Environmental Health Perspectives
Vol. 15, pp. 135-140, 1976

Mercury in Alaskan Eskimo Mothers and Infants

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The potential danger of natural mercury accumulation in the diet of the Eskimo is evaluated through mercury levels determined in cord blood, placenta, maternal blood, hair, and milk of 38 maternal-infant pairs from Anchorage and the Yukon-Kuskokwim Delta. Although mercury levels are not discernably dangerous, trends to larger accumulations in maternal and fetal RBC and placental tissue with proximity to the sea and consumption of seals during pregnancy provide the basis for considering possible indicators of neonatal involvement. Mercury level in RBC from cord blood appeared as the best potential indicator of this involvement, although relationships with the mother's diet and level of mercury in the placenta also appear useful. In this area, average and maximal mercury levels in cord blood are 39 and 78 ng/ml, respectively, far below the acknowledged toxic level in infants of these mothers who eat seals or fish every day during their pregnancy.

Introduction

A potential health hazard in remote coastal villages in the arctic and subarctic was recognized when apparently dangerous levels of methyl mercury were found in marine mammals (*1-5*). Food is obtained primarily from the sea in these communities, marine mammals and fish being the major sources. Thus, appreciable amounts of toxic methylmercury are most likely injested in a predominately marine diet, although varying amounts of terrestrial game and commercial food are also available. The body burden of adults, however, indicated by mercury levels in blood, are less than half the level considered dangerous (*6,7*). Furthermore, no record of mercuralism has been reported, even in areas frequented by seals with large apparently natural burdens of mercury (*5*). The larger risk for the developing child exposed to the combined effects of methylmercury from the mother's placenta and milk (*8,9*) have not been evaluated, however.

The Yukon-Kuskokwim Delta, where elevated mercury levels are found in people and seals (*4,7*) is the site of this study (Fig. 1). The potential neonatal involvement associated with the consumption of native foods during pregnancy is evaluated through the mercury content of cord (infant) and maternal blood, milk, and placental tissue.

Materials and Methods

Thirty-eight Eskimo mothers entering the hospitals for childbirth in Anchorage and Bethel were selected according to their residence in urban Anchorage, and interior and coastal villages on the Yukon-Kuskokwim Delta. Samples of cord (infant) blood and placental tissue taken during the delivery and maternal venous blood, hair, and milk taken a few days after the delivery were collected with the mother's consent. Infant weight and vital signs (Apgar score) at birth were obtained from physician's records. Consumption of seal meat and oil, fish, shore birds, and shellfish during pregnancy were recorded by using a standard questionnaire during an interview by a registered nurse.

Blood plasma and cells were separated by centrifugation, and cells were washed three times with mercury-free saline to remove plasma.

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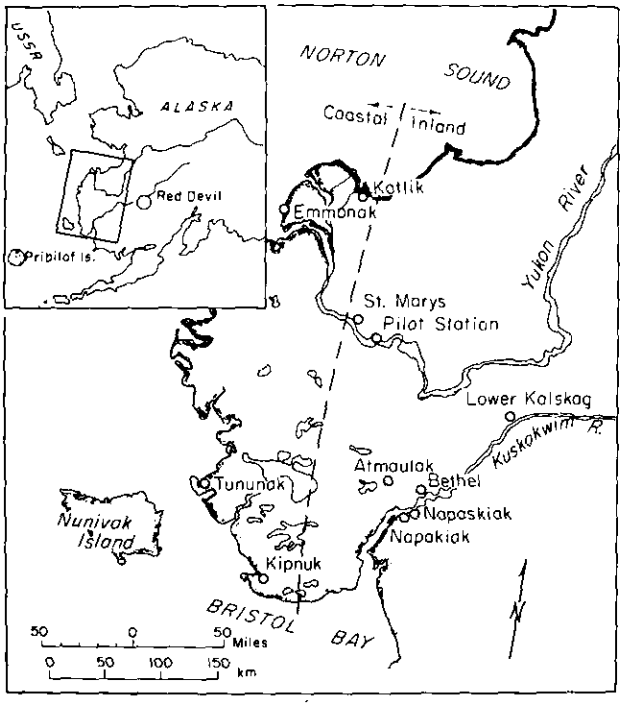

FIGURE 1. Map of area where mother-infant pairs live; interior and coastal regions on the Yukon-Kuskokwim Delta.

