

Effects of perinatal exposure to organochlorine pesticides, PCBs and dioxins on total development in 10-month-old Japanese male and female infants

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Introduction

Organochlorine pesticides such as hexachlorocyclohexanes (HCHs), dichlorodiphenyltrichloroethane (DDT), dieldrin, heptachlor and chlordane, and polychlorinated biphenyls (PCBs) have been banned to use in late 1960s and in early 1970s in Japan, because of their persistence and bioaccumulation in the environment, their appearance in animal and human tissue, and their toxicity. However, these chemicals and their metabolites still have been contaminating our environment, food and human beings ^{1, 2, 3}. Polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and coplanar PCBs (Co-PCBs), highly toxic organochlorine compounds and so-called dioxins, are also determined in human beings ^{1, 3, 4}. Consequently, the chemicals mentioned above and their metabolites have been measured in Japanese breast milk ^{5, 6, 7}, which indicates Japanese mothers are also contaminated with these compounds.

These compounds in Japanese mothers may cause some deleterious effects on the developmental condition of Japanese infants. Therefore, we investigated the relationship between perinatal exposure to the organochlorine pesticides, PCBs and dioxins and the total developmental condition at about 10 months of age in Japanese male and female infants.

Materials and Methods

One hundred twenty-four breast milk samples (50~100 ml each) were obtained at 2 to 4 months after childbirth. These samples were used to determine the concentrations of organochlorine pesticides (HCH, heptachlor epoxide (HCE), chlordane, dieldrin and DDT) and their metabolites, PCBs and dioxins by ECD gas chromatography or high resolution GC/MS method^{6, 7}. Toxic equivalency factor approaches were used for dioxins⁸ and toxic equivalent (TEQ)-sum of all congeners of PCDDs, PCDFs and Co-PCBs detected in the breast milk was summarized as the total TEQ concentration or level. Perinatal exposures to the organochlorine compounds were evaluated by their concentrations in the breast milk on whole weight basis.

At about 10 months of mean age, total developmental condition was assessed using age-specific developmental examination, that is, the Enjohji Scales of Infant Development⁹. The Enjohji consists of three categories and each of them has two indices – the motor developmental category (gross motor and hand skill or fine motor indices), the social ability category (social habit and personal relation indices) and the language developmental category (speech and comprehension indices). Each index is scaled like standard IQs. Testing was carried out at medical checkup in the presence of the mother.

We are studying the relative risks of toxic chemicals to the developmental condition, but not their causality. For this purpose and in order to conduct reliable and robust statistical analysis, the intakes of the organochlorine compounds and the Enjohji Scales were categorized into two groups ; namely, the measurements which were less than the mean and equal to or over the mean in each year set by 0 and 1, respectively. Then, Fisher's exact test was applied to the resulted fourfold tables and odds ratios were computed from the tables by logistic regression to evaluate the relative risks. In this study, less than 10 percent of *p*-value was considered as statistically significant.

Results and Discussion

Concentration on whole weight basis of HCH or DDT was about 100 times higher than that of dieldrin or HCE. Contamination levels of chlordane and PCBs were around 4ng/g and 3 to 5 times less than those of HCH and DDT. In dioxins, the mean concentration was about 1 pg-TEQ/g, which was around 140 times lower than that of dieldrin or HCE.

Respective mean scores of the six indices for the Enjohji Scales of Infant Development are shown in Table 1. Although the Enjohji was originally standardized to a mean of 100 and standard deviation (SD) of 15, our actual means were higher and SDs 16~20. This has also been observed in the Bayley Scales of

Infant Development¹⁰, and may indicate a need for new standards¹¹. This seems to be also the case in the Enjohji Scales, because it was revised at about 23 years ago.

We examined the effects of perinatal exposure to the organochlorine compounds on the motor development, social ability and language development in male and female infants together, as indicated in Table 2. HCH negatively operated on the development of fine motor, social habit and speech at around 10 months of age, and PCBs also on the development of comprehension.

