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Microelements: Study of The Impact of Imbalance on Metabolic Processes in The Body of Newborns

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Abstract: The aim of the study is to investigate the effect of microelement imbalance on metabolic processes in the body of newborns born with normal and low birth weight, as well as to determine the influence of their interrelationship on growth and development.

Materials and methods. A total of 35 newborns born with low birth weight (LBW) from mothers with anemia, as well as their mothers, were examined. The control group consisted of 30 practically healthy newborns with normal weight (NBW) born from mothers without anemia.

Results. The conducted studies demonstrated that iron ions are capable of reducing the level of calcium absorption. There is a certain interaction between microelements, in which they act in the body either as synergists or antagonists relative to each other, which should be taken into account in the treatment of iron deficiency anemia (IDA), and a comprehensive approach to the treatment of anemia in pregnant women is recommended.

Keywords: Microelements, antagonism, newborns, intrauterine development.

Introduction: Anemia experienced by women during pregnancy and its treatment only with iron-containing preparations (ICP) may cause an imbalance of calcium and iron in the body of the fetus and the child after birth. Microelements (ME) are involved in all metabolic processes of the body, and their deficiency reduces the intensity of metabolic processes and causes delayed fetal development [1, 4, 8]. Among the various risk conditions for morbidity in newborns during the neonatal period, an important place belongs to intrauterine growth retardation, which is the result of various pathological conditions in pregnant women [6, 10]. Despite numerous studies devoted to identifying the causes of low birth weight in children, this problem remains relevant in pediatrics [5].

The cause of microelement deficiency in the body may be the interaction of microelements, such as antagonism or synergism [2]. In the body, an excess of phosphorus and iron may impair calcium utilization and contribute to its excretion from bone tissue. Thus, calcium in large amounts interferes with the absorption of zinc. The consumption of dietary supplements containing zinc in doses exceeding the daily requirement by more than 10 times leads to copper deficiency and anemia [8]. The question of the possible effect of iron on the bioavailability of calcium has been studied for a long time. Many studies have shown that iron reduces calcium absorption either by inhibiting its uptake, or by binding to receptors, or by affecting its transport in the gastrointestinal tract [10].

The aim of the study is to assess the levels of certain microelements in newborns born with normal and low birth weight, as well as to determine the influence of the characteristics of the interrelationship of microelements on their growth and development.

METHODS

A total of 35 newborns born with low birth weight (LBW) from mothers with anemia were examined. The control group consisted of 30 practically healthy full-term newborns with normal birth weight (NBW) born from mothers without anemia, as well as their mothers.

The content of microelements (ME) was determined in umbilical cord blood serum, amniotic fluid, and breast

milk of mothers. The study of microelements was carried out using the method of inductively coupled plasma mass spectrometry (ICP-MS).

In addition, complete anthropometric assessment, clinical examination of the children, and blood testing for main parameters were performed.

RESULTS AND DISCUSSION

As a result of the conducted studies, it was revealed that, according to clinical indicators, children with low birth weight (LBW) lag behind newborns with normal birth weight (NBW).

In terms of weight, children with NBW exceeded those with LBW by an average of 931.1 grams (3370.6 ± 2.19 and 2439.5 ± 0.87, respectively). Gestational age was also higher in the group of newborns with NBW by 1.6 weeks (39.5 ± 1.2 and 37.9 ± 2.3, respectively).

The body mass index (BMI) was assessed according to WHO tables. Values above 12.0 correspond to children born with NBW relative to their birth length and gestational age, while children with values below this level correspond to those born with LBW [3].

Assessment of the condition using the Apgar score at 1 and 5 minutes indicated lower scores in children with LBW at birth (Table 1).

Table 1.

Clinical characteristics of newborns

Indicator	Newborns with NBW from mothers without anemia (n=30)	Newborns with LBW from mothers with anemia receiving iron supplements (n=35)
Birth weight (g)	3370.6 ± 2.19	2439.5 ± 0.87
Apgar score at 1 min (points)	7.1 ± 1.07	6.8 ± 2.02
Apgar score at 5 min (points)	8.1 ± 0.94	7.7 ± 1.59
Physiological jaundice (days)	2.7 ± 0.37	6.6 ± 0.41
BMI	12.6	10.7

Note:* – statistically significant difference between the indicators of the compared groups (p<0.001).

Physiological jaundice in newborns with normal birth weight (NBW) from mothers without anemia was observed on average for 2.7 ± 0.37 days, whereas in newborns with low birth weight (LBW) from mothers with anemia who received iron-containing preparations (ICP), physiological jaundice was observed on average for 6.6 ± 0.41 days, which is 3.9 days longer.

The hemoglobin content in the blood of practically healthy full-term newborns with NBW generally does not decrease. The average level was 191.5 ± 5.8 g/L, erythrocytes – 5.9 ± 0.2 million, and leukocytes – 14.4 ± 0.6 thousand, whereas in newborns with LBW these показатели were lower – 165.9 ± 3.9 g/L, 5.8 ± 0.4 million, and 13.7 ± 0.8 thousand, respectively. Anemia was observed in 60% of children.

