Comparison of Mercury Contents in Maternal Blood, Umbilical Cord Blood, and Placental Tissues

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The mouse placenta has been reported not to act as a barrier to methylmercury; in contrast it blocked the transfer of inorganic mercury and phenylmercury (1, 2). In man, fetal injuries supposed due to methylmercury suggested that methylmercury easily passed through the placenta. The mercury level in the umbilical cord blood of healthy newborns in the Minamata district ranged from 0.24 to 1.42 ppm (3). A comparative study carried out in Sweden (4) showed no substantial difference between the mercury levels in the maternal blood and in the umbilical cord blood from healthy mothers and newborns.

This paper reports a study of mercury levels in maternal blood, umbilical cord blood and placental tissues from women spontaneously delivered at the Obstetrical Clinic of University of Tokyo Hospital in January 1970.

Materials and Methods

Nine paired placenta, maternal blood and umbilical cord blood specimens were collected from women at delivery. Eight women had lived in Tokyo and one in Yokohama. None had a particular exposure to mercury compounds in their history.

The placenta was homogenized and extracted by a solution of 1 N HCl : 2 g of the placenta, which was minced and washed repeatedly by 0.9% NaCl solution, were mixed with 20 ml of 1 N HCl solution in a glass homogenizer and homogenized with a glass pestle. The homogenate was shaken for 60 minutes in a water bath of 37°C, after which it was centrifuged at 3000 rpm for about 10 minutes. The supernatant was separated. The mercury was nearly completely extracted by a repetition of extraction. An aliquot of combined supernatant was oxidized by solutions of conc. H_2SO_4 and 3% $KMnO_4$ at 60°C for 30 minutes. Then, a few drops of

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20% hydroxylamine hydrochloride were added. Finally, the oxidized supernatant was analyzed by the mercury vapor photometry according to Magos and Cernik's method (5).

The blood was heparinized. The red cells and plasma were separately by a centrifugation. One ml of each was oxidized by a mixed solution of conc. H_2SO_4 and conc. HNO_3 in a reflux condenser. The oxidized solutions were neutralized to pH 4 with 30% NaOH and analyzed by the mercury vapor photometry (5).

Results

The results are summarized in Tab. 1 and depicted in Figs. 1 and 2.

The mercury content in the red cell of umbilical cord blood tended to become higher than that in the maternal red cell with an increase of mercury level in the maternal blood (Fig. 1). This same trend was observed in Swedish cases (4). The standard deviation was significantly greater among samples of red cells from umbilical cord blood than among cells from maternal blood ($p < 0.05$). Though the difference was very small, the mercury content of plasma from umbilical cord blood was significantly lower than that from ma-

TABLE 1

Concentration of Mercury in the Maternal Blood, Umbilical Cord Blood and Placenta

Items	Mean	Standard Deviation
Maternal Blood		
Red Cells	22.9 ng/ml	11.9 ng/ml
Plasma	12.4 ng/ml	7.3 ng/ml
Ratio (R.C./P.)	2.1	0.7
Umbilical Cord Blood		
Red Cells	30.8 ng/ml	21.6 ng/ml
Plasma	11.2 ng/ml	7.2 ng/ml
Ratio (R.C./P.)	3.2	1.7
Placenta	71.5 ng/g	27.4 ng/g

