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Original Article

Correlation between Lead in Maternal Blood, Umbilical Cord Blood, and Breast Milk with Newborn Anthropometric Characteristics

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ABSTRACT

Background: Breast milk can be a source of toxic material, along with the transfer of nutrients needed for infant growth. This study was conducted to measure the level of lead in maternal and neonatal blood and breast milk in Tehran, Iran.

Methods: In this cross-sectional study, 150 mothers and their infants were studied. Samples of maternal blood, fetal umbilical cord blood, breast milk, and amount of lead measured by atomic absorption method were collected. Correlations between lead levels and demographic characteristics of mother and infants were assessed.

Results: The mean levels of lead in maternal and neonatal blood and breast milk were 9.79±4.31, 8.29±4.83, and 8.65±3.67 µg/dl, respectively. The different levels of lead were associated with cord blood, maternal blood, and breast milk. No significant relationship was found between lead levels and neonatal parameters (i.e., weight, height, and head circumference). The Spearman's correlation also showed the association between different levels of lead with cord blood, maternal blood, and breast milk. Linear regression also did not show any relationship between lead levels in cord blood, milk, and mother blood with newborn growth parameters.

Conclusion: The present study failed to find a significant correlation between lead and newborn birth parameters. In our study, lead levels in maternal blood, breast milk, and cord blood were lower, compared those of the previous years in Iran; however, it needs to decrease, because lead even at very low concentrations may also have adverse effects.

Keywords: Breast milk, Contaminant, Lead, Maternal blood, Umbilical cord blood

Introduction

Lead is one of the world 10 toxic metals found everywhere and can pollute humans through air, contaminated water, and food chain (1). A significant amount of lead is delivered by airborne particles as the main source of mother's contact with this pollutant (2, 3). In total, 90% of lead in adults is stored in the bones that considered a reservoir for a decade. This is why infants are at risk for a long time after mothers' exposure.

The level of lead in mothers' blood increases during pregnancy and lactation that can be due to the separation of lead from the bone tissue of the mother (4). There is no safe threshold for this heavy metal in the body (5). There is no safe threshold for this heavy metal in the body (6). Evidence suggests that the embryo's brain is more susceptible to the toxic effects of the lead and cannot prevent the entry of this metal (7, 8).

Breast milk is an essential nutrient for the brain and body development of neonates. The World Health Organization (WHO) recommends exclusive breastfeeding to 6 months of age. Breast milk contains components, such as lactoferrin, lysozyme, and α-lactalbumin that protect infants against many harmful environmental factors; however, breast milk can be a source of toxic

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substances(9). One of these toxic agents is lead that even at low concentrations, has toxic effects on the nervous system, liver, kidneys, and lungs(10, 11). In addition to a mother's diet, smoking also increases the amount of these contaminants in the milk (9).

The level of lead in breast milk varies greatly from country to country (from 0.5 to 126.6 μg/L) that can be due to the environmental, geographical, nutritional, occupational and individual habits of sampling and breastfeeding time (1). Given that in different countries, annual pollution levels are measured, and trends in their levels are monitored in Iran in recent years, especially in large cities, different levels of lead have been reported. Therefore, this study was designed and implemented in order to measure the level of lead in maternal and neonatal blood and breast milk in Tehran, Iran.

Methods

This cross-sectional study was conducted on mothers and their infants who were referred to Vali-Asr Hospital in Tehran -an academic governmental and referral center- for delivery during 2016 January to 2017 April. All the mothers who delivered their neonates in this hospital were recruited in the present study (n=500) out of whom 260 were willing to participate in the study. Moreover, 110 mothers were excluded because of the lack of inclusion criteria and missing one of samples; finally, 150 mothers entered to the study. All the subjects were informed of the purpose and procedure of the study verbally, and their participation in the study was on a purely voluntary basis.

Then, 5 ml of the heparinized blood sample of maternal blood -before delivery- and fetal umbilical cord blood -during delivery- was taken. The samples were sent to a toxicology laboratory to determine the amount of lead by atomic absorption method up to 2 h after the blood sampling (Agilent AA240-GTA120, Germany). The mothers milked with hands under the sterile conditions during the first week after delivery, and it was frozen immediately at a temperature of -20°C until delivery to a laboratory for measuring lead concentration by atomic absorption.

