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IMPACT OF MATERNAL TOXIC TRACE ELEMENT IMBALANCE ON FETAL GROWTH RESTRICTION AND DEVELOPMENT

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Abstract

Objective. This study aims to assess how disturbances in maternal trace element balance affect the protective interactions within the mother–placenta–fetus system, potentially leading to delayed fetal development and intrauterine growth restriction.

Materials and Methods. Concentrations of the trace elements cobalt (Co), nickel (Ni), and lead (Pb) were analyzed in both the blood serum and erythrocytes of 25 neonates with low birth weight (LBW). These results were compared with a control group of 25 full-term newborns of normal birth weight (NBW) and their mothers.

Results. The findings revealed that elevated and unbalanced levels of toxic elements in pregnant women, combined with placental insufficiency, disrupt the metabolism of these elements in both the fetus and newborn. In LBW infants, the observed trace element imbalance correlates with impaired placental transport and storage. Specifically, mothers of these infants had a marked cobalt deficiency and significantly higher levels of lead and nickel in their serum. These changes were associated with perinatal hypoxic damage in the newborns.

Keywords: Placenta, fetus, trace elements, neonatal health.

Introduction

Perinatal disorders often arise from complex mechanisms, including disruptions in fetoplacental blood flow, metabolic and endocrine imbalances, immune dysfunctions, labor complications, and the developmental stage of the fetus and newborn [1]. Heavy metals pose a particular prenatal hazard due to their ability to cross the placental barrier, where they may exert teratogenic, toxic, or carcinogenic effects, as well as interfere with immune function [2]. Proper growth and development are critical indicators of health in infancy and childhood [3]. When the fetal environment is deficient in essential or balanced micronutrients, it may lead to delays in physical

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and cognitive development, weakened adaptive capacity, and chronic health issues later in life [4,5].

Multiple studies have emphasized that maternal micronutrient and vitamin deficiencies are major contributors to intrauterine growth retardation, organ dysfunction, and neonatal anemia. These conditions increase the likelihood of delivering LBW infants, with higher rates of neonatal morbidity [6]. During pregnancy and lactation, the maternal body's demand for bio elements increases significantly. Inadequate supply can adversely impact both maternal and infant health, raising the risks of perinatal complications, premature birth, congenital anomalies, and developmental disorders [7,8].

Furthermore, environmental degradation and increasing exposure to toxic substances, especially heavy metals, exacerbate the strain on the fetoplacental system, leading to exhaustion of compensatory mechanisms and higher rates of perinatal pathology [9]. Infants born under such pathological conditions often exhibit disrupted trace element metabolism [5,2].

Objective of the study

To evaluate how maternal imbalance of certain toxic trace elements specifically cobalt, nickel, and lead affects fetal growth restriction and developmental delays.

Materials and Methods

The study assessed the concentrations of Co, Ni, and Pb in both the blood serum and erythrocytes of 25 pregnant women and their LBW newborns. A control group included 25 healthy pregnant women and their full-term NBW infants. The classification of newborns into LBW and NBW categories was done using the World Health Organization's BMI-based growth charts, which assess weight relative to body length [3]. Trace element levels were determined using atomic absorption mass spectrometry (Japan), supported by computerized data analysis for precise element quantification.

Results and Discussion

Analysis of the mother–placenta–fetus–newborn system showed that maternal serum cobalt concentrations were significantly reduced in cases where infants were born with LBW and hypoxic complications, compared to mothers with uncomplicated pregnancies. In contrast, maternal levels of lead and nickel were 2.6 and 1.2 times higher, respectively, than in the control group (Table 1).

Table 1. Quantitative assessment of trace elements in blood serum of women with uncomplicated pregnancies and mothers of LBW infants, including neonatal data

Trace elements (μmol/l)	Serum of mothers with normal birth weight (nbw) babies	Serum of mothers with low birth weight (lbw) babies	Serum of newborns with nbw	Serum of newborns with lbw
Co	6,24 ± 0,6	4,71 ± 0,46 p, 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* – statistical significance of the difference between maternal serum trace element levels in physiological pregnancies and those in mothers who delivered LBW infants ($p < 0.05$); p_1 – significance of the difference between maternal and newborn serum levels in cases with perinatal CNS pathology ($p < 0.01$); p_2 – difference between trace element levels in NBW and LBW newborns ($p < 0.01$).

In infants born with normal birth weight (NBW), serum concentrations of cobalt, nickel, and lead closely matched those found in their mothers. However, among LBW newborns suffering from hypoxia, serum cobalt levels were reduced by approximately 1.4 times, and nickel levels were 1.1 times lower than their mothers' values. In contrast, lead levels showed a slight elevation in these infants.

A comparison of neonatal serum trace element levels revealed that cobalt in LBW newborns with hypoxia was 34.6% lower than in NBW newborns, while nickel levels were 38.2% higher, and lead concentrations were elevated by a factor of 2.6.

These findings suggest that pregnant women who delivered hypoxic LBW infants exhibited significant cobalt deficiency in serum, alongside elevated nickel and lead levels. Correspondingly, LBW neonates also showed decreased serum cobalt and markedly increased concentrations of nickel and lead compared to NBW infants.

In erythrocytes of mothers who delivered LBW infants with hypoxia, the nickel concentration exceeded that of mothers with healthy pregnancies by 42.6%, and lead by 7.9%, while cobalt levels were comparable between the two groups.

In LBW newborns, erythrocytic trace element profiles also differed significantly from those in the NBW group. The average concentrations of cobalt, nickel, and lead were approximately 40% higher than those observed in healthy neonates (Table 2).