Placental tissue was homogenized to obtain a representative sample and hemoglobin, as cyanmethemoglobin, was determined spectrophotometrically in extracts to estimate the contributions of mercury from red cells (*10*). Lengths of hair equivalent to a year's growth (30 cm) were collected by thinning the hair, dividing it into four equal portions, and washing it according to the procedure of Ota (*11*) to remove superficial contamination. Total mercury level in the samples was measured by flameless atomic absorption (*7,12*) after digestion in nitric and sulfuric acid overnight under reflux conditions. A 22-cm length vapor chamber was used to increase sensitivity to 0.5 ng/ml. Duplicate and standard addition analyses in our laboratory and paired analyses by the Environmental Trace Substance Research Center (Missouri) provided analytical control values ± 3%, ± 6%, and + 10% of the expected values.

Significant difference between groups at $p>0.05$ was determined with the Student t test for unpaired values. Relationships between parameters were determined using a one way analysis of covariance. Relationships between the diet and mercury accumulations were determined by grouping the data, determining the discriminating parameter, and calculating the fractional contribution of dietary components with a computer (*13,14*). Shellfish, not eaten by the preponderance of this population, were not included in the statistical analyses.

Results

Mercury levels in red blood cells (RBC) and placental tissue were considered possible indicators of fetal involvement with the mercury in the mother's diet when larger levels in maternal infant pairs were found in mothers living close to the sea (Table 1). Average RBC and placental mercury levels are two to four times larger in both mothers and infants from the Yukon-Kuskokwim Delta than from Anchorage. Additional increases of average mercury levels of RBC from mother and infant appear on comparison of the respective levels from the interior and coastal villages on the delta. A similar trend to high mercury levels appears in the placentas of women from the coast, but the difference is insignificant ($p<0.05$) when compared with the small samples from the interior. Four fifths of the total blood mercury is found in the RBC of both the mother and infant with substantially more appearing in the relatively small plasma levels of mothers and infants from the delta than from Anchorage. No consistent pattern can be seen in mercury accumulation in maternal milk, average levels in women from Anchorage and the interior delta are similar and about half those of mothers from coastal villages. Expected seasonal trends and differences in the mercury levels in hair were not found even in average levels of the three groups. Involvement of the newborn with mercury were not evident in either their weight or vital signs (Apgar score) just after birth.

The frequency of seal oil consumption during pregnancy is the discriminating factor in the diet separating these women into five distinct groups where a trend to higher average maternal and infant RBC levels is seen in Table 2. Although seal meat and fish seemed more logically involved, this relationship could not be altered by the appropriate weighting of the data to consider the usual practice of dipping food in seal oil. None the less the marine diet and most likely seals are implicated as the source of this mercury. Thus, levels can be predicted in the mother's RBC with fair confidence ($r=0.81$) in Figure 2 by considering how frequently she consumes the various marine foods. The fetus appears to concentrate the mer-

Table 1. Mercury accumulated in maternal-infant pairs.[a]

	Coastal	Interior	Urban
Maternal Hg levels			
Plasma, ng/ml	5.8 ± 0.7(16)	5.0 ± 0.8(11)	2.6 ± 0.3(10)[c]
RBC, ng/ml	33.5 ± 5.1(17)	22.6 ± 3.0(11)[b]	8.9 ± 0.9(10)[c]
Milk, ng/ml	7.6 ± 2.7(11)	3.2 ± 0.8(5)[b]	3.3 ± 0.5(5)
Hair, μg/g	4.257± 0.621(12)	3.574 ± 0.740(6)	4.045 ± 0.796(4)
Placenta, ng/g	38.9 ± 5.1(8)	30.7 ± 14.8(3)	11.6 ± 1.3(7)[c]
Infant parameters			
Plasma Hg, ng/ml	4.5 ± 0.4(17)	5.0 ± 0.8(11)	3.3 ± 0.5(10)[c]
RBC Hg, ng/ml	60.2 ± 10.0(17)	32.5 ± 6.0(11)[b]	10.8 ± 1.6(10)[c]
Birth wt, kg	3.306± 0.154(17)	3.576 ± 0.113(11)	3.717 ± 0.423(10)
Apgar	8.4 ± 0.4(17)	9.0 ± 0.4(11)	8.7 ± 0.1(10)

[a] Reported as $X \pm$S.E. (N) The number N is in parentheses.
[b] $p>0.05$, interior vs. coastal.
[c] $p>0.05$ coastal and interior vs. urban.