Demographic characteristics of mothers and infants were recorded. Exclusion criteria were a) having a job that directly targets mothers with lead exposure (e.g., working in cannery, carpentry, and cosmetic factories), b) addiction to cigarettes and other drugs, c) having a disease that directly and indirectly affects the development of the fetus, such as maternal diabetes and high blood pressure, d) abnormality in pregnancy duration, such as having a pre-eclampsia, and e) living near factories that produce lead contamination. Considering the provisions of the Helsinki Declaration principles, this study was approved by the Medical Ethics Committee of Tehran University of Medical Sciences (ID: 95-03-105-33119).

Sample size

The number of the samples was calculated based on the estimated mean in a society with 95% confidence and 15% of standard deviation, and finally 150 patients (i.e., 150 mothers and 150 infants) were assessed.

Statistical analysis

After entering data in SPSS Software (version 23), the results of the single-variable Kolmogorov-Smirnov test used to verify the normalization of data distribution showed that all of the quantitative variables had no normal distribution. Since the relationship between lead level and growth parameters were quantitative, we used the Spearman's correlation for abnormal distribution and Pearson's correlation for normal distribution. Crude model of linear regression was used to show the linear relationship between lead levels in maternal blood, breast milk, and umbilical cord blood samples with infant growth parameters.

Results

In this study, 150 mothers and their infants were examined. The demographic characteristics of the mother and infants are presented in Table 1. Pearson's correlation test did not show any significant relationship between lead levels with weight, height, and head circumference. Only the different levels of lead were associated with cord blood, maternal blood, and breast milk (P<0.001 for each of two-to-two relationships). The Spearman's correlation for the evaluation of these relationships is presented in Table 2.

The Spearman's correlation also showed the association between different levels of lead with cord blood, maternal blood, and breast milk (P<0.001 for each of two-to-two relationships). Also, the relationship between umbilical cord blood lead, mother's blood, and breast milk with head circumference, height, and weight were assessed by linear regression (Table 3). Linear regression also did not show any relationship between lead levels in cord blood, milk, and mother blood with newborn growth parameters.

Table 1. Demographic characteristics of mothers and neonates

Variable		n	%
Job	Housewife	142	91.6
	Employed	10	6.5
Educational level	Under diploma	64	41.3
	Diploma	63	40.6
	Associate degree	8	5.2
	Undergraduate	18	11.6
	Masters and higher	1	0.6
Breastfeeding	Yes	111	71.6
	No	42	27.1
Maternal diseases	Heart	3	1.9
	Renal	2	1.3
	Blood pressure	21	13.5
	Neurologic disorders*	5	3.2
	Gestational diabetes	2	1.3
Gender of neonate	Male	76	49
	Female	79	51
Delivery type	NVD [a]	21	13.5
	C/S [b]	132	85.2
Infant status	Term	121	78.1
	Pre-term	23	20.6
Variable		**Mean±SD[c]**	**Min-Max**
Maternal	Age (year)	30.26±5.96	15-44
	Gestational weight (kg)	82.2±16.6	55-165
	Daily work hours	0.37±1.73	0-12
	Weekly workdays	0.27±1.21	0-6
	Parity	2.49±1.07	1-4
	Delivery time	2.12±0.88	1-4
	Blood lead (µg/dl)	9.79±4.31	2-24
	Milk lead (µg/dl)	8.29±4.83	2.6-40.6
Neonatal	Birthweight (gr)	3113.75±557.66	900-4300
	Height (cm)	49.43±4.94	45-57
	Head circumference (cm)	34.70±1.49	31-38
	Cord blood lead (µg/dl)	8.65±3.67	3-26

a: Normal vaginal delivery; b: Cesarean section; c: Standard deviation
* Neurologic disorders, such as seizure and psychoses

Table 2. Spearman correlation between lead levels in blood and breastmilk of mother and umbilical cord blood with neonatal variables

