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THE ROLE OF COBALT, NICKEL, AND LEAD IMBALANCE IN PREGNANT WOMEN IN FETAL DEVELOPMENT DELAY

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Abstract. *To determine the role of disrupted protective mechanisms within the mother–placenta–fetus system due to micronutrient imbalance in maternal organisms in relation to fetal growth and development delay. The levels of micronutrients—cobalt, nickel, and lead (Co, Ni, Pb)—were measured in the blood serum and erythrocytes of 25 newborns with low birth weight (LBW). A comparison group consisted of 25 healthy full-term newborns with normal birth weight (NBW) and their mothers. It was demonstrated that an excess and imbalance of toxic trace elements in a pregnant woman's body, along with placental dysfunction, lead to a disruption of these elements in the fetus and newborn. The imbalance of micronutrients in LBW newborns is associated with impaired placental transport and storage functions. This is evidenced by cobalt deficiency and significantly elevated levels of lead and nickel in the blood serum of pregnant women who gave birth to children with perinatal hypoxic lesions and LBW.*

Keywords: *placenta, fetus, micronutrients, newborn.*

Many studies have proven that deficiency of bioelements and vitamins in mothers is a common cause of intrauterine fetal growth retardation, serious disorders of organs and systems, anemia, which lead to the birth of low-weight children and increased morbidity in the neonatal period [1]. The female body's need for these essential nutrients is especially high during pregnancy and lactation, insufficiency damages the health of mother and child, increases the risk of developing perinatal pathology, increases infant mortality, and is one of the causes of prematurity, congenital deformities, and impaired physical and mental development of children [9, 10].

The deterioration of the environmental situation in modern conditions leads to an increased burden on the body of toxic substances, in particular heavy metals, which lead to depletion of the adaptive reactions of the fetoplacental system and perinatal pathology [3]. In turn, newborns with perinatal pathology have a high risk of developing disorders of the metabolism of trace elements (ME) [6, 7].

The mechanism of occurrence of perinatal pathology is complex and is caused by disorders of fetoplacental circulation, endocrine, metabolic and immunological disorders in the mother –placenta–fetus system, the peculiarities of the course of labor and the degree of maturity of the fetus and newborn [5]. The toxic effect of heavy metals in the prenatal period is determined by their penetration through the placental barrier, followed by teratogenic, embryotoxic, carcinogenic effects, and impaired immunity [7]. The intensity of growth and development processes is the main feature of childhood [2]. The negative impact of ME deficiency and imbalance on the fetus in later life is manifested by delayed physical and mental development, impaired adaptation of functions, and chronic diseases [4, 6].

The aim of the study was to determine the role of impaired protective mechanisms of the mother-placenta-fetus system in the case of micronutrient imbalance in mothers in stunting fetal growth and development.

Materials and methods.

The determination of trace elements - cobalt (Co), nickel (Ni) and lead (Pb) in the blood serum and red blood cells of 25 pregnant women and their 25 newborns born with low birth weight (MB). The comparison group consisted of 25 healthy women and their full-term children born at normal weight (HB). To group newborns into MB or NV at birth, the WHO table for assessing a child's

physical development was used, indicating the body mass index (BMI) in terms of weight to body length [2]. To determine the ME content, the method of atomic absorption mass spectrometry (Japan) was used, which was equipped with a computer console for automatically calculating the ME content.

The results and their discussion.

When studying the ME content in the mother-placenta-fetus-newborn system, we found that the serum cobalt content in mothers who gave birth to children in hypoxia and with MV was significantly lower compared with women with the physiological course of pregnancy. On the contrary, the lead and nickel content was 2.6 and 1.2 times higher, respectively, than in women with physiological pregnancy. (Table 1).

Table 1

The content of trace elements in the blood serum of women with the physiological course of pregnancy and women who gave birth to children with CF and their newborns

ME (mmol/L)	Mothers who have given birth to children with HBV	Mothers who have given birth to children with CF	Newborns with HB	Newborns with CF
Co	6,24 ± 0,6	4,71 ± 0,46 p1	5,0 ± 0,7	3,27 ± 0,21 p2
Ni	0,60 ± 0,04	0,73 ± 0,04 p	0,50 ± 0,09	0,81 ± 0,04 p2
Pb	0,08 ± 0,004	0,21 ± 0,02 p	0,10 ± 0,01	0,26 ± 0,02 p2
	n=30	n=30	n=30	n=30

Note: *p is the significance of the difference between the serum of mothers with physiological pregnancy and the serum of mothers who gave birth to children with MB (p <0.05); p1 is the significance of the difference between the serum of mothers and children with CNS PHP (p<0.01); p2 is the significance of the difference between the serum of HB and children with MB (p<0.01).*

In newborns with HC, the content of Co, Ni and Pb in the blood serum was the same as in their mothers. Newborns with hypoxia and MB had 1.4 times less Co and 1.1 times less Ni in their blood serum compared to their mothers, while the average Pb content increased slightly. When comparing the content of ME in the blood serum of newborns, it was found that the concentration of Co in newborns with hypoxia and MV was 34.6% lower, and Ni was 38.2% higher, in contrast to children with NV, the content of Pb was 2.6 times higher, in contrast to children with NV.

