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Microelements and Their Significance for Fetal Development and Adaptation of Newborn Children in the Early Neonatal Period

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Abstract: This article examines microelements and their importance for fetal development and adaptation of newborns in the early neonatal period.The study was carried out on 66 test fetuses, where the control group was 16, and the base group was 50 children of the neonatal period. The aim of the study was to investigate 4 elements Mg, Cu, Zn, and Fe, where the following results were obtained that in multiparous women of the first study group, as the number of births in the anamnesis increases, the concentration of Mg, Cu, and Fe increases in comparison with the concentration of these ME in women in the control group. There was a lower zinc content in mothers of full-term newborns, regardless of the number of pregnancies. An increase in the concentration of magnesium, copper and iron and a decrease in the concentration of zinc in the first group studied were significant mainly in multiparous women.

Keywords: microelements, deficiency, nutrition

INTRODUCTION

Achievements of the doctrine of microelementosis testify to the significant role of a balanced supply of body tissues with ME in maintaining normal homeostasis [1, 2, 3]. In the context of the influence of unfavorable environmental factors on the human body, the issues of the formation of infant homeostasis of ME have acquired particular relevance [9, 16]. In this case, changes in ME homeostasis should be expected even before the birth of a child, which is reflected in the adaptation processes [3, 10, 11].

Despite the general interest in the problem of microelementosis, the issue of their content in the human body has not been sufficiently covered. The content of trace elements in organs, tissues, and biological fluids of a person is very uneven. The content of ME in the blood is usually low [5,15]. These data deserve attention when compared with the corresponding indicators for microelementosis. At the same time, it should be noted that high or unusually low levels of ME in the blood can occur in other diseases as well.

The effect of bioelements on the body largely depends on the amount of extracellular fluid in the tissues, the degree of development of subcutaneous tissue, as well as on the calcium content in bone tissue, and the degree of calcification of other tissues. Especially a lot of ME is accumulated in bones and teeth [5,6].

The age dynamics of the concentration of some ME in the central nervous system are associated with the peculiarities of metabolic processes characteristic of a certain age period, and, first of all, with changes in the intensity of oxidative processes. In the study of V.A. Batsevich (1988), using neutron activation analysis, regular age-related changes in the content of such MEs as zinc at puberty were established.

For the optimal course of metabolic processes in humans, at least nine essential ME (iron, copper, zinc, iodine, manganese, chromium, selenium, molybdenum, cobalt) are required. It is the listed MEs that perform various functions, including catalytic, structural, and regulatory. In the course of these functions, they interact with macromolecules, such as enzymes, prohormones, as well as with presecretory granules and biological membranes, participating in all types of metabolism. The levels of exchange at which this occurs are so fundamental that the signs of failure of many MEs are variable.

Metabolic processes in the body take place with the participation of many metalloenzymes, which have trace element coordination centers of metalloenzyme complexes that also contain various metals (zinc, cobalt, manganese, nickel, iron, copper, barium, etc.). Metals absorbed by the body and contained in tissues and tissue fluids can be activators of the action of enzymes (zinc, manganese, iron, cadmium, cobalt, nickel, mercury, cesium, lithium, aluminum) or their inhibitors (iron, beryllium, strontium, barium, cadmium, mercury, nickel, rubidium).

It should be noted that all these chemical elements have a great effect on the body, coming into contact with organic substances synthesized in living cells [1,5,7,16]. They affect fertilization, development, growth, viability, immunobiological properties, the respiratory

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function of hemoglobin, and other important functions. The manifestations and syndromes of true ME deficiency in humans have been proven only for iron, copper, zinc, manganese, chromium, selenium, molybdenum, iodine, cobalt, and fluorine [5,8,13].

The body of a healthy person has a fairly clear self-regulating system of homeostasis. For most ME, the main regulators of the homeostasis mechanism are the processes of absorption, mainly from the gastrointestinal tract, as well as excretion in urine and feces [1,11,14]. ME enter the body from food and in much smaller quantities from the air. For a developing organism, the transplacental pathway of providing microelements is important. ME are excreted from the body with urine, feces, and in small amounts with sweat, hair, and menstrual blood [7,9].

The increased content of elements in the diet is accompanied by an increase in their concentration in the tissues. With an excess intake of ME, the elimination system comes into play.

