

# Concentrations of lead in maternal blood, cord blood, and breast milk

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**SUMMARY** Lead concentrations in maternal blood, umbilical cord blood, and breast milk from 114 women who were not occupationally exposed to lead were determined by graphite atomic absorption spectrophotometry. The mean concentrations of lead in maternal blood, umbilical cord blood and breast milk were 0.7, 0.55, and 0.23  $\mu\text{mol/l}$ , respectively. A significant correlation was observed between maternal and umbilical cord blood ( $r=0.63$ ). A lower correlation was noted between maternal blood and breast milk ( $r=0.29$ ). These results suggest that lead freely crosses the placental barrier from mother to fetus and the transfer of this heavy metal from maternal tissues to breast milk is possible, but the metabolic mechanisms are more complicated. In addition, a longitudinal study was conducted of concentrations of lead in breast milk in nine lactating women. Results suggested no significant change in the content of lead in breast milk during early lactation.

The toxicology of lead has been well studied. The contention that excessive absorption of lead in pregnant women may pose a danger to the fetus has also been examined.<sup>1</sup> Infants and children are particularly susceptible to the toxicity of lead because of their developing central nervous system, small body size, higher rate of absorption, and tendency to put objects into their mouths.<sup>2</sup> Lead also has a higher affinity for fetal haemoglobin.<sup>3</sup> There is growing concern that in infants and young children excessive exposure to lead may result in subtle neurological damage, which may manifest as impaired learning ability, fine motor dysfunction, lack of sensory perception, and other psychological effects.<sup>4</sup>

Reports suggest that during lactation mobilisation of bone calcium occurs and as lead is known to interact with calcium, it may also be mobilised.<sup>5</sup> Ryu *et al*<sup>6</sup> showed that lead concentrations in maternal blood increase during lactation. These findings suggest that the mobilisation of lead in the maternal tissue may pose a health risk to young infants, particularly as breast feeding is actively encouraged.

The objectives of this study were to examine the metabolism of lead from the perinatal mother to the newborn and the concentrations of lead in the breast milk that may pose a health risk to infants by being breast fed.

## Subjects and methods

Maternal blood samples from 114 women were obtained by venepuncture within 30 minutes after delivery at an urban maternity hospital in Kuala Lumpur, Malaysia, during February 1983 to May 1984. Samples of umbilical cord blood were collected at delivery. Each mother was interviewed by the nursing staff using a standard questionnaire to collect pertinent information—namely, age, race, residence, occupation, and smoking and drinking habits.

Samples of breast milk were collected on days 3-5 after delivery. Precautions were taken where possible to prevent contamination: the area around the nipple was cleaned with water before the milk was expressed, the first few drops were discarded, and only the midstream flow was collected in acid wash lead free polystyrene tubes. All samples were sealed immediately before they were transported to the laboratory. To minimise the risk of contamination from unsuspected sources collection kits for blood and milk were prepared in large numbers and supplied to the maternity hospital in batches when requested.

Nine mothers who were breast feeding and had had normal deliveries at a maternity hospital in Singapore volunteered to participate in the longitu-

dinal study of the content of lead in breast milk during the perinatal period. The protocol was explained to each mother in detail. Samples of breast milk (4 ml) were collected from each subject three, seven, 10, 14, and 20 days and one month postpartum. To obtain a more representative sample of milk subjects were instructed to collect the sample during a morning feed (about 9.00–10.00 am). Samples were frozen immediately and stored until analysed.

**Analysis of lead in blood and breast milk.** Analysis of lead was carried out with a Pye-Unicam SP-9 graphite furnace atomic absorption spectrophotometer at the Department of Social Medicine and Public Health, which is a collaborating laboratory with the National External Quality Assessment Scheme in the United Kingdom. The degree of precision of the analysis of lead in blood over the concentration range 0.05–0.48  $\mu\text{mol/l}$  is within 0.02  $\mu\text{mol/l}$ . Generally, the analysis was carried out in triplicate, and samples were usually analysed within three days or, if necessary, stored at  $-4^\circ\text{C}$ . The detailed analytical procedures were as reported previously.<sup>7</sup>

Samples of milk were diluted 10 fold with double distilled water and 10  $\mu\text{l}$  aliquots were analysed directly by graphite AAS by the method shown in Table 1.

