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Assessment of lead, cadmium, copper and zinc content in women's blood during II trimester of gestation

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The global environmental pollution by heavy metals and the imbalance of trace elements has some detrimental effect on pregnancy, fetal development, maternal and newborn's health with further long-term consequences [1–4].

Heavy metals, particularly lead and cadmium, which are classified as global environmental pollutants, adversely affect the generative function even in low concentrations. Lead excess can cause miscarriage, intrauterine growth retardation, chronic fetal hypoxia, bleeding during pregnancy and labor and the occurrence of birth defects in infants [5,6]. The elevated lead level in pregnant woman's blood leads to the higher content of this metal in the blood of a newborn child that can cause disorders of the psychological development and child's mental abilities [6].

The experimental study has shown that the inhalation of cadmium can cause fewer offsprings and higher frequency of congenital malformations, namely embryotoxic and teratogenic effects and in adults – liver damage and alterations in the immune system [7]. The high levels of placental cadmium can result in the reduction of neonatal anthropometric data (weight, height, chest circumference) [8].

Copper as a trace element plays an important in the maturation of hematopoietic cells, in normal pregnancy and embryogenesis, fetal and post-natal growth. Lower plasma copper levels have been found in some conditions diagnosed during the first trimester including a spontaneous, threatened and missed abortion and a blighted ovum [9].

Copper deficiency can result in anemia, neutropenia, bone marrow dysplasia, chronic intrauterine hypoxia, fetal hypotrophy, coagulation abnormalities [9,10]. Serum and placental copper levels and placental lipid peroxides, a marker of oxidative stress, were increased in women with a severe preeclampsia [11].

Zinc deficiency during the pregnancy is associated with preeclampsia, a threatened abortion, a premature birth syndrome, a low birth weight, birth defects, circulatory disorders, impairment of the immune response and disorders of the psychological development [12–14].

Thus, modern ecological situation creates preconditions for increasing the frequency of gestational complications and some negative impact on women and children's health. In this regard, a scientific search for risk factors of a potential adverse effect on the gestation process for timely implementation of adequate preventive and corrective measures is an important issue.

The aim of this study was to evaluate lead, cadmium, copper and zinc levels in women's blood during II trimester of gestation and to assess the significance of their influence on the gestational process.

Materials and methods. The content of lead, cadmium, copper and zinc in the blood of 95 pregnant women was investigated. These women were under medical supervision in the prenatal first city community clinic in Lviv. The following criteria were chosen: the second trimester of pregnancy, homogeneity of social status, absence of physical, genetic and oncological diseases, a burdened obstetric and gynecological history.

The investigation of metal levels in the blood of 40 women with uncomplicated pregnancy and 45 women with gestation complicated by anemia (33.3 %), a threatened abortion (40.0 %) and gestational pyelonephritis 26.7 %) was carried out. The course of pregnancy was analyzed by processing primary statistical documents – an individual map of a pregnant and parturient woman (form 111/o).

The determination of metal concentration was performed by using the inversion voltammetry method. The preparation of blood samples was conducted in the Central Research Laboratory and Laboratory of industrial toxicology of Danylo Halytsky Lviv National Medical University. Measurements were carried out using the voltammetry analyzer AVA-2 in the Sanitary Epidemiological Station of Lviv Railway.

The statistical analysis included the calculation of mean values, their standard errors (SE), the probability difference by using Mann-Whitney method, the correlation analysis by using Pearson's method and the binary logistic regression.

Results and discussion. The average level of lead and cadmium in women's blood during II trimester of complicated pregnancy were relatively higher ($p < 0.01$) than in women with the uncomplicated course of gestation (Table 1).

The highest concentration of lead was recorded in the blood of women with anemia which was significantly 4.3 times higher than in women without complications. Women with a threatened abortion also had the elevated lead content that 4.2 times exceeded the index in uncomplicated gestation. At the same time, the level of lead in women with pyelonephritis was 2.8 times higher than in healthy ones.