In particular, there may be a blockage of the processes of their absorption in the gastrointestinal tract and subsequent excretion in the feces. The excess ME absorbed into the blood is excreted in the urine, bile, sweat, and milk, and is also deposited in the depot. A defect in a certain link in the system, which provides microelement homeostasis, leads to the fact that a deficiency or excess of ME may occur in the body, accompanied by the corresponding clinical symptoms and the development of the disease [6,10].

Frequent pathological changes in the processes of digestion and absorption can become the basis for metabolic disorders of ME. A number of researchers [12] noted an increase in the number of Paneth cells with a large and maximum, as well as with a low moderate content of zinc. As you know, the level of absorption of zinc in the gastrointestinal tract is associated with the content of the zinc-binding ligand.

Alimentary and metabolic correction of trace element status is not an easy task. It cannot always be solved only by simple replacement of the absent or moderately deficient ME. The coordinated effects of several ME are widespread in nature. There are pairs and triads of ME, which have a synergistic or antagonistic effect on various physiological and pathological parameters. Interactions between iron and zinc, iron and manganese, cadmium, and copper were also revealed [4].

A deeper study of the mechanisms of absorption and elimination brings more and more evidence of the participation of the body's regulatory systems - nervous, endocrine, and immune - in them.

For the development of microelementosis, it is necessary to combine several pathogenetic factors at once, contributing to the clinical manifestations of the disease. When assessing the

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severity of hypomicroelementosis, the use of the concept of risk groups, formed on the basis of complications of the identified indicators from the permissible level. A conditionally permissible level was considered to be such an amount of a substance in an organism or a critical organ, which, with its constant content, does not cause changes in the state of health detected by modern research methods [14,15].

It is known that a number of essential MEs play a significant role in the process of hematopoiesis. So, iron is a structural part of hemoglobin, and its deficiency leads to a violation of hemoglobin formation and the development of anemia. Zinc, as a result of its direct participation in the metabolism of nucleic acids and protein synthesis, significantly affects the processes of hematopoiesis and the life span of cells, since it stabilizes the structure of cell membranes, 85% of blood zinc is contained in erythrocytes. The cause of hypochromic anemias may also be a copper deficiency, since copper through oxidative enzymes affects iron metabolism, providing hemoglobin synthesis and erythrocyte maturation. It is copper that facilitates the transition of iron into an organically bound form and its transfer to the bone marrow. Physiological synergy in the processes of hematopoiesis is between copper and iron, cobalt and zinc. Studies of the content of essential ME in children revealed a decrease in the level of iron in the blood serum in 54.7%, zinc - in 30.3%, copper - in 29.5%. Moreover, the deficit of all three ME was found in 23.8% of the examined children [6].

According to A.V. Skalny, who studied the prevalence of the main hyper and hypomicroelements, hypomicroelementosis of iron and zinc was most often detected, contributing to a decrease in the resistance and adaptive capacity of the body of children, and a deterioration in the indicators of their growth and development. In addition, zinc and copper imbalances were frequently found in children with chronic diseases. Perhaps the features of mineral metabolism were determined by the features of chronic pathology, which was present in the examined children and their mothers. For patients with gastroduodenitis, a high incidence of imbalance of zinc (38%), copper (35%), iron (31%) was characteristic, for patients with pyelonephritis - deficiency of zinc and copper (50% each), iron (25%).

ME metabolism in early childhood is less perfect than in adults. The problem of the ME balance at the early stages of ontogenesis is undoubted of great importance, but much of it has not yet been studied. This is especially true for the periods of intrauterine development, neonatal and early childhood. By the time of birth, the concentration of many MEs in the child's liver is many times higher than in any other period of his subsequent life. In particular, the content of copper is 16 times, and zinc is 2 times higher, compared to infancy and early childhood. This is the period of micronutrient well-being when the newborn is supplied with even an excess of these

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substances.

Features of the level of some trace elements in the blood of the mothers of the examined children

As is known from literary sources [8, 10], the body of a newborn contains the maximum amount of most ME (the phenomenon of "over-storage") due to the increased need for intrauterine and postnatal development. However, already during the first months of life, there is a significant decrease in this reserve of trace elements. The replenishment of their content increases only in the second half of the first year of life [3]. A number of studies [7, 8, 14] have shown that under the influence of pathological conditions during pregnancy and childbirth, ME homeostasis is disturbed in newborns. IS Sidorova [13] considered the main cause of these disorders to be functional and morphological changes in the placenta that occur during viral and bacterial diseases of women during pregnancy.

Homeostasis of the fetus under conditions of accelerated intrauterine growth and development is supported by continuous placental transfer of various substances necessary for this.