Table 2. Mercury in infant and maternal RBC grouped according to the mother's diet during pregnancy.

	Group A $N=6$	Group B $N=9$	Group C $N=5$	Group D $N=9$	Group E $N=6$
(Hg) of RBC, ng/ml ± S.E.					
Maternal		13.0 ± 2.5[a]	24.8 ± 2.8	24.7 ± 4.0[a]	50.0 ± 10.6
Infant		17.4 ± 3.3[a]	37.3 ± 4.3	40.3 ± 6.9[a]	94.0 ± 18.4
Native foods eaten, × frequency/yr ± S.E.					
Seal oil	1.9 ± 1.4	38.9 ± 5.2	89.5 ± 34.3	184.7 ± 39.2	395.2 ± 27.9
Seal meat	1.7 ± 1.5	13.8 ± 4.6	24.0 ± 10.0	50.0 ± 17.6	133.8 ± 25.5
Fish	6.7 ± 3.6	73.0 ± 18.1	224.5 ± 26.3	315.4 ± 51.7	458 ± 31.6
Birds	2.6 ± 1.2	9.7 ± 3.0	17.7 ± 3.3	44.2 ± 8.3	57.0 ± 9.8

[a] Significantly different from succeeding group, $p < 0.05$.

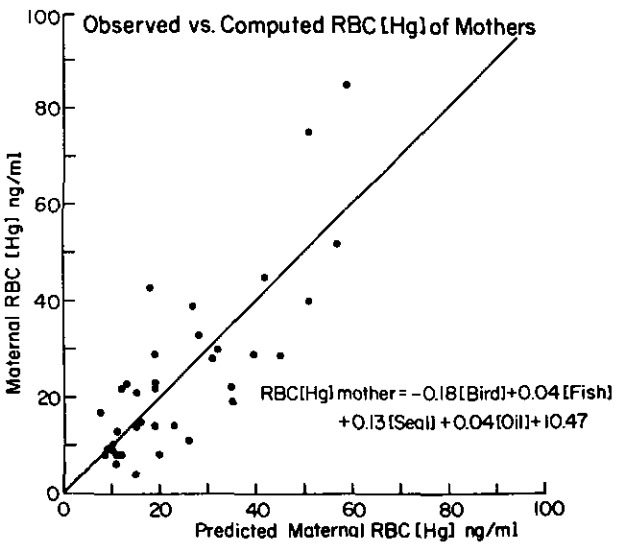

FIGURE 2. Mercury level in maternal RBC predicted from the diet during pregnancy and observed after childbirth. Frequency of marine food consumption is expressed in times per year; $r = 0.81$.

cury from its mother, for the RBC level of the infant is nearly two times (1.8-fold) larger than that of the mothers (Fig. 3). Thus, the fetal involvement with mercury can be anticipated from the mothers' RBC level which reflects in the marine diet during pregnancy. Another indicator of fetal involvement with mercury is found in the placenta which may be easier to examine (Fig. 4). Average mercury levels in placental tissue from women in group E eating seal meat or fish every day are four to five times those from women in groups A-C, who eat marine food less frequently. This relationship is not changed by the presence of blood in the placenta. The mercury level in the placenta correlates well ($r = 0.92$) with the level in the infant RBC and is also a potential indicator of fetal involvement with mercury (Fig. 5).

Discussion

The average mercury level in blood, milk, placenta, and cord blood of Eskimo mothers in Anchorage are about the same as for other

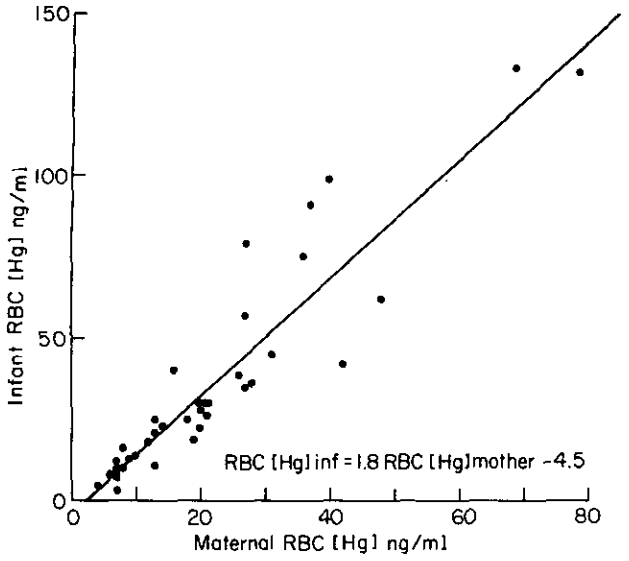

FIGURE 3. Relationship of RBC mercury level in mother and infant cord blood after birth; $r = 0.91$.