Thus, Co deficiency was observed in the blood serum of pregnant women who gave birth to children with MB in hypoxia, and the content of Ni and Pb was significantly increased. In the blood serum of newborns with MB, the Co content was also significantly lower, while the content of Ni and Pb was on average 2 times higher than in HC.

In the red blood cells of mothers who gave birth to children with MB in hypoxia, the Ni content was 42.6% and Pb was 7.9% higher than in healthy women, and the Co saturation was almost the same as in those who gave birth with HC. The content of ME in the erythrocytes of newborns with MB was significantly different from children with NV. Thus, the average levels of Co, Ni, and Pb were significantly higher (by 40%) than in children with HC (Table 2).

Table 2.

The content of trace elements in the red blood cells of mothers and their newborns

МЭ (мкмоль/л)	Mothers who have given birth to children with HBV	Mothers who have given birth to children with CF	Newborns with HB	Newborns with CF
Co	0,059 ± 0,005	0,062 ± 0,004 p	0,033 ± 0,003 p2	0,056 ± 0,005 p1
Ni	0,086 ± 0,003	0,15 ± 0,009 p	0,029 ± 0,002 p2	0,044 ± 0,004 p1

Pb	0,58 ± 0,006	0,63 ± 0,027 p	0,25 ± 0,024 p2	0,41 ± 0,040 p1
	n=30	n=30	n=30	n=30

Note: *p - reliability of the difference in the red blood cell counts of mothers with physiological pregnancy and the red blood cell counts of mothers who gave birth to children with CF ($p<0.001$); p1 - reliability of the difference in the red blood cell counts of children with HB and CF ($p<0.01$); p2 - reliability of the difference in the indicators in the erythrocytes of mothers with a physiological course of pregnancy and their children with CF ($p<0.001$); p3 - reliability of the difference in the indicators of the erythrocytes of mothers who gave birth to children with CF and their newborns ($p<0.001$).*

Taking into account such features of the content of ME in the blood serum and erythrocytes of mothers who have given birth to children with CF and their newborns, there is a natural need to study the role of the placenta in ensuring the microelement balance of the mother-placenta-fetus system. According to our data, placental Co deficiency facilitates its rapid penetration into the fetus, while its storage function is suppressed. This means that the preservation of the essential fatty acids, which are actively involved in fetal development, is impaired (Table 3).

Table 3

Indicators of transplacental migration of ME

ME	Penetration Index (%)		Accumulation index (%)	
	Newborns with CF	**Newborns with NV**	**Newborns with CF**	**Newborns with NV**
Co	96,2	80,1	79,3	121,2
Ni	54,2	83,3	325,5	275,8
Pb	145,2	125,0	246,1	204,0

The penetration index for Ni was 34.9% lower than in the control group, while the accumulation index, on the contrary, was 15.3% higher. The concentration of Pb in the placentas of women who gave birth to children with CF tended to increase compared to the placentas of those who gave birth to newborns with HBV.

Thus, for this ME, the index of penetration through the placenta during hypoxia was greater than in the case of physiological pregnancy and was 145.2% versus 125.0%, the accumulation index was also slightly higher and was 246.1% versus 204%.

Analysis of the serum ME ratio in mothers of children with CF indicates a clear imbalance in the Co/Ni and Co/Pb pairs, which occurs due to Co deficiency and serum Ni and Pb oversaturation. Mothers who gave birth to children with CF had serum Co deficiency and, conversely, elevated Ni and Pb levels. Elevated levels of Pb in the blood of pregnant women lead to a reduction in the duration of pregnancy, a decrease in the birth weight of the fetus, the occurrence of birth defects in newborns, and a decrease in the child's mental abilities [8, 11].

Conclusion.

1. The study revealed low Co levels in the serum and erythrocytes of newborns with CF and in the placentas of their mothers, leading to a deficiency in their bodies. Meanwhile, Ni and Pb levels were, on average, twice as high as in newborns with NV.

2. The identified imbalance reduces the effectiveness of the placental barrier in relation to Ni and Pb, and also leads to the accumulation of these toxic MEs in the fetus's body, which leads to intrauterine weight gain and the birth of low-weight newborns.

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