Anemia is characterized by a decrease in hemoglobin levels in the blood, a reduction in the number of erythrocytes, as well as changes in vitamin balance, a decrease in the content of microelements (ME) and enzymes in the body. The role of microelements in the etiopathogenesis of anemia is not always adequately assessed, and unfortunately, the main role is often attributed only to iron [7]. A decrease in the concentration of a number of vitamins and microelements such as cobalt, manganese, zinc, chromium, copper, selenium, and iodine also contributes to the development of anemia in the body.

In the study of microelement content, particular

attention was paid to iron and calcium levels. The study of iron in umbilical cord blood in the examined groups of newborns with NBW revealed that normally umbilical cord blood contains on average 98.66 ± 0.62 µg/mL of iron, while in amniotic fluid this value is 97.51 ± 0.62 µg/mL.

The total iron content in the human body averages 4.2 g. About 75% of its total amount is included in the hemoglobin of erythrocytes, which transport oxygen from the lungs to tissues [9]. Of the total amount, 20% of iron is reserve (bone marrow, liver, macrophages), 4% is part of myoglobin, and about 1% is contained in respiratory enzymes that catalyze respiration processes in cells and tissues, as well as in other enzymatic structures [2].

The maximum values up to 139.35 µg/mL of iron (Fe) in umbilical cord blood were observed in children with LBW under the influence of regular intake of iron-containing preparations by mothers with anemia, whereas in amniotic fluid the content was lower – 82.09 ± 0.50 µg/mL. The highest levels of Fe in umbilical cord blood and, conversely, the lowest levels in amniotic fluid were observed in children with LBW from mothers with anemia who received iron-containing preparations.

The presence of a number of mineral substances in the body in strictly defined quantities is an essential condition for maintaining human health [7]. The set of processes of absorption, distribution, assimilation, and excretion of mineral substances, which are present in the form of inorganic compounds, constitutes mineral metabolism [9].

The body of a healthy person has a fairly well-defined system of self-regulation. A defect in any link is the cause of excess or imbalance of other biologically active substances (hormones, vitamins, enzymes) involved in complex regulatory processes and is manifested by various clinical symptoms [6].

Analyzing the average calcium content in umbilical cord blood in the studied group of newborns with normal birth weight (NBW) from mothers without anemia, it was found that its level was 55.37 ± 0.50 µg/mL, and in amniotic fluid — 58.87 ± 0.53 µg/mL. In the group of newborns with low birth weight (LBW) from mothers with anemia who received iron-containing preparations (ICP), the calcium (Ca) content in umbilical cord blood was predictably low and amounted to 42.23 ± 0.35 µg/mL, while in amniotic fluid it was 77.17 ± 0.60 µg/mL, which indicates the excretion of calcium into the amniotic fluid.

As indicated by D. Bosscher and R. Van Cauwenbergh, hypocalcemia during the first two days of life can be detected in approximately 30% of low birth weight infants or children born in asphyxia, and in 50% of children [7]. Similar data are presented by Roughead Z.K. and Zito C.A., who report that in one-third of children, hypocalcemia can be detected in the first days of life in cases of severe asphyxia [10].

Calcium is contained in bones in the form of calcium hydroxyphosphate — $Ca_{10}(PO_4)_6(OH)_2$. Its daily intake for an adult is 800–1200 mg [13]. A decrease in blood Ca levels leads to increased internal secretion of the parathyroid glands, i.e., an increase in its entry into the blood. Conversely, an increase in blood Ca levels causes a sharp increase in the excitability of the central nervous system.

When pregnant women take iron-containing preparations, an increase in Ca levels in amniotic fluid and a decrease in umbilical cord blood are observed, while for Fe the opposite pattern is noted: an increase in umbilical cord blood and a decrease in amniotic fluid. This pattern is more pronounced in children with LBW than in children with NBW at birth.

The conducted studies have shown that iron ions are capable of reducing the level of calcium absorption. Microelements (ME) interact with each other in the body either as synergists or as antagonists. A deficiency of essential microelements corresponded to the degree of fetal and neonatal hypotrophy, which confirms the role of microelements, especially calcium, in the formation of the body. Calcium is the main element in the formation of the skeletal system; therefore, its deficiency manifests as delayed growth and development of the fetus [15, 16].

CONCLUSIONS

1. Thus, the results of the study confirm the role of microelement imbalance, which affects calcium levels with its excretion into the amniotic fluid; iron ions are also capable of reducing calcium absorption.

2. The possibility of such interactions between microelements is highly relevant and should be taken into account in the treatment of iron deficiency anemia; therefore, a comprehensive approach to the treatment of anemia in pregnant women is recommended.

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