Table 1

Content of lead and cadmium in the women's blood ($M \pm m$)

Course of pregnancy	Metal content, mg/L	
	Lead	Cadmium
Uncomplicated pregnancy	$0,086 \pm 0,013$	$0,0040 \pm 0,0007$
Complicated pregnancy	$0,360 \pm 0,036^{**}$	$0,0118 \pm 0,0018^{**}$
Threatened abortion	$0,367 \pm 0,035^{**}$	$0,0127 \pm 0,0020^{**}$
Anemia	$0,373 \pm 0,062^{**}$	$0,0115 \pm 0,0037^{**}$
Pyelonephritis	$0,242 \pm 0,033^{**}$	$0,0105 \pm 0,0015^{**}$

Note: ** – $p < 0.01$ as compared with uncomplicated pregnancy

The average level of cadmium during complicated pregnancy was 2.9 times higher than in uncomplicated pregnancy. The highest content of cadmium was recorded in threatened miscarriage which exceeded thrice the index in physiological gestation. Pregnant women with anemia and pyelonephritis had respectively 2.8 and 2.6 times higher cadmium level ($p < 0.01$) than healthy ones.

It was also recorded that during the complicated gestation period, the average concentrations of trace elements were significantly lower than the indices of physiological pregnancy (Table 2).

The average copper content during the second trimester of gestation was significantly lower by 36.4 % as compared with uncomplicated pregnancy. The lowest level of copper ($1,049 \pm 0,301$ mg/L) was found in the blood of pregnant women with pyelonephritis that was twice lower than in women with physio-

logical gestation. Women with threatened miscarriage and anemia had by 47.0 and 35.9 % respectively lower copper content than healthy ones.

It was established that the average level of zinc in the blood of women with physiological pregnancy was equal to 4.687 ± 0.275 mg/L, which exceeded by 61.3 % the index in complicated gestation. The lowest zinc level was also found in the blood of women with pyelonephritis that was twice lower than during physiological pregnancy. Women with threatened miscarriage and anemia had by 35.7 % and 38.3 % respectively lower zinc content than healthy ones.

Table 2

Content of copper and zinc in the women’s blood (M ± m)

Course of pregnancy	Metal content, mg/L	
	Copper	Zinc
Uncomplicated pregnancy	2,131 ± 0,117	4,687 ± 0,275
Complicated pregnancy	1,356 ± 0,120**	2,906 ± 0,258**
Threatened abortion	1,365 ± 0,134**	3,015 ± 0,236**
Anemia	1,129 ± 0,155**	2,890 ± 0,272**
Pyelonephritis	1,049 ± 0,301**	2,260 ± 1,130*

Note: * – $p < 0.05$; ** – $p < 0.01$ as compared with uncomplicated pregnancy.

By evaluating the correlations between the content of investigated elements in the second trimester of physiological gestation, the elevation of copper level in case of the increased zinc concentration ($r=0.58$; $p < 0.05$) and the decreased lead level ($r = -0.60$; $p < 0.05$) were detected. The tendency to a direct correlation between cadmium and lead levels ($r = 0.39$; $p > 0.05$) was found.

The lowest level of copper (up to 1.2 mg/L) was combined with the decreased zinc content (up to 4.0 mg/L) and the high lead concentration (over 0.2 mg/L). At the same time, the high level of copper (over 2.4 mg/L) was observed in the case of the increased zinc content (over 5.5 mg/L) and the decreased lead level (up to 0.08 mg/L) (Fig. 1).

Fig. 1. The correlation between lead, copper and zinc content in the blood of women during the II trimester of physiological gestation

The direct correlation between zinc and copper levels ($r = 0.59$; $p > 0.05$) was discovered in the second trimester of complicated pregnancy. The elevation of copper level ($r = 0.45$; $p > 0.05$) and the decreasing of lead content ($r = -0.53$; $p > 0.05$) in the case of the increased zinc concentration was observed in women with threatened miscarriage. At the same time, the tendency to the elevation of cadmium level with the increased lead content was found ($r = 0.28$; $p > 0.05$).

The tendency to the increased cadmium level with the increased lead content ($r = 0.33$; $p > 0.05$) and the decreased copper ($r = -0.27$; $p > 0.05$) and zinc ($r = -0.78$; $p > 0.05$) concentrations was found in women with anemia. At the same time, the elevated copper content was combined with the increased zinc level ($r = 0.59$; $p > 0.05$).

Taking into account the elevated content of toxic metals and low levels of trace elements during pathological gestation, the relationships between them and complications using the pair correlation have been analyzed thoroughly (Fig. 2).

