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Mercury in Human Colostrum and Early Breast Milk. Its Dependence on Dental Amalgam and other Factors

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Summary

The mercury concentration in 70 breast milk samples (Hg-M) from 46 mothers, collected within the first 7 days after delivery, was determined by cold vapour atomic absorption spectrometry. For comparison, 9 formula milk samples (reconstituted with Hg-free water) were investigated. The Hg-M in the human milk samples ranged from <0.2 to 6.86 µg/L (median 0.37), in the formula milk samples from 0.4 to 2.5 µg/L (median 0.76). The Hg-M in the breast milk samples correlates positively with the number of maternal teeth with dental amalgam. The mean Hg-M of amalgam-free mothers was < 0.2 µg/L, while milk from mothers with 1-4 amalgam fillings contained 0.57 µg/L, with 5-7 fillings 0.50 µg/L and with more than 7 fillings 2.11 µg/L. Hg-M correlated negatively to the day after delivery. Frequency of fish consumption tends to influence Hg-M positively, while the age of the mother shows no significant correlation. In the first 2 to 3 days after delivery some colostrum samples with Hg-M higher than in formula milk were found. Later on, the Hg-concentration in the breast milk was equal or even lower to that in formula milk. The higher Hg burden of infants' tissues from mothers with dental amalgam, as reported previously, must be explained (1) by a prenatal transfer of Hg from the mother's fillings through the placenta to the fetus, followed by a redistribution of this Hg in the body of the newborn, and (2) an additional burden via breast milk. Nevertheless, the comparison of Hg-M in breast and formula milk, the relatively moderate Hg burden in both kinds of milk, and the multiple manifest advantages of breast feeding speak against any limitation of nursing, even for mothers with a large number of dental amalgam fillings.

Keywords: Mercury, colostrum, breast milk, human, dental amalgam, fish-consumption.

Introduction

Recently we showed (3), that the mercury (Hg) concentration in human fetal liver and kidney tissues is correlated with the number of the dental amalgam fillings of the mother. It was proven that Hg from these fillings crosses the placenta. Moreover, in the first year of life of an infant, the Hg-concentration in the brain and in the kidney still correlates with the number of the mother's amalgam fillings. To explain this, breast milk as a second pathway for the Hg transfer from mother to infant was theoretically discussed (4). The design of this former study did not allow clarification of the influence of nursing on the Hg burden of infants. Therefore, in this study the Hg concentrations in human breast milk samples (Hg-M) were determined and the results compared with the

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number of dental amalgam fillings of the mothers and other factors which may influence the Hg-M (day after delivery, fish consumption, age and occupational Hg burden of the mothers).

Materials and Methods

From 46 mothers (age 22 - 39 years, mean 31.4 years) at least one breast milk sample (approximately 5 ml each) was collected on the 2nd to the 7th day after delivery in the I. Gynaecological Clinic of the Ludwig-Maximilians-University of Munich. Additionally, in 24 cases a second milk sample from the same mother was collected on the following day. After cleaning of the breast, the breast milk was squeezed out by hand directly into plastic tubes. The tubes had been previously tested to make certain that they were not contaminated with Hg and did not absorb the element. Until analysis, the breast milk samples were stored at -20°C.

The mothers' dental status and age were recorded (Table 1). The mother were questioned on their fish consumption and the possibility of an occupational burden. All women lived in the area of Southern Bavaria.

For comparison, 9 formula milk samples (Aptamil, Milumil 1, Milumil 2, pre-Aponti Anfangsmilch, Alete Folgemilch, Hipp HA, Hipp Anfangsmilch, Humana Anfangsmilch, Humana HA,) were bought and reconstituted with Hg-free water (i.e. water with a Hg concentration < 0.1 µg/L, the quantitative detection limit of the analytic method).

To determine the Hg concentration, 1.0 ml of the milk sample was digested in PTFE-lined Parr digestors (Klimer, Rosenheim, Germany) with 1.0 ml 65% nitric acid (Suprapur grade, E. Merck, Darmstadt, Germany) at 140 °C for 6 hours. After cooling, the samples were diluted to 10.0 ml with destilled water and the Hg-concentrations determined in duplicate aliquots by Cold Vapour Atomic Absorption Spectrometry (CV-AAS) after enrichment on a gold-platinum net (equipment and parameters: Perkin-Elmer HGA 20, amalgamation mode, purge I 30 s, reaction 10 s, purge II 40 s, cell temp. 200 °C, purge gas N_2, $NaBH_4$-solution 3% in 1% NaOH, Perkin-Elmer AAS 1100 B, EDL-lamp, wl 253.6 nm, slit 0.7nm).