The wavelength used throughout the study was 283.5 nm, the sample size 10  $\mu\text{l}$ , and the lamp current 7 mA. The lead absorbance signal, corrected for a blank reagent, was compared with values from a standard curve. This standard curve was prepared daily by the methods of addition. Standards were linear from 0.02  $\mu\text{mol/l}$  to 7.2  $\mu\text{mol/l}$ . We consistently obtained greater than 98% recovery. Precision was determined by measuring the daily percentage variation of absorbance of a fresh sample of milk. The coefficient of variation seldom exceeded 5%. Based on criteria proposed by Currie<sup>8</sup> the limit of detection of this method was 7 nmol/l. Interbatch analytical stability was assessed by a 0.19  $\mu\text{mol/l}$  standard. Over a period of 10 months the variation was 4.8%. Internal quality control for accuracy was checked by an analysis of a bovine liver standard from the United States of America National Bureau

of Standard. The value (SD) obtained from this laboratory was 0.35 (0.04)  $\mu\text{g/g}$  for a sample certified to contain 0.34 (0.01)  $\mu\text{g/g}$ .

**Results**

**Blood lead concentrations in mothers and infants.**

Table 2 shows the mean and range of lead concentrations for maternal blood, umbilical cord blood, and breast milk. Figure 1 shows the relation between maternal and umbilical cord blood. The scattergram suggests a direct correlation between the two variables, giving a significant coefficient of correlation ( $r=0.63$ ,  $P<0.001$ ). There was a clear indication of the decrease of blood lead concentration from mother to the infant. A less significant correlation was observed ( $r=0.29$ ,  $P<0.01$ ) for the relation between maternal blood and breast milk (Fig. 2).

Table 2 Lead concentrations ( $\mu\text{mol/l}$ ) for maternal blood, umbilical cord blood, and breast milk ( $n=114$ )

Sample	Mean (SD)	Range
Maternal blood	0.73 (0.2)	0.36–1.15
Cord blood	0.55 (0.15)	0.24–1.23
Breast milk	0.23 (0.06)	0.12–0.51

Conversion: SI to traditional units—Lead: 1  $\mu\text{mol/l} \approx 20.8 \mu\text{g/100 ml}$ .

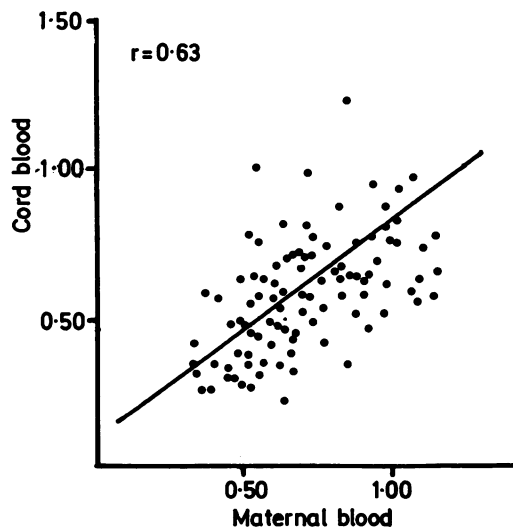


Fig. 1. Correlation of lead concentration ( $\mu\text{mol/l}$ ) in maternal and umbilical cord blood ( $n=114$ ,  $r=0.63$  ( $P<0.001$ ),  $y=4.02 + 0.55x$ ). Conversion: SI to traditional units—Lead: 1  $\mu\text{mol/l} \approx 20.8 \mu\text{g/100 ml}$ .

Table 1 Analysis of milk samples

Atomisation	Temperature ( $^\circ\text{C}$ )	Time (seconds)
Drying	120	20
Ashing 1	300	30
Ashing 2	700	3
Atomisation	2150	4

Table 3 Lead concentrations ( $\mu\text{mol/l}$ ) in breast milk during lactation

Days postpartum	Case no								
	1	2	3	4	5	6	7	8	9
3	0.15	0.21	0.21	0.25	0.18	0.26	0.22	0.21	0.18
7	0.13	0.18	0.23	0.23		0.25	0.30	0.23	0.18
10	0.18	0.25	0.18	0.19	0.16	0.24	0.21	0.21	0.22
14	0.12	0.23	0.19	0.22	0.21	0.23	0.31	0.16	0.21
20	0.17	0.24	0.22	0.23	0.18	0.21	0.26	0.18	0.24
>30	0.16	0.20	0.20	0.25	0.23	0.24	0.23	0.16	0.23

Conversion: SI to traditional units—Lead:  $1 \mu\text{mol/l} \approx 20.8 \mu\text{g}/100 \text{ ml}$ .

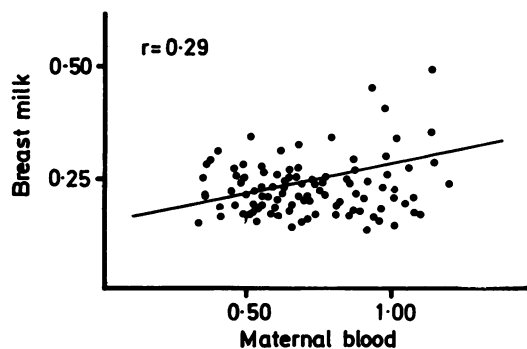


Fig. 2. Correlation of lead concentration ( $\mu\text{mol/l}$ ) in maternal blood and breast milk ( $n=114$ ,  $r=0.29$  ( $P<0.01$ ),  $y=3.72 + 0.13x$ ). Conversion: SI to traditional units—Lead:  $1 \mu\text{mol/l} \approx 20.8 \mu\text{g}/100 \text{ ml}$ .

