EFFECTS OF EXPOSURE TO ORGANOCHLORINE PESTICIDES, PCBs AND DIOXINS THROUGH HUMAN MILK ON TOTAL DEVELOPMENT IN 10-MONTH-OLD JAPANESE 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].

These compounds in the breast milk may cause some deleterious effects on the developmental condition of breast-fed infants. Therefore, we investigated the relationship between lactational exposure to the organochlorine pesticides, PCBs and dioxins and the total developmental condition at about 10 months of age.

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 dioxins [8] 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. Lactational exposures of the organochlorine compounds were evaluated with individual intakes through the breast milk, which were estimated with multiplying their daily intakes by individual duration of breast-feeding (days).

At about 1 year after birth and 10 months of mean age, total developmental condition was assessed using age-specific developmental examination, that is, the Enjohji Scales of Infant Development [9]. 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 developmental category (social habit and personal relation indices) and the language developmental category (speech and understanding indices). Each index is scaled like standard IQs. Testing was carried out at clinic visits in the presence of the mother(s).

In order to conduct more reliable statistical analysis, data were categorized into two groups according to the intakes of the compounds, which were adjusted for years, and the Enjohji scores, donated by 0 (less than the mean value including minimum one) and 1 (the last quartile including maximum value). Then, we examined the relationship between the Enjohji scores and the lactational exposures of the organochlorine pesticides, PCBs and dioxins by simple logistic regression analysis, and calculated odds ratios. In addition, multiple logistic regression analysis was done to compute the joint effect of every two compounds, each of which showed less than 0.300 of *p*-value in simple logistic regression analysis, on the developmental condition.

Results and Discussion

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 been observed in the Bayley Scales of Infant Development [10], and may indicate a need for new standards [11]. This seems to be also the case in the Enjohji, because it was revised at about 23 years ago.

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	Hand skill Understanding	Social habit	Personal relation	Speech	
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.

Relationship between the Enjohji Scales of Infant Development and exposure to organochlorine pesticides, PCBs and dioxins through breast milk were examined by simple logistic regression analysis and the results are shown in Table 2. Lactational exposures to three compounds, HCE, DDT and dioxins, showed positive effects on the total development. Among them, the effect was significant only in HCE. Like, however, perinatal exposure to these chemicals [12], their effects seemed mostly deleterious and that of DDT was significant on the personal relation index. Taking results of our study concerning their perinatal effects [12] into consideration, their negative influence on the total development at 10 months of age was considered stronger in transplacental exposure than in lactational one.

Table 2. Relationship between Enjohji Scales of Infant Development scores and lactational exposure to organochlorine pesticides, PCBs or dioxins by simple logistic regression analysis (p-value<0.250)

Response Variable (Enjohji Scale)	Exposure Variable (Odds Ratio, p-value) Organochlorine pesticides, PCBs and Dioxins
Motor Development	
Gross motor	Dieldrin (0.66, 0.146)
Hand skill	HCH (0.71, 0.217), **HCE (1.63, 0.068)**, Chlordane (0.66, 0.160) PCBs (0.72, 0.243)
Social Development	
Social habit	HCH (0.62, 0.124), DDT (1.43, 0.208)
Personal relation	HCH (0.64, 0.134), Dieldrin (0.66, 0.134), **DDT (0.60, 0.100)**
Language Development	
Speech	Dioxins (1.41, 0.201)
Understanding	—

Boldface shows statistically significant exposure variable (p-value<0.100).

Table 3. Joint effects of two compounds exposed through breast milk on Enjohji Scales of Infant Development scores by multiple logistic regression analysis

Response Variable (Enjohji Score)	Exposure Variables (Organochlorine pesticides, PCBs and Dioxins) X_1	X_2	Odds Ratio	p-value
Motor Development				
Gross motor	—	—	—	--
Hand skill	Dioxins (0.92)	Chlordane (0.66)	0.60	0.300
		HCH (0.65)	PCBs (0.76)	0.50
	0.200			
	Chlordane (0.50)	**PCBs (0.86)**	**0.43**	**0.070**
Social Development				
Social habit	**HCH (0.59)**	**Dieldrin (0.64)**	**0.38**	**0.071**
Personal relation	HCH (0.83)	Dieldrin (0.57)	0.47	0.110
	HCH (0.73)	DDT (0.60)	0.44	0.116
Language Development				
Speech	—	—	—	--
Understanding	—	—	—	--

Number in parenthesis is odds ratio of the single compound.
Boldface indicates statistically significant joint effect of the two compounds (X_1, X_2) at p-value less than 0.100.

Joint effects of two compounds were also studied by multiple logistic regression analysis and the results are indicated in Table 3. Combination of chlordane and PCBs showed more negative profound effect on the hand skill index than each of them did. A negative joint influence of HCH and dieldrin is also observed on the social habit.

Although greater amounts of these compounds are transferred via nursing than via placental passage, transplacental exposure to PCBs was associated with lower psychomotor scores at both 6 and 12 months of age [13] and has a small negative effect on the neurological condition in 18 month-old toddlers [14]. In addition, they could not detect deleterious effects of lactational exposure to PCBs and dioxins [14], or to PCBs and DDE, metabolite of DDT [13]. In this study, however, some organochlorine compounds showed negative joint effects on the total developmental condition, except the language development, at about 10 months old Japanese infants.

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