The passage of chemicals through the placenta depends on their molecular weight, their ability to dissolve in water and fats, on the size and thickness of the placental membrane, taking into account the timing of pregnancy. The transmembrane exchange of ME between the mother and the fetus is carried out by simple diffusion without energy consumption until the concentration on both sides of the membrane becomes equal. An increase in the permeability of the placenta is noted with an increase in the duration of pregnancy, the membrane of the placenta progressively becomes thinner, and maximum conditions are created for the transfer of various substances from the maternal bloodstream into the chorioembryonic circulation. The protective function of the placenta decreases with its inferiority of various types [5].

According to V.V.Sofronov et al., In the pathological course of pregnancy, a slight increase in the level of zinc and iron was noted, which is associated with the hyperosmolar state of the blood and a decrease in renal excretory function, characteristic of severe forms of late toxicosis of pregnant women. Particularly noteworthy was the level of zinc content in women in childbirth with preterm labor: it was halved compared to pregnant women in the control group, and a tendency towards a decrease in zinc was noted even with the threat of termination of pregnancy. A correlation was found between the frequency of miscarriage and zinc levels. Thus, preterm labor occurs against the background of a sharp decline in zinc [13,14]. In women in labor who had ARVI in the first and/or second half of pregnancy, the levels of zinc and iron did not differ significantly from healthy women in labor.

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Table 1

The content of ME in the blood serum of mothers of term infants with hypoxic-ischemic encephalopathy and the control group, depending on the gestational age (M ± m)

ME	Treatment Group			
	Up to 29 weeks	30-32 weeks	33-35 weeks	36 weeksmore
Zn	12,4±1,3*	10,49±0,91*	11,61±1,12*	14±0,93
Fe	22,8±0,91*	21,6±1,1*	20,4±2,1*	21,4±1,2*
Mg	0,74±0,31	0,54±0,09*	0,60±0,03*	0,61±0,04*
Cu	17± 0,8	21,1± 2,0*	24,8± 4,1*	22,8± 2,4*

Control Group		
Before 32 weeks	33-35 weeks	36 and more
15,43±0,69	17,07±0,85	17,08±2,10
16,15±1,03	14,25±1,85	15,14±6,43
0,64±0,19	0,29±0,04	0,43±0,21
15,8± 0,6	16± 0,7	15,1± 6,1

* - reliability in comparison with the control group (p <0.05-0.001)

Table 2

The content of trace elements in mothers of term infants with hypoxic-ischemic encephalopathy, depending on the parity of pregnancy (M ± m)

ME	TreatmentGroup(n=16)			Control group (n=50)		
	1(n=9)	2(n=4)	3and more (n=3)	1(n=34)	2(n=8)	3 and more (n=8)
Zn	12,2±1,3*	12,41±0,91*	11,45±2,20*	16,69±1,16	16,0±1,59	17,18±0,66
Fe	24,23±1,8*	21,5±1,1*	22,6±0,9*	16,04±1,73	16,98±1,14	17,87±1,30
Mg	0,55±0,08	0,54±0,07*	0,58±0,09*	0,53±0,14	0,37±0,09	0,29±0,05
Cu	17,1±0,8	22±2,0*	28±4,0*	15,7±0,7	18,4±0,5	18,5±6,1

* - reliability in comparison with the control group (p <0.05-0.001).

MATERIALS AND METHODS

The first included 9 (56.2%) primiparous women, the second - 4 (25%) women with second births, and the third - 3 (18.8%) pregnant women who had three or more births (Table 2).

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From the presented data, it follows that in multiparous women of the first Treatment group, as the number of births in the anamnesis increases, the concentration of Mg, Cu, and Fe increases in comparison with the concentration of these MEs in women in the control group.

At the same time, there is a lower zinc content in mothers of full-term newborns, regardless of the number of pregnancies.

An increase in the concentration of magnesium, copper, and iron and a decrease in the concentration of zinc in the first group studied were significant mainly in multiparous women.

RESULTS AND DISCUSSION

Significant differences in the ME content in the blood serum of mothers of premature newborns with hypoxic-ischemic encephalopathy (HIE) and mothers of the control group were revealed (Table 3). There was a significant decrease in the serum zinc concentration (8.4 ± 1.4 μmol / L) in the mothers of this group, compared with the indicators of the mothers in the control group (15.43 ± 0.69 μmol / L) ($p < 0.05$).

As can be seen from the table, the pregnancy of the mothers of newborns in this group proceeded against the background of a zinc deficiency state.