		CB[a]	WB[b]	MM[c]	HC[d]	Height	Weight
CB	Correlation coefficient	1.00	0.497**	0.563**	0.060	-0.053	0.014
	P-value	-	0.000***	0.000***	0.627	0.515	0.862
WB	Correlation coefficient	0.497**	1.00	0.632**	0.188	0.048	0.058
	P-value	0.000***	-	0.000***	0.121	0.556	0.483
MM	Correlation coefficient	0.563**	0.632**	1.00	0.062	0.015	0.015
	P-value	0.000***	0.000***	-	0.615	0.856	0.856
HC	Correlation coefficient	0.060	0.188	0.062	1.00	0.633**	0.629**
	P-value	0.627	0.121	0.615	-	0.000***	0.000***
Height	Correlation coefficient	-0.053	0.048	0.015	0.633**	1.00	0.684**
	P-value	0.515	0.556	0.856	0.000***	-	0.000***
Weight	Correlation coefficient	0.014	0.058	0.063	0.015	0.684**	1.00
	P-value	0.862	0.483	0.454	0.856	0.000***	-

a: Cord blood, b: Whole blood, c: Mother milk, d: Head circumference
*** P<0.001, **P<0.01

Discussion

In the present study, the concentration of lead in the maternal blood, umbilical cord, and breast milk was significantly correlated with each other. We found no significant relationship between milk lead level and maternal/neonatal demographic characteristics. The mean value of lead levels in umbilical cord blood, maternal blood, and breast milk was lower than those of other studies in Iran

Table 3. Linear regression between lead levels in blood and breastmilk of mother and umbilical cord blood with neonatal variables

		HC[d]	Height	Weight
CB[a]	B[e]	8.479	0.101	-0.001
	95% CI (L, U)[f]	-0.904, 0.748	-0.071, 0.273	-.003, 0.002
	P-value	0.851	0.245	0.641
WB[b]	B	0.282	0.131	-0.001
	95% CI (L, U)[f]	-0.717, 1.281	-0.076, 0.339	-0.004, 0.002
	P-value	0.575	0.211	0.646
MM[c]	B	-0.369	0.120	0.001
	95% CI (L, U)[f]	-1.577, 0.839	0.593	0.593
	P-value	0.544	-0.131, 0.005	-0.003, 0.005

a: Cord blood, b: Whole blood, c: Mother milk, d: Head circumference, e: Standardized coefficient, f: Lower bound, Upper bound

during previous years. The present study failed to find a significant correlation between lead and newborn birth parameters.

The mean concentration of lead in maternal blood, umbilical cord, and breast milk has been reported in many countries during the years. Due to the importance of pollutants, especially trace metals and their effects on the community health, monitoring of their levels at regular intervals is necessary to make managerial decisions if needed. In Iran, Soleimani et al. (2012-Tahran) reported that the value of lead in human milk was 23.66±22.43 µg/l that was higher than those of other countries (11).

Also, in a study by Farhat et al. (2013, Mashhad), the mean value of mothers' blood lead level (BLL) was 75.9 (31.1) µg/L. In addition, the mean value of BLL in infants was 63.6±26.8 µg/L. In eight mothers (13.3%) and four infants, (6.7%) BLL was higher than 100 µg/L(12). In our study, the mean lead levels in umbilical cord blood, maternal blood, and breast milk were 8.65±3.67, 9.79±4.31, and 8.29±4.83, respectively. Furthermore, it was near to the levels of this contaminant reported by Rahimi et al. as 10.39±4.72 µg/L in breast milk in Isfahan during 2009(13).

The WHO value for children's blood lead levels was lowered from 10 to 5 µg/dL (14)and continuation of lactation is possible up to 40 µg/dL of lead level in maternal blood(15). In the present study, despite a decrease in maternal blood, breast milk, and umbilical cord blood lead levels, compared to that of similar studies in the metropolis of Iran during previous years, it is higher than the recent cut-off and has yet to decline.