A certified spiked skim milk powder (BCR 150, Commission of the European Communities) was used for validation of the analytical method. Four different reference samples (2 x 200 mg, 2 x 100 mg) were dissolved in 1 ml water and worked up as described above. Hg concentrations (based on dry mass) of 9.0 - 9.5 µg/kg were found (certified 9.4 ± 1.7 µg/kg). Since composition of human colostrum and skimed cow's milk is quite different, 10 different colostrum samples were spiked with either 10 ng Hg^{++} or 10 ng $MeHg^{+}$ per ml and digested and analysed as described above. The recovery was 92 - 103% for Hg^{++} and 90 - 105% for $MeHg^{+}$. The determination limit was 0.2 µg Hg/L milk.

Statistics

All statistics were calculated by SPSS 6.0. "Statistically significant" was defined as a probability of $p \leq 0.05$.

Results

In the reconstituted formula milk samples (n = 9) Hg concentrations between 0.4 µg/L and 2.5 µg/L (median 0.76 µg/L) were found.

In all 70 breast milk samples investigated Hg concentrations (Hg-M) between 6.86 µg/l. (maximum) and below the determination limit of 0.2 µg/L were found. The median of all first samples (n=46) was 0.37 µg/L. An occupational burden was anticipated in one case (a volunteer teaching chemistry), but the Hg-M of this mother was 0.2 µg/L, i.e. in the lowest range. Therefore, an occupational influence was rejected and this case not excluded. For further calculations, the Hg-M of all samples below 0.2 µg/L (n = 28) were set to 1/2 of the determination limit, i.e. 0.1 µg/L.

In the 24 cases where two milk samples had been collected on two consecutive days the Hg-M decreased with time after delivery (Figure 1). The decrease was shown to be significant by an intra-individual pair-wise comparison (Wilcoxon Matched-Pairs Signed-Ranks Test, $p<0.01$.)

To avoid statistical interdependence of some of the values (i.e. in milk samples from the same mother taken on different days) only one milk sample from each mother (n = 46) was taken into account for further statistical analysis (in the case of two samples from one mother the first one).

Hg-M is positively rank-correlated on a significant level to the mother's number of teeth with amalgam (Spearman rank correlation, $r = + 0.55$, $p < 0.001$, Figure 2). The Hg concentration in milk samples from mothers without dental amalgam (median < 0.2 µg/L) is statistically (Mann-Witney U-Test, $p < 0.01$) lower than in for-

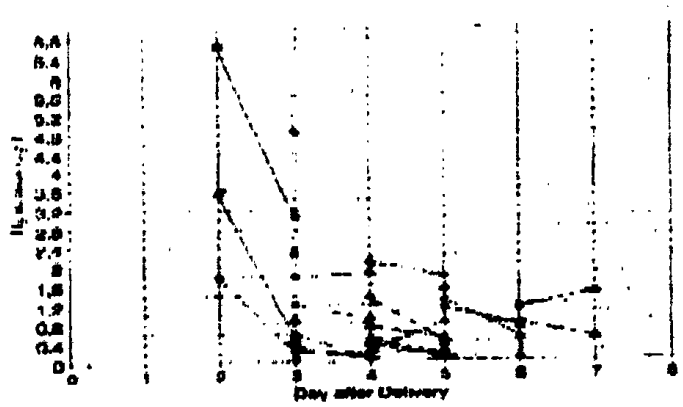

Figure 1. Concentration of mercury in human breast milk in dependence on the day after delivery (consecutive samples from one mother are connected by a line)

mula milk samples (0.76 µg/L), while Hg-M from mothers with more than 7 amalgam fillings is significantly higher (median 2.11 µg/L) than in formula milk ($p < 0.01$). The Hg-M's of the group with 1 - 4 fillings (0.57 µg/L) and 5 - 7 fillings (0.50 µg/L) do not differ statistically from the Hg-M in formula milk (Figure 2).

Furthermore, Hg-M is negatively correlated to the day after delivery ($r = -0.26$, $p = 0.04$) (in contrast to the calculation above this is an inter-individual comparison). From Table 1 can be seen that the dependence on the day after delivery is largely determined by a decline of Hg-M within the first 3 days post partem. If only Hg-M's from day 4 to 7 post partem are correlated to the day after delivery, the result ($r = -0.09$, $p = 0.28$) is no longer statistically significant. Fish consumption frequency tends to

