующимся высокой смертностью и значительным риском развития отдалённых осложнений. В условиях ограничения энтерального питания у новорождённых с НЭК особое значение приобретает адекватная нутритивная поддержка. Целью настоящего обзора является анализ современных данных о роли оптимизации парентерального питания в профилактике метаболических нарушений, инфекционных осложнений и улучшении клинических исходов у новорождённых с некротизирующим энтероколитом. Рассматриваются особенности обеспечения потребностей в белках, липидах, углеводах, микроэлементах и витаминах, а также современные стратегии индивидуализации нутритивной поддержки. Представлены данные о влиянии сбалансированного парентерального питания на снижение частоты сепсиса, холестаза, задержки роста и синдрома короткой кишки.

Keywords: necrotizing enterocolitis, newborns, parenteral nutrition, nutritional support, preterm infants, cholestasis, sepsis, short bowel syndrome, complications, neonatology.
некротизирующий энтероколит, новорождённые, парентеральное питание, нутритивная поддержка, недоношенные дети, холестаз, сепсис, синдром короткой кишки, осложнения, неонатология

Necrotizing enterocolitis remains one of the leading causes of morbidity and mortality among preterm infants. The incidence of NEC in extremely low birth weight infants reaches 7-10%, while mortality in severe forms of the disease ranges from 20% to 50%. The development of an inflammatory and necrotic process in the intestine is accompanied by impaired digestion and nutrient absorption, often necessitating complete cessation of enteral feeding for an extended period.

Under these conditions, parenteral nutrition becomes the primary source of energy and essential substrates, ensuring the maintenance of metabolic processes, growth, and development of the infant. However, prolonged use of parenteral nutrition may be associated with serious complications, including catheter-related infections, metabolic disturbances, and liver injury. Therefore, optimization of the composition and administration regimen of parenteral nutrition is considered one of the key factors in improving the prognosis of patients with NEC.

Necrotizing enterocolitis (NEC) is accompanied by profound metabolic and functional disturbances caused by inflammatory and necrotic damage to the intestinal wall, systemic inflammatory response, and the

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development of a hypercatabolic state. As the disease progresses, the newborn's body experiences an increased demand for energy and structural substrates, highlighting the importance of timely and adequate nutritional support.

During the acute phase of NEC, activation of proinflammatory cytokines, including interleukin (IL)-1β, IL-6, IL-8, and tumor necrosis factor-alpha (TNF-α), is observed, leading to enhanced catabolic processes and increased basal metabolic rate. Systemic inflammation promotes protein breakdown, impairs the synthesis of structural tissue components, and results in a negative nitrogen balance. In preterm infants, who possess limited nutrient reserves and immature adaptive mechanisms, these alterations may rapidly lead to severe protein-energy malnutrition.

Simultaneously, inflammatory injury to the intestinal wall is associated with impaired gastrointestinal motility, reduced digestive and absorptive capacity, and increased intestinal permeability. The development of mucosal ischemia and necrosis precludes adequate enteral feeding and, in some cases, necessitates its complete discontinuation for prolonged periods. Consequently, parenteral nutrition becomes the only means of providing the body with essential nutrients.

A key component in the pathogenesis of NEC is the development of systemic inflammatory response syndrome, accompanied by increased energy consumption, enhanced lipolysis and proteolysis, and impaired carbohydrate metabolism. Metabolic stress contributes to hyperglycemia, insulin resistance, and increased free radical production, further exacerbating tissue damage and worsening the disease.

Microcirculatory disorders and tissue hypoxia play a significant role. Reduced intestinal perfusion and the development of reperfusion syndrome lead to a deficiency of oxygen and energy substrates, accompanied by lactate accumulation and metabolic acidosis. Under these conditions, the body's need for amino acids, essential fatty acids, vitamins, and microelements, necessary for supporting tissue regeneration and repair, increases.

In newborns who have undergone surgical treatment for NEC, short bowel syndrome is an additional factor determining the need for long-term nutritional support. A reduction in the functionally active intestinal surface area is accompanied by malabsorption, fluid and electrolyte loss, and macro- and micronutrient deficiencies, significantly limiting enteral nutrition options and increasing dependence on parenteral nutrient administration.

Insufficient protein and energy intake in the early neonatal period negatively impacts not only the child's physical development but also the maturation of the central nervous system. Nutrient deficiency is associated with growth retardation, impaired myelination of nerve fibers, cognitive decline, and an increased risk of adverse neurological outcomes in the long term.

Thus, the pathophysiological mechanisms of necrotizing enterocolitis, including systemic inflammation, hypermetabolism, impaired intestinal barrier function, malabsorption, and increased nutrient requirements, justify the need for early initiation and optimization of nutritional support. Adequate parenteral nutrition helps compensate for the deficiency of energy and plastic substrates, reduce the severity of catabolic processes, and create conditions for the restoration of gastrointestinal tract function and normal development of the newborn.