women who seldom eat fish (*6,9,10*). Although mercury levels in mother-infant pairs from the interior of the Yukon-Kuskokwim Delta are more than twice the average mercury level of pairs from Anchorage they are only three fourths the blood mercury levels in mothers in Northern Saskatchewan eating mostly fish (*9*). Blood mercury levels of women from coastal villages on the delta, who eat more seal, are greater than three times the mean value of Anchorage women, only half the level of people living near Victoria Island in the Canadian arctic (*5*) who eat seals (*6*) with a large natural accumulation of mercury. Mothers from dietary group E (Table 2) who eat seal oil twice a day and seal meat or fish from on the Yukon-Kuskokwim coast every day have estimated average and maximal levels of 22.7, 37.5, 49.3, and 73.8 ng/ml mercury in maternal and fetal whole blood, respectively, assuming their packed cell volumes are 40 and 50%. Fortunately all these blood levels are well below the 200 ng/ml level considered dangerous by Swedish investigators. The chemical form and presence of selenium, however, have profound effects on the relative toxicity of the mercury in the diet. Methylmercury, which accumulates primarily in RBC, has been identified as the mercurial species involved (*7*), explaining why most of the mercury appears in the infant and maternal RBC (Table 1). Seal oil is implicated as the major source of this mercury; however, the total levels in seal blubber and meat are generally similar (*1*).

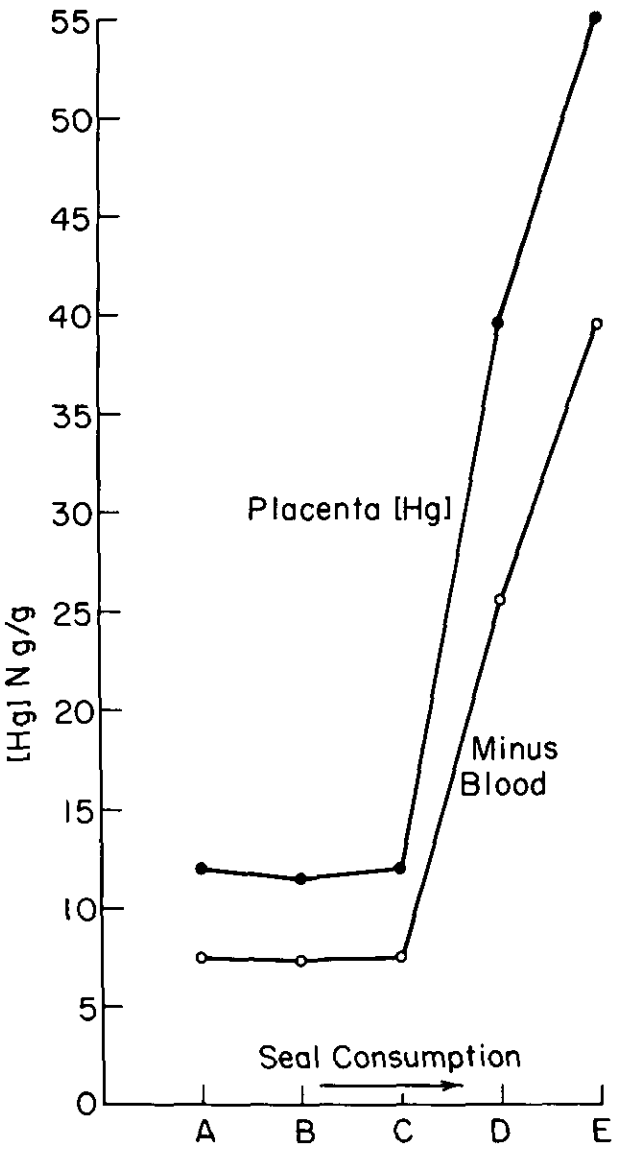

FIGURE 4. Average mercury concentration of women grouped according to their consumption of seals during pregnancy: (•) total mercury concentration; (O) mercury concentration corrected for contamination by maternal blood.