In a study by Ettinger et al., Maternal lead levels were reported in blood: 7.7±4.0 µg/dL, plasma: 0.1±0.1 µg/L, and milk: 0.8±0.7 µg/L. The average milk/blood lead ratio was 1.2±0.9. The results of the aforementioned study suggested that the transfer of lead from plasma into breast milk depending on the amount of lead in blood plasma is different, and the transfer of lead from plasma into breast milk even at low levels in plasma can be high. In addition, breast milk is an important source for the transfer of lead to infant (16); The average maternal milk/blood lead ratio in our study was 0.84. This could be explained by passive transfer of low concentrations of lead into breast milk driven by high-affinity compartment in milk.

In addition, maternal blood/cord blood lead ratio in our study was 1.31 indicating that lead passes from the mother's blood through the umbilical cord and breast milk. However, according to a study by Ettinger et al. and Center for Disease Control announcement in 2010, lactation should probably be discontinued if the lead in the blood of lactating mothers is more than 40 µg/dL (15, 16). Therefore, it seems that the level of blood lead in mothers less than 10 µg/dL is not worrying because the lead in milk will be less than 5% in this case(7).

There is a large correlation between blood and milk lead levels, and blood lead levels are good predictors of milk lead concentrations (6, 15, 17). In some reports, breast milk concentrations are 20% lead in the blood, because the lead is not soluble in the fat and binds to protein (3). The present study also found a significant correlation between the concentration of lead in the maternal blood, umbilical cord, and breast milk (P<0.001 for each of two-to-two relationships). Given that lead concentrations in the mother's milk and blood samples were roughly the same, milk sampling could be a good alternative for blood sampling.

There are several reports about the relationship between mother's milk and blood lead levels with demographic characteristics of the mother. In a study by Soleimani et al., milk lead level was not related to maternal education, age, parity, height, and weight (11). In line with the results of the aforementioned study, we found no significant relationship between milk lead level with maternal education, age, parity, maternal height and body weight, as well as height and weight of the infant. However, in a study by Rahimi et al., there were positive relationships between lead concentration in milk with maternal age and parity(13). Nishioka et al. found an inverse correlation between birth weight and the logarithm of maternal blood lead at 12 weeks of gestation only in male newborns (18).

Concerning the relationship between the level of lead and milk of the mother with the demographic characteristics of the baby, Atabek et al. reported a positive correlation between umbilical cord lead and birth weight. However, no statistically significant association with other neonatal parameters was found (19). Nonetheless, the mean cord blood lead level in this study was 144±89 mg/l about 18 times more than this level in our study that may be the cause of this relationship.

The results of our study showed no relationship between lead levels in umbilical cord blood, maternal blood, and breast milk with birthweight that was similar to a study by Farhat et al(12). They found no significant correlation between maternal BLL with infants' age and birthweight, while mothers' BLL in the aforementioned study was 9 times more than maternal BLL in our study.

Some of the maternal factors may increase lead levels in maternal blood and consequently in cord blood and breast milk, such as living in polluted environments, individual habits, and some health conditions, such as pre-eclampsia (20). To eliminate these confounding factors, we excluded all mothers with these underlying factors. We measured the level of infant cord blood lead in the present study, while the measurement of lead in the infant's blood in the months after birth is a more accurate index of the rate of lead transfer from mother to infant. Also, the follow-up of the growth and development of the infant over long periods can be a better indicator of the effects of different levels of lead.

In the present study, the average lead levels were lower than those obtained in Iran in recent years. In addition, continued annual monitoring may look at the impact of possible environmental health interventions. Due to the elimination of premature babies from the study, most neonates were in the normal weight range, and it was not possible to study lead levels comparatively in low-birth-weight and normal-weight infants. Performing future studies with higher sample sizes at all gestational ages may provide more information.

Conclusion

The present study failed to find a significant correlation between lead and newborn birth parameters. In our study, lead levels in maternal blood, breast milk, and cord blood were lower, compared to those of previous years in Iran. However, it needs to decrease because lead even at very low concentrations may also have adverse effects. Nonetheless, lead levels were lower than toxic cut-off in our samples, and it is recommended to breastfeed up to 6 months of age. Performing future studies in order to monitor the changes in the levels of this pollutant appear to be necessary.

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Conflicts of interests

The authors declare that there is no conflict of interest.

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