Table 2. Distribution of cobalt, nickel, and lead in erythrocytes of maternal and neonatal blood

Trace elements (μmol/l)	Serum of mothers with normal birth weight (nbw) babies	Serum of mothers with low birth weight (lbw) babies	Serum of newborns with nbw	Serum of newborns with lbw
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* – statistical significance of erythrocyte differences between mothers with normal pregnancies and those who delivered LBW infants ($p < 0.001$); p_1 – significance of differences in erythrocyte parameters between NBW and LBW newborns ($p < 0.01$); p_2 – significance of erythrocyte differences between mothers with physiological pregnancies and their NBW infants ($p < 0.001$); p_3 – significance of differences in erythrocyte indicators between mothers of LBW infants and their newborns ($p < 0.001$).

Given the observed levels of trace elements (TE) in both serum and erythrocytes of mothers who delivered LBW newborns and their infants, it is essential to explore the placenta's role in regulating microelement homeostasis within the mother–placenta–fetus system. Our findings indicate that cobalt (Co) deficiency in the placenta facilitates its accelerated transfer to the fetus, while the organ's capacity to accumulate this micronutrient diminishes. This suggests a disruption in the placenta's ability to preserve essential microelements that are critical for fetal growth and development (see Table 3).

Table 3. Assessment of trace element passage through the placental barrier

Trace Element (TE)	Penetration Index (%)		Accumulation Index (%)	
	Newborns with LBW	Newborns with LBW	Newborns with LBW	Newborns with NBW
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 nickel (Ni) penetration index was 34.9% lower in comparison with the control group, whereas its accumulation index was elevated by 15.3%. Lead (Pb) concentration in the placentas of women delivering low birth weight (LBW) infants tended to be higher than in placentas from mothers of normal birth weight (NBW) newborns. Under hypoxic conditions, the placental penetration index for lead increased to 145.2%, compared to 125.0% in physiological pregnancies, while the accumulation index also rose from 204.0% to 246.1%.

Analysis of maternal serum trace element ratios in mothers of LBW infants revealed a distinct imbalance between cobalt (Co), nickel (Ni), and lead (Pb), characterized by Co deficiency alongside elevated Ni and Pb levels. Specifically, mothers with LBW deliveries exhibited lower serum Co but higher Ni and Pb concentrations. Elevated lead levels during pregnancy have been linked to shortened gestational periods, lower fetal birth weights, congenital anomalies, and impaired cognitive development in children [10,11].

Conclusions:

1. The study identified significantly reduced cobalt concentrations in the serum and erythrocytes of LBW newborns and their mothers' placentas, indicating cobalt deficiency in these individuals. Conversely, nickel and lead levels were approximately twice as high in LBW infants compared to those with normal birth weights.
2. This imbalance compromises the placental barrier's protective capacity against nickel and lead, leading to their increased accumulation in the fetus. Such accumulation contributes to intrauterine growth restriction and the delivery of low-birth-weight newborns.

References

1. Kvashnina T.V., Rodionov V.P., Rakovskaya V.V. Macro- and microelement homeostasis and problems of dysmicroelementosis in children // Perinatology and Pediatrics. – 2008, 3 (35): 91–96.
2. Lodyagina N.S., Livanov G.A., Malov A.M. et al. Relationship between heavy metal content in biological media of pregnant women and pregnancy outcomes in Saint Petersburg // Trace Elements in Clinical Medicine. – 2018, Vol. 9, Issue 12: 58.

3. Ashurova D.T., Akhmedova N.R., Akhmedova D.I. Dynamics of physical development and nutritional status in children under 3 years in the Republic of Karakalpakstan // Pediatrics. – Tashkent, 2014, 3-4: 271-274.
4. Znamenska T.K., Godovanets Yu.D., Godovanets O.S. Forecasting and principles of differential diagnosis of antioxidant deficiency in newborns due to intrauterine growth retardation and birth stress // Neonatology, Surgery and Perinatal Medicine. – 2011, 1: 41–44.
5. Mukhina Yu.G., Dubrovskaya M.I., Gribakin S.G., Yudina O.V. Trace elements: involvement in metabolic processes and significance in child nutrition // Department of Pediatric Diseases № 2 with course of dietology and nutrition, Russian State Medical University, Moscow, Lecture, 2005.
6. Akhrarova N.A., Umarova M.S., Shermatova Z.A. Evaluation of the influence of certain trace elements relationships in newborns. Pediatrics. – Tashkent, 2022, 1: 28-33.
7. Turova L.O. Role of trace elements in the pathogenesis of disorders during intrauterine development: abstract of dissertation for Candidate of Medical Sciences: specialty 14.00.10 ―Pediatrics‖ / L.O. Turova. – Kyiv, 2011. – 24 p.
8. Droz N., Marques-Vida P. Multivitamins/multiminerals in Switzerland: not as good as it seems // Nutrition Journal. 2014. 13: 24. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3994331/
9. Batman Yu.A., Ivanitskaya N.F., Zykov A.S. et al. Levels of heavy metals in newborns and their mothers under ecologically unfavorable conditions of the Donbas region // Neonatology, Surgery and Perinatal Medicine. – 2012, 4(6): 77–81.
10. Tarasova I.V. Trace element imbalance in newborns with perinatal pathology: diagnosis and prognosis: abstract of dissertation for Doctor of Medical Sciences: 14.01.10 ―Pediatrics‖ / I.V. Tarasova. – Kharkov, 2013. – 36 p.
11. Haider B.A., Bhutta Z.A. Multiple-micronutrient supplementation for women during pregnancy. Cochrane Database Syst Rev. 2015, 1(11): CD004905.

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