The level of iron in the blood of mothers who gave birth to premature babies with HIE before 29 weeks of gestation corresponded to those of the mothers in the control group (16.8 ± 0.9 μmol / L). In periods from 30 to 35 weeks, a pregnant woman has a decrease in iron concentration.

Table 3

The content of ME in the blood serum of mothers of premature infants with hypoxic-ischemic encephalopathy, depending on the gestational age and the control group (M ± m)

ME	Treatmentgroup			
	Up to 29 weeks	30-32 weeks	33-35 weeks	36 weeksandmore
Zn	8,4±1,4	9,49±0,9*	10,6±1,1*	11,3±0,93*
Fe	16,8±0,9	11,1±1,0	11,6±1,0	16±0,7
Mg	0,70±0,31	0,50±0,09*	0,55±0,1*	0,64±0,04*
Cu	18±2,1	22,1±2,0*	26,4±2,9*	24,8±2,6*

Controlgroup		
Before 32 weeks	33-35 weeks	36 and more
15,43±0,69	17,07±0,85	17,08±2,10
16,15±1,03	14,23±1,85	15,14±6,43
0,64±0,19	0,29±0,04	0,43±0,21
15,8±0,6	16,0±0,7	15,1±6,1

* - reliabilityp<0,05-0,001.

It was found that in mothers of premature infants with HIE, a decrease in the content of zinc and iron was accompanied by a tendency to an increase in magnesium - (0.70 ± 0.31 mmol / l) and copper - (26.4 ± 2.9 μmol / l), compared with their indicators in mothers of children of the control group.

The results of study ME in mothers of premature infants with HIE, depending on the parity of pregnancy as can be seen from Table 3. There is a significant decrease in the concentration of zinc in the mothers of the studied group, both in primiparous and multiparous ($p < 0.001$). At the same time, an increase in the concentration of magnesium and copper remains significant in multiparous women ($p < 0.01$).

Table 4

ME content in mothers of premature babieswith hypoxic-ischemic encephalopathy, depending on the parity of pregnancy (M ± m)

ME	Treatment groupn=40			Control Groupn=50		
	1(n=26)	2(n=10)	3(n=4)	1(n=34)	2(n=8)	3(n=8)
Zn	8,87±0,7*	10,41±0,91*	10,45±0,9*	16,69±1,16	16,0±1,59	17,18±0,66
Fe	22,8±1,2	19,4±1,2	22,3±0,8	16,04±1,73	16,98±1,14	17,87±1,30
Mg	0,60±0,1	0,55±0,07	0,65±0,11*	0,53±0,14	0,37±0,09	0,29±0,05
Cu	17,9±0,1	23±2,0	27±4,0*	15,7±0,7	18,4±0,5	18,1±6,1

* - reliability in comparison with the control group ($p < 0.05$-0.001).

The iron concentration in mothers of this group remains insignificantly high ($p > 0.05$), regardless of the number of pregnancies.

A significant decrease in the concentration of serum zinc (8.4 ± 1.5 μmol / l) was found in mothers who gave birth to premature babies with HIE and intrauterine growth retardation (IUGR), in contrast to mothers of children in the control group ($p < 0.05$). The indicators of magnesium and copper content were reliably high and amounted to 0.61 ± 0.04 mmol / l and 26.1 ± 2.7 μmol / l in women of premature infants with HIE and IUGR and in mothers of children in the control group - 0.43 ± 0.21 mmol / L and 15.1 ± 6.1 μmol / L (Table 3.5).

Low content of zinc concentration (5.87 ± 0.78 μmol / l) was revealed in primiparous women of the studied third group and a significant decrease in multiparous mothers of premature infants with IUGR and HIE (9.41 ± 0.8 μmol / l and 10.4 ± 2.2 μmol / L) versus (16.0 ± 1.59 μmol / L and 17.18 ± 0.66 μmol / L) control (p <0.001). The content of zinc concentration is 3 times less than in the control.