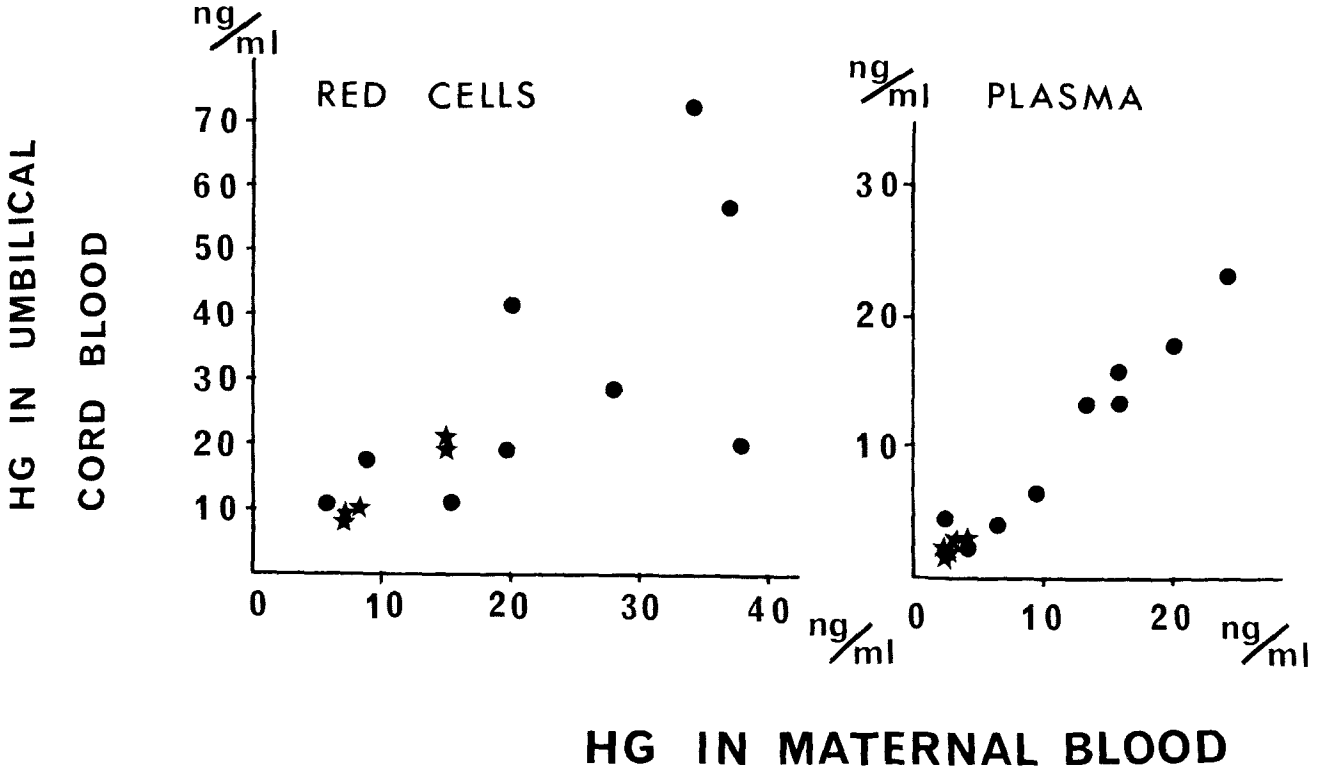

Fig. 1. Relationship of Mercury Contents between Maternal and Umbilical Cord Blood

