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Transfer of Lead via Placenta and Breast Milk in Human

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The mean lead levels in the maternal blood, cord blood, breast milk and placental tissue, were 0.63 μmol/L (13.2 μg/dL), 0.33 μmol/L (6.90 μg/dL), 4.74 μg/L and 0.86 μmol/kg (17.85 μg/100g) respectively for 165 parturient women occupationally non-exposed to lead in 2 hospitals in Shanghai. No significant difference was found between maternal age groups for these indicators. However, the lead levels in the cord blood and breast milk increased with the lead level in the maternal blood, with coefficient of correlation of 0.714 ($P < 0.0001$) and 0.353 ($P < 0.01$) respectively. The mean concentration of lead in breast milk for 12 occupationally lead exposed women was 52.7 μg/L, which was almost 12 times higher than that for the occupationally non-exposed population. These results suggested that transfer of lead via placenta prenatally and breast milk postnatally were possible and might pose a potential health hazard to the fetuses and the neonates.

INTRODUCTION

Environmental pollution of lead has become increasingly serious with the industrialization process in China, especially with the rapid increase in the number of automobiles and motorcycles. It is well known that extra lead intake is hazardous to human health (Klein *et al.*, 1994), especially to the health of children and infants (Shen *et al.*, 1997). Placenta is the only passage for fetus to obtain nutrition from and to excrete metabolites to the maternal blood while breast milk is becoming more and more important to infants with the increasing breast-feeding rate. Therefore, studies on the transfer of lead via placenta to fetus and via breast milk to infants are essential.

It has been verified by the isotope method that lead can be transferred to fetus via placental tissue and breast milk in animals (Hackett, Hess, and Sikov, 1982; Tachon, 1983; Ding *et al.*, 1986). However, few investigations have so far been done in human beings. The present study reports the placental and lacteal transfer of lead in parturient women with versus without occupational exposure to lead.

MATERIALS AND METHODS

Maternal blood, cord blood, breast milk and placental tissue were collected from 165 samples parturient women nor occupationally exposed to lead in the Shanghai Women Health Care Hospital and the Rehui District Hospital. A total of 119 samples for breast milk, 153 samples of placental tissue and 165 samples for the maternal and cord blood were collected.

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In addition, samples of breast milk were collected from 12 women occupationally exposed to lead in a small battery factory in Shanghai suburbs. The maternal blood samples were collected from vein before child birth, while cord blood samples were collected from the fetus side during child birth. All the blood samples were stored in polytetrafluoroethylene (PTFE) tubes with heparin. Breast milk was also collected in the PTFE tubes.

The lead levels in the above mentioned samples were measured with Zeeman Atomic Absorption Spectrometer. The standard lead solution was bought from the Shanghai Institute of Meteorological Technology, and the standard blood lead sample was obtained from the American National Standard Bureau (SRM955). The results of measurements were within analytical ranges. Lead level in breast milk was measured in the same way, and for that in placental tissue it was quality controlled with the standard cow liver tissue sample.

The results were analyzed for groups divided according to lead levels in maternal blood which were compared by variance analysis, and the lead levels in maternal blood, cord blood, breast milk and placental tissue were analyzed by linear regression. The lead levels in breast milk from occupationally exposed and non-exposed women were compared by Wilcoxon's rank-sum test.

RESULTS

The data listed in Table 1 indicate the relatively great individual differences among the subjects. Further analysis shows that they were not age-related.

TABLE 1

Lead Levels in Maternal Blood, Cord Blood, Breast Milk and Placental Tissue From Occupationally Non-exposed Women

	Maternal Blood ($\mu g/L$)	Cord Blood ($\mu g/L$)	Breast Milk ($\mu g/L$)	Placental Tissue ($\mu g/kg$)
Number of samples	165	165	119	153
$\bar{x} \pm s$	0.68 ± 0.33	0.40 ± 0.23	5.63 ± 4.39	1.14 ± 1.10
Range	0.06 ~ 1.83	0.02 ~ 1.20	0.60 ~ 33.18	0 ~ 6.09
Median	0.63	0.33	4.74	0.86
95% Percentile	1.30	0.85	14.18	3.46

Table 2 further analyzes the relationship within lead levels in maternal blood, cord blood, placental tissue and breast milk from data in Table 1. It shows that lead levels in cord blood and maternal blood were correlated significantly ($r = 0.714$, $P < 0.0001$), and those in breast milk and maternal blood are also linearly correlated ($r = 0.353$, $P < 0.01$).

Table 3 shows the result of 12 exposed women in a small battery factory in Shanghai suburbs, which is compared with 119 breast milk samples from occupationally non-exposed women. The average age of the 12 exposed women was 24 years old and the average exposed period was 1 years and 9 months. The difference between the 2 groups was significant ($P < 0.01$). The listed data shows that the maximum lead level in breast milk from the exposed women was 291 $\mu g/L$.

