Estimation of Fetal Exposure to Organochlorines from Total PCBs Levels in Maternal Serum

Mariko Omori-Inoue[1], Hideki Fukata[2], Emiko Todaka[3], Hisao Osada[4], Chisato Mori[5]

[1]Department of Reproductive Medicine, Graduate School of Medicine, Chiba University
[2]Environmental Health Science Project for Future Generation, Graduate School of Medicine, Chbia University, Chiba
[3]Center for Environment, Health and Field Sciences, Chiba University
[4]Division of Maternal-Fetal Medicine, Department of Obstetrics and Gynecology, Chiba University Hospital
[5]Department of Bioenvironmental Medicine, Graduate school of Medicine, Chiba University

Introduction

Organochlorine pollutants have been recognized as environmental pollutants[1]. From the 1950's to 1972, polychlorinated biphenyls (PCBs) were used in a wide variety of industries. In 1968, Yusho (oil disease), was caused by ingestion of rice oil contaminated with PCBs and polychlorinated dibenzofurans (PCDFs), occurred in Japan[2]. Mixture of α-, β-, γ-, and δ-hexachlorocychlohexane (HCHs) and 1,1'-(2,2,2-trichloroethylidene)bis[4-chlorobenzene] (*p,p'*-DDT) was used as organochlorine insecticides from 1940's to 1971 in Japan. Hexachlorobenzene (HCB), which was used as a bactericide and an organic synthetic raw material, has not been registered in Japan. 1,1'-(2,2-Dichloroethylidene)bis[4-chlorobenzene] (*p,p'*-DDE) is a metabolite of *p,p'*-DDT. PCBs, HCB, HCHs, and *p,p'*-DDE are highly resistant to environmental degradation and they are extremely lipophilic[1]. Because of orgnochlorine pollutant persistence and lipophilicity, human exposure continues to be a problem.

Organochlorine pollutants have been detected in maternal serum, cord serum, and the umbilical cord. Organochlorine pollutants cross the placenta reaching the fetus[3-9]. Previous studies suggested that fetal exposure to organochlorine pollutants have adverse effects on development[8]. Some studies suggest that fetal exposure to organochlorine pollutants also have an adverse effect on the reproductive system[8,9]. Other studies suggest that fetal exposure to PCBs have an adverse effect on the neuropsychological development[10-12]. It is believed that the fetus is more sensitive to various chemicals and thus the effects of chemicals may be more serious than in adults[13,14]. In this study, we investigated organochlorine pollutants in maternal serum, umbilical cord serum, and umbilical cord tissue to assess the fetal exposure to organochlorine pollutants in Japan.

Material and Methods

Forty-seven women who planned to undergo a caesarean section in Chiba University Hospital from April 2002 to June 2004 volunteered to participate in our study. The mean age of the mothers was 33 years (range 19-45 years). Prior to the operation, potential participants were informed about the study. Women confirmed their participation by signing a consent form. This study has been approved by the "Congress of Medical Bioethics" of Chiba University.

Maternal blood from 47 women, cord blood from 35 neonates, and umbilical cord tissue from 47 neonates were collected immediately after the delivery. Blood serum samples and umbilical cord samples were analyzed for total PCBs, each PCB homolog, HCHs, HCB, and *p,p'*-DDE. Approximately 4 ml of serum and 20 g of umbilical cord tissue were used. The extracts from both serum and umbilical cord tissue, were analyzed by gas chromatography/mass spectrometry (GC-MS) using a HP-6800 series equipped with a MicromassAutoSpecUltima mass spectrometer (Hewlett Packard).

The data obtained from the samples collected from 47 participants was used for the examination of maternal serum and the umbilical cord, and that from 35 participants was used for the examination of maternal serum, cord serum, and the umbilical cord. The examination of each homolog was performed using data of 35 participants for whom all three kinds of samples were available.

The data analysis was carried out with a personal computer using Microsoft Excel ver. X for Mac. Descriptive statistics were produced for total PCBs and each congener, including the minimum, median, and maximum

concentration levels, and percent detects. Student t-test was performed to test for the overall differences between the groups. A *p*-value of less than 0.05 indicated a significant difference between the groups being tested.

Results and Discussion

1. Analysis of Lipids in the samples

Total lipids in the serum and tissue were quantified. In maternal serum, the total lipid concentration was 0.76±0.13%. In cord serum it was 0.23±0.04%, and in cord tissue it was 0.11±0.02%.

2. Analysis of the total PCBs in the maternal serum, the cord serum, and the umbilical cord

PCBs were detected in all maternal serum, cord serum, and umbilical cord samples. The mean concentration of PCBs on both the wet base and the lipid base was in the sequence maternal serum>cord serum>umbilical cord. On the wet base, there were statistically significant differences between maternal serum and cord serum, maternal serum and the umbilical cord, and cord serum and the umbilical cord, respectively ($p < 0.01$). On the other hand, the 10th percentile, median, and 90th percentile of the total PCBs concentration on lipid base was similar among the three kinds of samples (Table I). Similar findings were reported from Netherlands, where the concentration of PCBs were similar in umbilical cord and maternal serum on the lipid base[4,5]. It shows the possibility that the most part of fetus have PCBs and some of the lipophilic organochlorine pollutants contamination with similar level to adults, especially in the lipid-rich tissue.