We also examined their effects in male and female infants, respectively and results are shown in Table 3, 4 and 5. In case of motor development, as shown in Table 3, exposure to dioxins and PCBs seemed to more sensitive in female infants than in male infants and disturb the gross motor development only in female infants. Such kinds of effects were also observed in high exposed female infants to dioxins, HCH and DDT and in high exposed male infants to chlordane in the development of fine motor. Table 4 indicates the sexual distinction in effects of the organochlorine compounds on the development of social ability. High exposure to HCH seemed to cause significant negative effects on the development of social habit and personal relation only in female infants, but not in male infants. In the language development, however, high exposure to PCB caused male infants, but not female infants, to be backward on the development of comprehension, as shown in Table 5.

Taking all the results mentioned above in consideration, we could say high exposure to some organochlorine compounds examined in the work caused Japanese infants to be backward in the developments of motor, social ability and language, and their negative effects on the development may differ by sex.

Table 1. Enjohji Scales of Infant Development scores at about 10 months of age in 106 Japanese infants

Developmental Category					
Motor		Social		Language	
Gross motor	Fine motor	Social habit	Personal relation	Speech	Comprehension
116.6 ± 16.3	116.7 ± 18.2	115.9 ± 19.3	123.2 ± 19.0	113.5 ± 20.3	114.2 ± 17.5

Entries are means ± standard deviations.

Table 2. Effects of perinatal exposure to the organochlorine pesticides, PCBs and dioxins on whole weight basis on Enjohji Scales of Infant Development (p -value<0.20)

Compound	Odds Ratio	p -value
< Motor Development >		
Gross motor		
Dioxins	0.51	0.19
HCH	0.46	0.13
Fine motor		
HCH	0.35	0.06
Dieldrin	2.36	0.11
Chlordane	0.48	0.12
< Social Ability >		
Social habit		
HCH	0.22	0.02
Dieldrin	0.49	0.17
Personal relation		
DDT	0.42	0.13
< Language Development >		
Speech		
HCH	0.39	0.10
Comprehension		
HCH	0.51	0.15
PCBs	0.34	0.03

Boldface shows statistically significant compound (p <0.10)

In this analysis, the measurements which were less than the mean and equal to or over the 75 percentile point in each year set by 0 and 1, respectively.

Table 3. Sexual distinction in effects of perinatal exposure to the organochlorine pesticides, PCBs and dioxins on whole weight basis on Enjohji Scales of Motor Development in Japanese male and female infants

Compound	Male Infant		Female Infant	
	Odds Ratio	<i>p</i> -value	Odds Ratio	<i>p</i> -value
< Gross motor >				
Dioxins	0.63	0.26	0.25	0.03
HCH	0.52	0.18	0.42	0.14
DDT	0.45	0.15	0.63	0.33
PCBs	1.14	0.51	0.32	0.06
< Fine motor >				
Dioxins	0.55	0.19	0.37	0.10
HCH	0.63	0.28	0.36	0.10
DDT	0.59	0.23	0.36	0.10
HCE	0.54	0.19	2.13	0.19
Chlordane	0.40	0.08	0.50	0.21
PCBs	0.77	0.41	0.45	0.18

Boldface shows statistically significant compound ($p < 0.10$)

Table 4. Sexual distinction in effects of perinatal exposure to the organochlorine pesticides, PCBs and dioxins on whole weight basis on Enjohji Scales of Social Ability in Japanese male and female infants

Compound	Male Infant		Female Infant	
	Odds Ratio	<i>p</i> -value	Odds Ratio	<i>p</i> -value
< Social habit >				
HCH	0.70	0.35	0.29	0.06
DDT	1.51	0.30	2.25	0.17
PCBs	2.04	0.15	1.08	0.57
< Personal relation >				
Dioxins	1.21	0.45	0.44	0.15
HCH	1.18	0.49	0.31	0.06
PCBs	1.92	0.17	1.08	0.57

Boldface shows statistically significant compound ($p < 0.100$)

Table 5. Sexual distinction in effects of perinatal exposure to the organochlorine pesticides, PCBs and dioxins on whole weight basis on Enjohji Scales of Language Development in Japanese male and female infants

Compound	Male Infant		Female Infant	
	Odds Ratio	<i>p</i> -value	Odds Ratio	<i>p</i> -value
< Speech >				
HCE	0.46	0.14	0.44	0.16
< Comprehension >				
PCBs	0.39	0.07	0.80	0.48

Boldface indicates statistically significant compound ($p < 0.100$)

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