Key components of parenteral nutrition:

Proteins are a critical component of nutritional support. Early administration of amino acids helps reduce catabolic processes and ensure a positive nitrogen balance.

Current recommendations recommend administering amino acids at a dose of 2.0-3.5 g/kg/day, gradually increasing to 3.5-4.0 g/kg/day in preterm infants. Adequate protein intake helps improve growth rates and reduce the incidence of postnatal growth retardation.

Lipids are an important source of energy and essential fatty acids. The use of modern multicomponent lipid emulsions containing fish oil, olive oil, and medium-chain triglycerides can reduce the severity of inflammatory reactions and decrease the risk of parenteral-associated cholestasis.

The recommended lipid dose is 1.0-3.0 g/kg/day, with mandatory monitoring of serum triglyceride levels.

Glucose is the primary source of carbohydrates. The rate of administration is individually adjusted based on glycemic control and averages 4-12 mg/kg/min. Excessive glucose intake can lead to hyperglycemia, increased carbon dioxide production, and increased oxidative stress.

Micronutrient and vitamin deficiencies can worsen the disease and slow tissue repair processes. Zinc, selenium, copper, vitamin D, B vitamins, and antioxidant vitamins A, C, and E are particularly important.

Optimization of parenteral nutrition in newborns with necrotizing enterocolitis (NEC) is a key component of intensive care aimed at ensuring adequate energy and nutritional needs, as well as preventing metabolic, infectious, and organ complications. Modern approaches are based on the principles of early initiation of nutritional support, individualization of the

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composition, and strict monitoring of metabolic parameters.

One of the main areas of optimization is the early administration of parenteral nutrition. Initiating amino acid and glucose administration within the first 24 hours of life or within the first 24 hours after diagnosis of NEC helps reduce the severity of catabolism, lower the risk of negative nitrogen balance, and prevent postnatal growth retardation. Gradual titration of doses based on clinical status and laboratory parameters ensures metabolic stability and reduces the risk of complications.

Adequate protein and energy requirements are essential. The use of balanced amino acid solutions combined with controlled glucose administration helps maintain protein synthesis and prevent hyperglycemia. Excessive carbohydrate administration is associated with the development of hyperosmolar conditions, increased oxidative stress, and increased carbon dioxide production, which can worsen respiratory failure in premature infants.

The rational use of lipid emulsions is particularly important. Modern formulas based on combined lipids, including omega-3 fatty acids, have anti-inflammatory potential and help reduce the risk of parenteral-associated cholestasis. Controlling blood triglyceride levels helps prevent hyperlipidemia and associated metabolic disorders.

A key element in preventing complications is the prevention of catheter-associated bloodstream infections. This requires strict aseptic technique during the insertion and maintenance of central venous catheters, minimizing their use over time, and preferring disposable infusion systems. Timely transition to enteral nutrition upon stabilization of the patient's condition also reduces the risk of infection.

Prevention of parenteral-associated cholestasis includes cyclic administration of nutritional solutions, limiting excess lipid intake, and early stimulation of enteral trophic loading. Of additional importance is the use of drugs high in omega-3 fatty acids, which have a hepatoprotective effect.

Metabolic monitoring is an integral part of optimizing parenteral nutrition. Regular monitoring of glucose, electrolyte levels, acid-base balance, liver enzymes, and triglycerides allows for timely adjustments to the composition of infusion solutions and prevents complications. Particular attention is paid to the prevention of hypo- and hyperglycemia, electrolyte imbalances, and metabolic acidosis. In premature infants with NEC, minimizing the duration of total parenteral nutrition is an important approach. Early initiation and gradual increase of enteral nutrition as intestinal function recovers helps prevent mucosal atrophy, improve the microbiota, and reduce the risk of infectious complications.

Thus, optimization of parenteral nutrition in necrotizing enterocolitis is based on early initiation of nutritional support, individualized nutritional composition, rational use of lipids, and strict metabolic control. This integrated approach can significantly reduce the incidence of infectious, metabolic, and hepatobiliary complications, improve clinical outcomes, and increase neonatal survival.

Promising areas include:

- personalized parenteral nutrition;
- use of multicomponent lipid emulsions;
- use of pharmaconutrients;
- real-time monitoring of metabolic parameters;
- implementation of artificial intelligence for calculating nutritional support;
- Combined enteral and parenteral nutrition strategies.

Optimization of parenteral nutrition is a critical component of comprehensive treatment for newborns with necrotizing enterocolitis. An individualized approach to meeting the body's energy and nutritional needs helps reduce the incidence of infectious and metabolic complications, prevent cholestasis, improve growth rates, and increase patient survival. Improving modern nutritional support protocols is a promising approach to increasing the effectiveness of treatment for newborns with NEC.

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