Table I. The concentration of total PCBs

	minimum	10th percentile	median	90th percentile	maximum	mean	SD
maternal serum							
(ng/g-lipid)	23	37	71	176	570	103.3	96.4
(pg/g-wet)	190	296	570	1460	5700	834.5*	912.9
cord serum							
(ng/g-lipid)	30	37	65	132	390	87.0	71.4
(pg/g-wet)	56	84	140	288	780	177.3*	127.7
mubilical cord							
(ng/g-lipid)	14	34	69	130	350	81.2	57.6
(pg/g-wet)	16	34	67	140	390	83.9*	63.9

(*p<0.01)

3. Comparison of total PCBs in the maternal serum and total PCBs, HCHs, HCB, and p,p'-DDE in the cord serum and the umbilical cord

On both the wet and the lipid basis, there was a strong positive correlation between the concentration of total PCBs in the maternal serum and that in either the cord serum or the umbilical cord (Fig. 1A). The percentage of each homolog to the total PCBs was similar among the three types of samples (Fig. 1B). It may indicate that PCBs transfer the placenta without specific selection. These data shows that we can estimate the fetal contamination levels and homolog pattern of PCBs from the data of maternal serum.

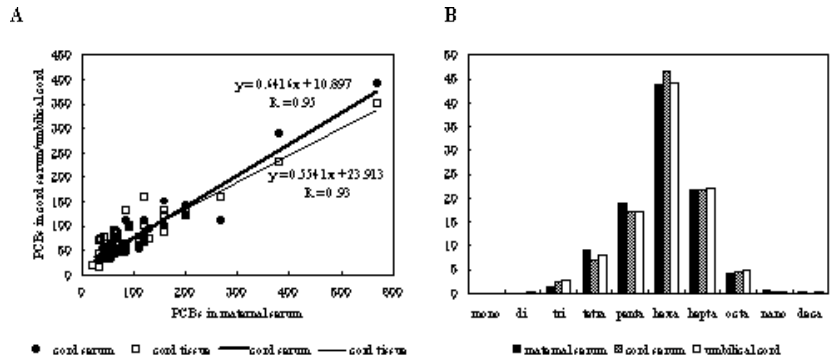

Fig1. (A) The correlation between the concentration of total PCBs (lipid adjusted) in the maternal serum and that in either the cord serum or the umbilical cord. (The slope, intercept and correlation coefficient are shown in the figure.) Similarly, on a total PCB per wet weight of sample, there was a positive correlation between maternal serum and cord serum (y=0.1182x +64.331, R=0.94), and maternal serum and umbilical cord (y=0.0632x +31.176, R=0.90) . (B) The percentage of each homolog to total PCBs. The percentage of each homolog was similar among the three kinds of the samples

As to the other organochlorine pollutants, the detection rate and the mean concentration of HCHs, HCB, and *p,p'*-DDE in the umbilical cord samples were 97.9% and 84.2±116.2ng/g-lipid, 97.9% and 22.0±9.8ng/g-lipid, and 100% and 72.5±46.8 ng/g-lipid, severally. There was a positive correlation between the concentration of total PCBs in maternal serum and the concentration of HCH, HCB, *p,p'*-DDE in umbilical cord (Fig. 2). These data show the possibility that we can estimate the fetal contamination of organochlorine pollutants roughly from the total PCBs level of maternal serum. The high correlation coefficient of HCHs indicates that HCHs transfer the placenta without specific barrier, like PCBs. On the other hand, the correlation coefficient of HCB and *p,p'*-DDE were not very high. It shows that there are different mechanisms of transferring the placenta or metabolism in the fetus depending on each chemical.

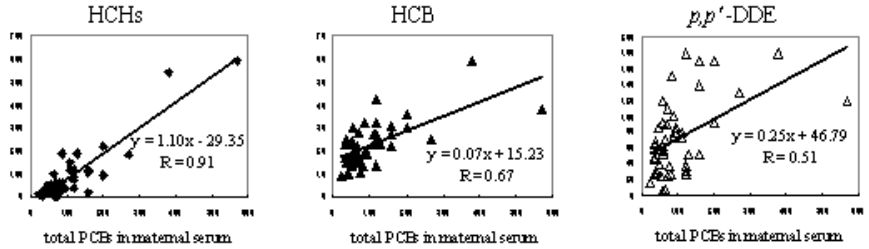

Fig. 2 The correlation between the concentration of total PCBs in the maternal serum and the concentration of HCHs, HCB, and *p,p'*-DDE in the umbilical cord (lipid adjusted). The slope, intercept and correlation coefficient are shown in the figure.

4. Conclusion

Our results show that fetal contamination levels of PCBs and some of the organochlorine pollutants are similar to adults in lipid-rich tissue, and that we could estimate the fetal exposure to PCBs and the other organochlorine pollutants from the total PCBs level in the maternal serum. These findings are very important and useful from the view of public health because an easy estimate of fetal contaminant load can be made from maternal contaminant load. If the contaminant load is know then we can identify the high-risk group in early their life stage and watch their development carefully.

Acknowledgments

This work is supported by the Ministry of Environment of Japan

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