Most likely selenium also present in seals provides some protection from this mercury (*15*). It is evident, however, in this and other studies that the involvement of the human neonate is potentially greater than that of the adult (*8,9,16*).

Predicting the dangerous involvement of the infant is especially important because marine mammals have a propensity for accumulating mercury (*5,16*) and because these species provide

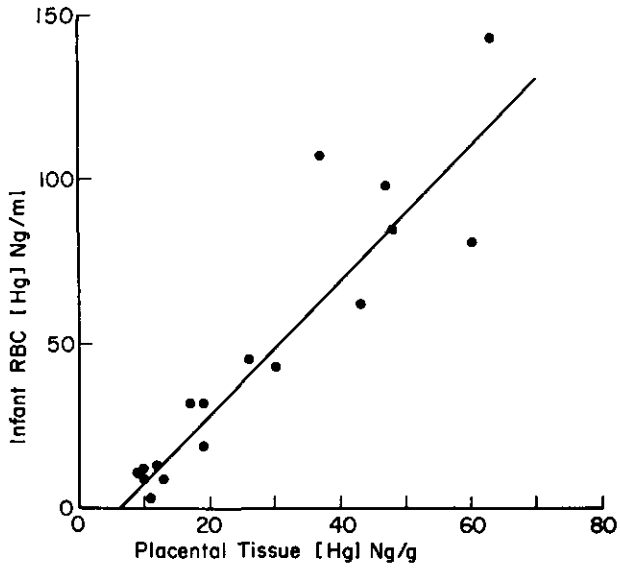

FIGURE 5. Evaluation of total mercury level of the placenta as an indicator of the mercury level in fetal RBC. Infant RBC [Hg] = 2.03 [Hg] placenta = 11.98; $r = 0.92$.

a major source of food in circumpolar regions. The threshold of this involvement appears near a fetal blood level of 550 ng/ml (D. O. Marsh, personal communication) which may also involve some congenital effects (*17*). The probability of attaining such a fetal blood level in this population appears extremely small ($p=10^{-6}$). However, the wide range of levels provides some basis for predicting potential fetal involvement. Evidence in Figure 3 suggesting that methylmercury penetrates the placenta and is enriched in the infant is now well established (*9,18*). The fetal/maternal RBC ratio indicator of placental transfer, however, is 1.8 in this study and only 1.3 in the report of Tejning (*18*), in which women with a much lower blood mercury level were studied. Differences in these ratios suggest placental transfer to the fetus may increase disproportionately as the burden of the mother increases. This burden can be predicted to some extent from the frequency with which marine foods are consumed during pregnancy (Fig. 2), but this is a poor indicator since even in an unpolluted environment large differences exist in the mercury burden in the various tissues and in individual seals (*5*).

A better indicator of fetal involvement may be the placenta, where some mercury apparently accumulates during the pregnancy. Although mercury levels are positively correlated with levels in the infants' blood (Fig. 5) and are elevated in women eating marine foods more frequently (Fig. 4), the placenta did not provide an integration of fetal exposure during the pregnancy. The placenta is a less sensitive indicator than cord blood, even over the low range of mercury levels (Fig. 5). The mother's hair is also a poor indicator of fetal exposure to mercury, at least in this study; however, the infant's hair might better reflect the temporal pattern and total burden of the child. The mercury content of the fetal cord blood RBC appears the best indicator of fetal involvement with methylmercury.

Contributions to the mercury burden of the infant through the mother's milk are also significant and potentially dangerous (*8*). The levels in milk from Eskimo mothers living on the coast are too small to represent any danger for these infants; however, the levels of mercury might be higher if the mothers were allowed to eat their usual diet instead of hospital food.

Micky Isenberg, Medical Epidemiologist from the Alaskan Public Health and Social Service, and Hope Chorney, R.N., provided the logistics necessary for obtaining samples, and Daniel B. Hawkins, Professor of Geology, University of Alaska, provided assistances with statistical evaluation. University of Alaska Sea Grant Program NOAA grant #04-5-158-35 and Alaska Public Health and Social Services provided the financial support.

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