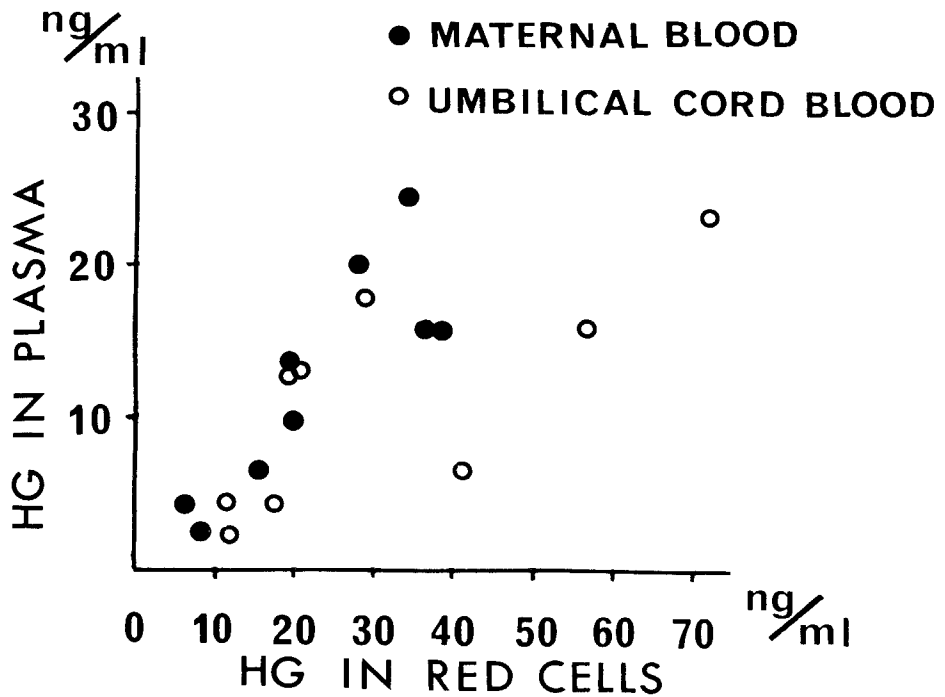

Fig. 2. Distribution of Mercury in the Blood

ternal blood ($p < 0.05$ by Sign test)(Fig. 1).

The mercury content in the placenta was the highest value among the paired specimens. This suggested that mercury accumulated in this organ. The mercury content was correlated with the other paired measurements. The highest correlation coefficient obtained with the mercury content of maternal plasma; 0.597 ($0.10 > p > 0.05$).

The distribution of mercury between cells and plasma was different when maternal and umbilical cord blood were compared (Tab. 1, Fig. 2). The ratio of mercury content in the red cell to that in the plasma was smaller in the maternal blood than in the umbilical cord one.

Discussion

The mercury content in our maternal and umbilical cord blood specimens was clearly higher than that found among Swedish women (4) and in the same range that reported recently by Kitamura et al. on Japanese women in Kobe city (6). In another study (7), it was found that the mercury content of whole blood from Japanese did not differ from the mercury levels in blood from populations of other countries. Considering the level of mercury in the hair of Japanese reported by Hoshino et al. (8), it is probable that the mercury content of the blood from Japanese is higher than in people in other countries. Even so, the values from healthy newborns in Minamata district were too high to be explained simply by some specific contamination in total living environment. Since they used the dithizone method for estimation of mercury, there should exist some technical difficulties in estimation of minute amount of mercury.

The mercury in our specimens can be considered to be mainly methylmercury or alkylmercury by following reasons; (1) the mercury in the hair from lay Japanese population and also the Japanese workers exposed to mercury vapor has been reported to be mainly methylmercury or alkylmercury (9, 10, 11), (2) the ratio of mercury content in the red cell to that in the plasma corresponds to the values already reported in human cases of alkylmercury exposure (11, 12, 13), and (3) the pattern observed in mercury contents in the maternal blood, the umbilical cord blood and the placenta is fairly comparable to that observed in the mouse injected with methylmercury compounds (1, 2). Then, the higher level of mercury in the umbilical cord than in the

maternal blood, especially in the red cell, become importan in the evaluation of toxicity of methylmercury or alkylmercury to the pregnant woman.

Cellular and chemical compositions of the fetal blood are markedly different from those of the maternal blood. Among them, the quantity and quality of proteins are of primary concern, because the proteins; hemoglobin in red cells and plasma protein, have been proved to bind mercury almost exclusively (14, 15, 16). The facts are adoptable as one of the causes which induce the elevation of mercury level in the red cell of cord blood that the hemoglobin level of cord blood is higher than that of maternal one and the fetal hemoglobin is richer in its content of thiol radicals (17). In contrast, the total protein level of the serum in the cord blood is lower than that in the maternal one (18). This may explain the slightly but significantly lowered mercury level in the plasma of cord blood. Besides these differences in protein levels, the contents of lipids in red cells and in the plasma of the cord blood are higher than those in the maternal one (19). Supposing the fetus has a high absorbing capacity to lipids through the placenta, the lipid soluble mercurial such as alkylmercury shall be taken in as much as the lipids.

An accumulation of mercury in the placenta is suggested by the present results. However, the underlying mechanism is not clear. Two possible explanations come to mind: (1) additive contamination due to inorganic or phenylmercury salts and (2) formation of inorganic mercury from methylmercury in the living organism and its accumulation in the placenta. Anyway, it is necessary to know whether the mercury in the placenta is inorganic or organic nature.

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