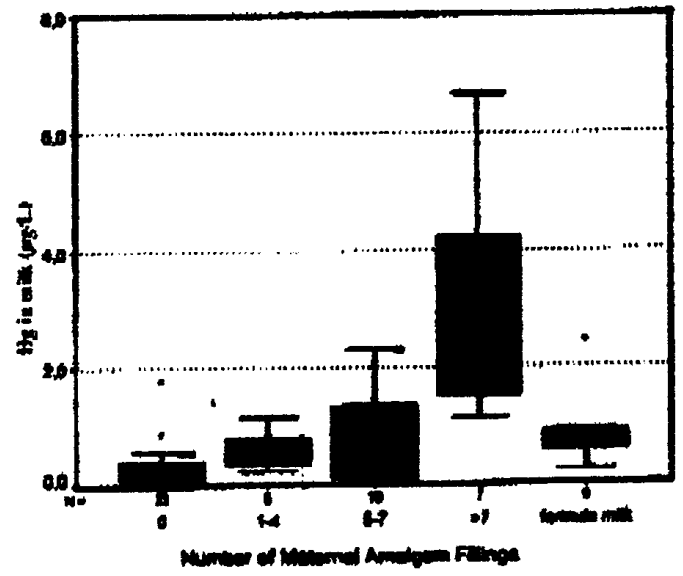

Figure 2. Box-plots of the mercury concentration in human breast milk (first sample of each mother) in dependence on the number of dental amalgam fillings, including a comparison to formula food samples. The mean lines represent the median, the "boxes" the central 50% region, the "whiskers" the total range.

influence Hg-M positively ($r = +0.22$, $p = 0.07$). If only the 23 cases without amalgam fillings were selected, the frequency of fish consumption does not influence the Hg-M at all ($r = -0.03$). In this group without dental amalgam the consumption of salt-water fish results in a higher Hg-M (median 0.39 µg/L, n = 5) than consumption of fresh water fish (median <0.2 µg/L, n = 18). The age of the mother shows no significant correlation with Hg-M ($r = +0.16$, $p = 0.15$).

To compare our results with the literature (7), a linear regression was calculated from the number of dental amalgam fillings of the mother to the Hg-M. The correlation shown by the regression line was statistically significant ($p < 0.03$), but due to the high deviation of the Hg-M's, the confidence interval is extremely large.

Discussion and Conclusion

Our results are in good agreement with previously published data on mercury in breast milk (7,9,10,12).

It was shown, that Hg from the mother's amalgam fillings increases the Hg concentration in human breast milk. This is to be expected, as dental amalgam is known to be the main factor for the Hg burden of men and women, at least in areas with moderate fish-consumption (5). Vimy at el. (12) found a similar dependence of Hg-M from dental amalgam. In contrast with our and Vimy's results a study recently performed in Hamburg, Germany (7) showed no correlation between Hg-M and maternal amalgam fillings. These contrasting results may be due to the fact that the statistical evaluation of the Hamburg data was performed by linear regression analysis only. The non-parametric Spearman rank correlation was chosen by us as the statistical method of choice because of the high deviation and non Gaussian-distribution of Hg-M's. The likelihood that more (Hg-containing) fish is eaten in a harbour town like Hamburg in comparison to South Germany may play an additional but minor role in explaining the contrasting results.

Hg-M decreases with time after delivery. This result is in good agreement with former studies on Hg-M by Negretti de Brätter et al. (9). In our study the evaluation of further changes of Hg-M with time after delivery was limited, because many of the mothers under investigation stopped nursing after the first week. Negretti de Brätter et al. had found 1.33 µg Hg/L mature human breast milk (median value).

In 9 formula milk samples we found an Hg-M from

Table 1. Concentration of mercury in human breast milk (µg/L). The numbers in the row "fish consumption" mean average fish consumption every 1, 2, 4 or 8 weeks.