**Lead content of perinatal milk.** A total of 53 samples of milk were obtained from nine lactating mothers (Table 3). The mean lead concentration in the breast milk of these mothers ( $0.21 \mu\text{mol/l}$ ) was slightly lower than that obtained from the 114 samples from Malaysia ( $0.23 \mu\text{mol/l}$ ).

A two way analysis of variance on the eight subjects with complete data showed that the lead concentrations in breast milk did not vary significantly from three days to over one month postpartum ( $F=0.16$ , NS). There was, however, a significant difference in the content of lead in the milk among the eight perinatal mothers ( $F=7.29$ ,  $P<0.001$ ).

## Discussion

The reported range of blood lead concentrations in occupationally unexposed populations varies from  $0.48 \mu\text{mol/l}$  to  $1.2 \mu\text{mol/l}$ . The concentrations found in the 114 mothers in our study also fell within this range. As all our subjects were residents of an urban setting with similar water supplies and none had any history of occupational exposure or consumption of

liquor or cigarettes, or both, the blood lead concentrations could be considered to be typical for an urban community in Malaysia.

The mean lead concentration of umbilical cord blood that we found was higher than the  $0.29 \mu\text{mol/l}$  observed during winter and  $0.34 \mu\text{mol/l}$  in summer by Rabinowitz and Needleman in Boston<sup>9</sup> and the  $0.4 \mu\text{mol/l}$  observed by Tsuchiya *et al* in Japan.<sup>10</sup> The higher concentrations found among the Malaysian samples could be due to different levels of exposure to dust as Malaysia is known to have high concentrations of lead in the air.<sup>11</sup> In addition, climatic conditions are important. Reports have suggested seasonal variations in the absorption of lead in the blood; a dry summer may increase the exposure to lead.<sup>9 12</sup> It is not surprising, therefore, that samples collected from a warm tropical climate, like Malaysia, showed higher values than samples from temperate countries.

A large range of lead concentrations in milk have been recorded. Murthy and Rhea reported a mean concentration of  $0.58 \mu\text{mol/l}$ <sup>13</sup> and Walker reported 26 parts per billion ( $0.13 \mu\text{mol/l}$ ).<sup>14</sup> The lowest concentration recorded has been  $0.01 \mu\text{mol/l}$ , reported by Kovar *et al*<sup>15</sup> and the highest value 85 parts per billion ( $0.41 \mu\text{mol/l}$ ).<sup>16</sup> The mean lead concentration found in this study was slightly higher than the  $0.14 \mu\text{mol/l}$  reported by Rockway *et al*.<sup>17</sup>

Ryu *et al* showed that maternal blood lead concentrations increased during lactation. This observation together with Barltrop's study, suggest that lead may be released from the skeleton during lactation.<sup>5</sup> We found no significant changes in the lead content of breast milk during one month. The release of lead from the bone may be of no significance to the mechanism of lactation.

Most studies cited confine their measurements to the relation between maternal and umbilical cord blood.<sup>5 10 12</sup> Zaremski *et al* showed that there was a significant correlation between lead in neonates and mothers ( $r=0.8$ ).<sup>12</sup> Rockway examined 39 sets of hair, milk, and blood samples and showed no relation among these three variables.<sup>17</sup> Our study

may be the first to examine the relation among maternal blood, umbilical cord blood, and breast milk. The results show a close correlation between fetal cord blood and maternal venous blood ( $r=0.63$ ,  $P<0.001$ ). This confirms that lead freely crosses the human placenta. The relation between maternal blood and breast milk, however, ( $r=0.29$ ,  $P<0.01$ ) indicates that the mechanism of lactation is more complicated than the passage of this heavy metal across the placenta.

Various studies of lead concentrations in human milk have reported relatively low concentrations,<sup>15 18</sup> and our findings were consistent with this overall picture. Calculation of the intake of lead for the group of infants fed breast milk only was based on the recommendation of Houston *et al.*<sup>19</sup> The estimated intake of lead for the infants included in this study was below the tolerable concentrations proposed by Mahaffey.<sup>20</sup>

The potential effect of the transfer of lead from mother to young infant, however, cannot be discounted. The importance of the quantities transferred to the infants remains unknown. Our results indicate that the placenta offers no noticeable barrier to this transfer. A possible potential health risk could arise from mothers with high blood lead concentrations transferring lead to the suckling infants through breast milk in addition to that already transported through the placenta.

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