Table 5

The content of ME in the blood serum of mothers of premature infants with hypoxic-ischemic encephalopathy and intrauterine growth retardation, depending on the gestational age and the control group (M ± m)

ME	**Treatment Group**				**Control Group**		
	Up to 29 weeks	30-32 weeks	33-35 weeks	36 weeksandmore	Before 32 weeks	33-35 weeks	36 and more
Zn	8,1±1,3	8,4±1,5*	10,6±1,1*	10,5±1,0*	15,43±0,69	17,07±0,85	17,08±2,10
Fe	22,7±0,7	20,0±1,0*	21,4±1,0*	21,3±0,9*	16,15±1,03	14,23±1,85	15,14±6,43
Mg	0,74±0,31	0,54±0,09*	0,6±0,03*	0,61±0,04*	0,64±0,19	0,29±0,04	0,43±0,21
Cu	17,4±1,0	22,0±2,0*	25,4±1,09*	26,1±2,7*	15,8±0,6	16,0±0,66	15,1±6,1

* - reliability in comparison with the control group (p <0.05-0.001).

A significant increase, regardless of the pregnancy parity, was found in iron ME - in primiparous (22.1 ± 1.2 μmol / L) versus (16.04 ± 1.7 μmol / L), in multiparous women (21.1 ± 1.2 μmol / L and 22.0 ± 0.8 μmol / L) versus (16.9 ± 1.14 μmol / L and 17.87 ± 1.3 μmol / L) control. The content of magnesium and copper remains significantly high in multiparous women (p <0.05) (Table 6).

Table 6

ME content in mothers of premature newborns with hypoxic-ischemic encephalopathyand intrauterine growth retardation depending on the parity of pregnancy (M ± m)

ME	Treatment Group			Контрольная группа		
	1 (n=15)	2 (n=6)	3 (n=4)	1 (n=34)	2 (n=8)	3 (n=8)
Zn	5,87±0,78*	9,41±0,8*	10,4±2,2*	16,69±1,16	16,0±1,59	17,18±0,66
Fe	22,1±1,2*	21,1±1,2*	22,0±0,8*	16,04±1,7	16,9±1,14	17,87±1,3
Mg	0,61±0,1	0,55±0,07*	0,60±0,05*	0,53±0,14	0,37±0,09	0,29±0,05
Cu	18,1±0,1	23,1±1,0*	28,2±4,0*	15,7±0,7	18,4±0,5	18,1±6,1

* - reliability in comparison with the control group ($p < 0.05$-0.001).

CONCLUSION

Thus, the results of studies of the trace element composition of blood in the mothers of the examined children were as follows: in the results of Treatmenting the ME in the blood serum of mothers of full-term infants with HIE and IUGR, depending on the gestational age, an imbalance of ME was noted. A reliably low zinc content was revealed in mothers of full-term newborns with signs of DIE at the level of 10.49 ± 0.91 μmol / L and 11.61 ± 1.12 μmol / L compared to the indicators of the control group of mothers - 15.43 ± 0.69 μmol / L and 17.07 ± 0.85 μmol / L ($p < 0.05$).

The level of magnesium and copper in the blood serum of mothers who gave birth to full-term infants with HIE and IUGR were characterized by high values of indicators, magnesium - 0.74 ± 0.31 mmol / l and copper - 17 ± 0.8 μmol / l, compared with their values in mothers of children of the control group - 0.29 ± 0.04 mmol / L and 16 ± 0.7 μmol / L (Table 3.1).

The concentration of iron in the blood serum of women in the Treatment group during pregnancy was significantly high ($p < 0.05$).

The content of ME was studied in mothers of full-term newborns with HIE and IUGR, depending on the parity of pregnancy. For this purpose, mothers of full-term newborns were divided by us into 3 groups.

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There are several ways to regulate the balance of ME. However, the significance of each of them is not the same for different ME. So, for copper, iron, zinc, the main way of regulation is a change in the level of absorption, while for iodine and cadmium, the most important way of their regulation in the body is urinary excretion. The latter route for most MEs is no more than 1-4% of their amount excreted in the feces. The trigger mechanism for the absorption of a number of ME (iron, zinc, etc.) in the gastrointestinal tract is a decrease in their concentration in tissue depots. However, the path of information transfer from tissues to epithelial cells of the mucous membrane of the gastrointestinal tract is still unknown. Consequently, the ME balance is a particular form of the general homeostatic system of the body. The elemental status of a person depends, first of all, on the nature of his nutrition. When analyzing the diet of women of childbearing age, the following data were obtained on the deficiency in the consumption of the following chemical elements: iodine (80%), selenium (80%), zinc (60%), iron (17%), copper (4%). That is, the women's diet did not correspond to the physiological needs, which created the preconditions for nutritional deficiencies of these vital micronutrients.

Thus, inflammatory, dystrophic, and especially atrophic changes in the duodenal mucosa are inevitably accompanied by malabsorption. This primarily refers to chronic duodenitis with a deep remodeling of the mucous membrane.

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