TABLE 2

The Correlations Between Lead Levels in Maternal Blood and Other Materials From Occupationally Non-exposed Women

	$\bar{x} \pm s$ (Number of Samples)		
Maternal blood (μmol/L) *	< 0.48	0.48 ~ 0.96	≥0.96
Maternal blood (μmol/L)	0.31 ± 0.10 (42)	0.68 ± 0.14 (94) **	1.21 ± 0.19 (29) **
Cord blood (μmol/L)	0.19 ± 0.10 (42)	0.41 ± 0.14 (94) **	0.67 ± 0.25 (29) **
Breast milk (μg/L)	4.30 ± 2.50 (32)	5.30 ± 3.90 (65)	8.40 ± 6.50 (22) **
Placental tissue (μmol/kg)	0.99 ± 1.09 (39)	1.17 ± 1.09 (85)	1.24 ± 1.13 (29)

* Grouped according to minimun, medium, maximun concentration in maternal blood.
** Comparison with maternal blood lead < 0.48 μmol/L ($p < 0.01$).

TABLE 3

Comparison of Lead Levels in Breast Milk From Lead Exposed and Occupationally Non-exposed Women (μg/L)

	Exposed ($n = 12$)	Non-exposed ($n = 119$)
$\bar{x} \pm s$	91.82 ± 100.29	5.63 ± 4.39 *
Range	10.70 ~ 291.10	0.60 ~ 33.18
Median	41.75	4.74
Geometric Mean	52.68	4.43

* Significantly different from the exposed ($P < 0.01$).

DISCUSSION

Up to now, most of the papers on the lead transfer via placental tissue in human have been related to the study of lead levels in maternal blood and cord blood. However, we have found that the mean concentrations of lead in the maternal blood were significantly correlated with that of the blood ($r = 0.925$, $P < 0.01$) (Sheng and Wang, 1987). Wan *et al*. (1991) investigated on 32 women exposed to lead and 32 women as control. The results showed that the concentration of lead in the cord blood were related with that of maternal blood, and the coefficient of correlation was 0.41 ($P < 0.05$). According to Lagerkvist *et al*. (1996), the mean concentration of lead in the maternal blood at delivery was 0.15 μmol/L for 290 women living near a smelter and 0.13 μmol/L for 194 controls. The mean concentration of lead in the cord blood was about 80%-87% of that of the maternal blood, and the correlation coefficient was $r = 0.50$ ($P < 0.001$). In our study, the lead concentrations of the samples were measured by AAS method, which was verified by standard blood lead samples. The results from 165 occupationally non-exposed women showed that the correlation coefficient was $r = 0.714$ ($P < 0.0001$) for lead concentrations in the maternal blood and cord blood. In addition, the age of the pregnant women had no effect on lead level of cord blood.

Direct determination of lead level in placental tissue is an alternative way to study the lead transfer via placenta. It has been reported that the lead level of placental tissue from occupationally non-exposed people was 0.29 μmol/kg (6.04 μg/100 g) (Sheng and Wang, 1987). In the present study the median lead concentration placental tissue in the of 153 occupationally non-exposed women was 0.86 μmol/kg (17.9 μg/100g). Khera *et al*. (1980) have found that the lead concentration in placental tissue of exposed women was significantly higher than that of occupationally non-exposed women.

All the above results show that lead can be transferred into placental tissue from maternal blood, which is a potential risk to infants.

Lead level in breast milk from occupationally non-exposed women was reported to be 2-5 μg/L (20 μg/L for exposed women) by Abadin *et al*. (1997), and 2 μg/L by WHO (Larsson, *et al*., 1981). In our study, for the occupationally non-exposed people in Shanghai, the median concentration was 4.74 μg/L which was close to the those reported by Abadin *et al*. and WHO, but lower than those from other authors (Friberg and Marie, 1983). As reported by Fong (1988), the geometric mean of lead concentration in breast milk of 15 exposed women was 250 μg/L and 8.7 μg/L for the controls. The difference was significant. It was reported that high lead level in breast milk could cause poisoning of the fetus. Fong (1988) reported 13 exposed women whose average lead level of breast milk was up to 357 μg/L. Our study showed the correlation coefficient was $r = 0.353$ ($P < 0.01$) for lead levels between maternal blood and breast milk. It is evident that lead can be transferred from mothers to babies via breast milk.

Since the intestinal absorption rate of babies is up to 30%-50%, lead poisoning in infants is likely to occur in breast feeding from women with high lead concentration. Consequently, strict measures to prevent lead exposure to women of child bearing age should be implemented.

Our study serves as a further evidence in supporting the ban on using lead additive to gasoline which was implemented since October of 1998 in Shanghai Municipality.

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