Fig. 2. Correlation coefficients between the metals blood content and the risk of gestational complications in the second trimester of pregnancy. * – $p < 0.05$

The correlation analysis of the metal content in women's blood showed a reliable dependence of the average strength between the level of studied elements and the risk of threatened abortion in the second trimester of gestation. It was determined that the probability of miscarriage is associated with high levels of lead and cadmium as well as low zinc and copper contents.

The risk of anemia in the second trimester of pregnancy slightly correlates with the level of cadmium and zinc, however, it is significantly combined with low concentrations of copper and high levels of lead.

Conclusion. The average levels of toxic metals in the blood of women with complicated gestation were significantly 2.9-4.3 times higher as compared to the physiological course of pregnancy while the content of trace elements was twice lower.

The direct correlation between zinc and copper levels was stated in the second trimester of complicated and uncomplicated gestation. The highest level of copper was observed in the case of the increased zinc content and the decreased lead level.

The arising risk of pregnancy loss correlated significantly with the high level of lead and cadmium as well as with the low zinc and copper content. The probability of anemia was combined with the low concentrations of copper and the high content of lead.

Thus, nowadays in ecological conditions with increased levels of abiotic substances and the lack of trace elements, the detection of lead, cadmium, copper and zinc levels in women's blood can be useful for predicting the individual risk of threatened abortion, anemia and pyelonephritis.

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RESEARCH ARTICLE

Assessment of Lead, Cadmium, Copper and Zinc Content in Women's Blood During II Trimester of Gestation*M. GZHEGOTSKYI, N. SUKHODOLSKA**Danylo Halytskyj Lviv National Medical University, Lviv, Ukraine**E-mail: natalia.suhodolska@gmail.com*

Introduction. The modern ecological situation creates preconditions for increasing the frequency of gestational complications and negative impact on women's and children's health. In this regard, the scientific search for risk factors of the potential adverse effect on the gestation process for timely implementation of adequate preventive and corrective measures is of great importance.

The purpose of this study was to evaluate lead, cadmium, copper and zinc levels in women's blood during the second trimester of gestation and to assess the significance of their influence on the gestational process.

Materials and methods. The investigation of lead, cadmium, copper and zinc levels in the blood of 40 women with uncomplicated pregnancy and 45 women with gestation complicated by anemia (33.3 %), threatened abortion (40.0 %) and gestational pyelonephritis 26.7 %) was carried out. The indication of metals was evaluated by the inversion voltammetry method.

The following criteria were chosen: the second trimester of pregnancy, the homogeneity of social status, the absence of physical, genetic and oncological diseases, burdened obstetric and gynecological history.

Results. The average levels of toxic metals in the blood of women with complicated gestation were significantly higher as compared to the physiological course of pregnancy while the content of trace elements was significantly lower.

The highest lead concentration was recorded in the blood of women with anemia and the highest cadmium content was recorded in a threatened miscarriage, which were respectively 4.3 and 3.0 times higher than in women without complications. At the same time, women with pyelonephritis had respectively 2.8 and 2.6 times higher lead and cadmium levels.

The average copper and zinc content during the second trimester of gestation was significantly lower by 36.4-38.7 % as compared with the uncomplicated pregnancy. The lowest levels of trace elements were found in the blood of pregnant women with pyelonephritis that were twice lower than during the physiological pregnancy. Women with a threatened miscarriage and anemia had respectively by 47.0 and 35.9 % lower copper content, and 35.7 % and 38.3 % lower zinc content.

The lowest level of copper was combined with the decreased zinc content and the high lead concentration. At the same time, the high level of copper was observed in the case of the increased zinc content and the decreased lead level.

It has been shown that combined effects of microelements such as cadmium and lead had some provocative action on the increase of the risk of gestational complications whereas copper and zinc had some preventive action.

In the second trimester of gestation, the development of a threatened abortion was combined with high levels of lead and cadmium, low levels of zinc and copper, and the risk of anemia was correlated with the low concentration of copper and the high content of lead in the blood of pregnant women.

Thus, nowadays in ecological conditions with the increased levels of abiotic substances and the lack of trace elements, the detection of lead, cadmium, copper and zinc levels in women's blood can be useful for predicting the individual risk of a threatened abortion, anemia and pyelonephritis.

Key words: second trimester of gestation, cadmium, lead, zinc, copper.