Case number	Amalgam fillings	Fish consumption	Age of mother	Day after delivery					
				2nd	3rd	4th	5th	6th	7th
1	0	8	25	-	-	<0.20	-	-	
2	0	8	29		0.58	-		-	
3	0	8	28	-		.	<0.20	<0.20	-
4	0	8	29	-	0.26	<0.20	-	-	
5	0	8	30		-	<0.20		-	-
6	0	8	35	-	-	0.41	-		-
7	0	8	36		-	0.24	-	-	
8	0	8	36	-	-	-	<0.20		-
9	0	8	38		<0.20	-	-	-	
10	0	4	32	-	0.35	<0.20	.	-	-
11	0	4	39	-	-	0.50	0.50	.	-
12	0	2	27		<0.20	-	-	-	
13	0	2	35	-	-	.	<0.20	<0.20	-
14	0	1	25	-	-	<0.20	<0.20	-	-
15	0	1	27		.	<0.20	-	-	-
16	0	1	28	-	0.89	-	-		-
17	0	1	29	-	-	.	<0.20	-	-
18	0	1	30	-	-	0.41	<0.20		-
19	0	1	30		-	<0.20	-	-	
20	0	1	31	-	-	<0.20	<0.20	-	-
21	0	1	31	1.78	<0.20	-	-	-	-
22	0	1	32	-	-	<0.20	-	-	-
23	0	1	35	-	-	0.39	<0.20	-	-
24	1	8	26	-	-	-	1.15	0.72	
25	1	2	38	-	-	.	0.24	-	-
26	2	1	33	-	-	0.75	0.45	-	-
27	2	1	36	-	-	-	0.80	-	-
28	4	2	27	-	0.39	<0.20	-	-	-
29	4	1	35	-	-	-	0.37	-	-
30	5	1	26	-	-	<0.20	-	-	-
31	5	1	33	-	-	-	<0.20	<0.20	-
32	6	2	34	0.25	-	0.25	0.81	-	-
33	6	1	29	-	-	1.36	0.37	-	-
34	6	1	30	-	-	<0.20	-	-	-
35	6	1	31	-	<0.20	-	-	-	-
36	6	1	36	-	-	-	-	0.76	0.49
37	7	1	22	-	-	-	1.53		
38	7	1	30	-	-	-	1.30	0.50	-
39	7	1	38	-	2.31	-	-	-	-
40	8	1	28	-	1.23	0.92	-	-	-
41	8	1	30	-	4.89	-		-	-
42	8	1	31	-	-	2.11	1.79	-	-
43	8	1	35	6.68	3.10	-	-		-
44	10	4	35	3.56	0.54	-	-	-	-
45	12	1	36	-	1.82	1.89	-	-	-
46	13	4	33	-	-	-	-	1.13	1.43

< 0.2 µg/L to 2.5 µg/L (median: 0.76 µg/L). It should be noted that in our study the formula milk samples were reconstituted with Hg-free water. At least in some areas the Hg-content in drinking water (up to 4 µg/L are allowed in Germany (11)) will contribute further to the total Hg-M of formula milk, reconstituted with tap water. For comparison, the upper acceptable limit for cow's milk in Germany is 10 µg/L (13). A German manufacturer reported for 13 samples of starting formula and 6 samples of follow-up formula of their company Hg concentrations of < 1 µg/kg (determination limit) to 2 µg/kg dry weight (8).

Some of the breast milk samples showed higher Hg-M's than in the formula samples. With the exception of one sample of colostrum from the 2nd day from an amal-

gum-free mother all other higher Hg M's derived from the mothers with a greater number of fillings (Table 1, Figure 2). Especially the highest Hg-M's in our study decreased markedly within one day. Sternowsky et al. (10) showed that Hg-M decreases from the 2nd to the 5th day, but is stable from the 5th day onward. We obtained a similar result (see above). From our results it could be expected that the Hg concentration in mature milk from mothers with a large number of amalgam fillings (> 7) is in the range 1 to 2 µg/L, while the mean Hg concentration in the mature milk from mothers without fillings should not be higher than in the colostrum of this group, i.e. < 0.2 µg/L. This is a difference of approximately a factor of 10. The Hg concentration in formula milk lies between this two extremes and in the same range as breast milk from mothers with a moderate number of amalgam fillings (1-7).

The higher Hg burden of infants from mothers with dental amalgam, as found by us previously (3), can be explained partly by (1) a prenatal transfer of Hg from the mother's filling through the placenta to the fetus and a redistribution of this Hg in the body of the new-born and (2) by a higher Hg intake from breast milk (if the infant is nursed).

From the toxicological point of view the high Hg-M's in the first colostrum samples are almost negligible, because the quantity of the first colostrum is rather low (< 100 ml). Much more relevant is the further supply of the child: Deriving from a mean daily intake of 850 ml milk by a baby weighing 5 to 6 kg (2), a Hg-M of 0.15 µg/L (mother without fillings) results in a weekly Hg intake of 0.16 µg Hg/kg body weight, while milk with a Hg concentration of 1.5 µg/L (mother with > 7 fillings) results in 1.6 µg Hg/kg/week, and for formula milk (mean Hg-M 0.76 µg/L) in 0.8 µg Hg/kg/week. For comparison: The FAO/WHO committee recommended a PTWI value (provisional tolerable weekly intake) of 5 µg Hg/kg/week (6). Assuming a greater vulnerability of the new-born, especially in the brain and the immune system, it seems questionable whether this PTWI value, primarily established for adults, can be applied to babies. Our results support the recommendation of the German Health Authorities from 1992 to restrict the application of dental amalgam in women before and during child-bearing age for reasons of public health (1). Nevertheless, the proven multiple advantages of breast feeding does not justify a limitation of nursing even for mothers with a large number of dental amalgam fillings.

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