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Polychlorinated Biphenyls in Taiwanese Primipara Human Milk and Associated Factors

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Halogenated aromatic hydrocarbons such as polychlorinated biphenyls (PCBs) are lipophilic, anthropogenic, and toxic chemicals (Abraham et al. 1999). PCBs had been used in various commercial mixtures, such as transformers, capacitors, non-flammable oils, heat transfer media and paints. These organochlorine compounds persist in the environment and enter the food chain. After consumption, they accumulate in fatty tissues of animals and humans (Gladen et al. 1999). Because of the high lipid contents in human breast milk, PCBs are found in human breast milk leading to serious health concerns (Hooper et al. 1997).

Human exposed to PCBs could induce various adverse health effects including teratogenicity, immunotoxicity, endocrine effects, reproductive effects, dermal toxicity, and carcinogenicity (Gladen et al. 1999). PCBs contamination of human breast milk was reported to alter the infant's neurological developments (Walkowiak et al. 2001). The aim of this study is to determine the background levels of PCB congeners and compare them to the World Health Organization (WHO) defined toxic equivalency (TEq) in maternal milk. We also tested the adequacy of using concentrations of indicator PCBs as markers of total and dioxin-like PCBs in Taiwanese human milk.

MATERIALS AND METHODS

Subjects were 30 primipara mothers without clinical complications between the ages from 20 to 35. Human milk was collected approximately two weeks after delivery in 2001 in Chung Shan Medical University Hospital located in Taichung.

The analytical methods, described elsewhere (WHO/EURO 1995), were used in the present study for analyses of human milk samples. Milk samples were collected by breast milk pumps, transferred to glass jars for storage, stored at –20°C refrigerator, centrifugated and separated, extracted, depolarized, and concentrated before analyses. The extract was identified and quantified by high resolution gas chromatograph and high resolution mass spectrometry (HP5890

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Series II/ VG-AutoSpec). Native dioxin-like PCBs and indicator PCBs as authentic standards were purchased from AkkuStandard Inc., New Haven, USA and LGC Promochem, Wesel, Germany, respectively. Two isotope masses are measured for each component. The quantification was carried out by using internal/external standard mixtures via isotope dilution method. Congener-specific dioxin-like PCBs (WHO-TEq) including non-ortho (PCB 77, 81, 126, 169) and mono-ortho (PCB 105, 114, 118, 123, 156, 157, 167, 189) groups and indicator PCBs (PCB 28, 52, 101, 138, 153, 180) were measured. Spearman correlation and linear regression analysis were utilized to evaluate the association of PCBs levels and mother's and infant's parameters by SPSS software.

RESULTS AND DISCUSSION

Table 1. General characteristics of pregnant women and their infants (n=30).

Subject characteristics	Min	Max	Mean	SD
Mother				
Age (years)	20.0	35.0	27.8	3.80
Pre-pregnant BMI (kg/m^2)	17.6	25.8	20.4	2.67
Perinatal BMI (kg/m^2) at 38 week	22.4	33.3	26.4	2.71
Increment of BMI (kg/m^2)[a]	3.58	10.9	5.97	1.47
Baby				
Gestational age (weeks)	35	42	39	1.47
Birth weight (g)	2400	3700	3140	278
Birth length (cm)	48.0	54.0	51.3	2.13
Head circumference (cm)	30.5	35.0	33.1	1.19
Chest circumference (cm)	29.0	35.0	33.0	1.10
Age at milk collection (days)	1.00	23.0	9.00	6.41
Lipid content (%)	0.890	5.79	2.92	1.27

[a] Increment of BMI = perinatal BMI - pre-pregnant BMI

Data on mother's age, mother's Body Mass Index (BMI), infant's weight and human milk lipid content are summarized in Table 1. PCBs were measured in 30 human milk specimens with duplicate measurements for each specimen. The concentrations of PCB congeners in breast milk were measured and transferred to PCB-TEqs in accordance to the WHO-TEq system (Van den Berg et al. 1998). The mean PCB-TEq level of dioxin-like PCB congeners for human milk samples was 4.87 pg-TEq/g-lipid (SD = 1.85 pg-TEq/g-lipid) (Table 2). The measurement of PCB 77 and 123 were not taken into account because their detected profiles were almost below method detection limits (MDL). PCB 126 (non-ortho PCB) and PCB 156 (mono-ortho PCB) were found to be predominant compounds comprising 49.3% and 23.1% of the total PCB-TEqs, respectively. The PCB-TEq levels of non-ortho PCB were 1.19 times higher than the PCB-TEq levels of mono-ortho PCB. The total TEq levels of PCBs in our study were slightly lower than those in the Korean study (Yang et al. 2002)

Table 2. WHO-TEq PCB levels of human milk in Taiwanese primipara women (n=30).

PCB Item	N<MDL [a]	Mean (pg-TEq/g-lipid)	Min (pg-TEq/g-lipid)	Median (pg-TEq/g-lipid)	Max (pg-TEq/g-lipid)	SD (pg-TEq/g-lipid)
3,3',4',4-TCB (PCB 77)	28	<MDL	<MDL	<MDL	0.001	NA
3,4,4',5-TCB (PCB 81) [b]	3	0.00016	<MDL	0.00014	0.0003	0.00008
3,3',4,4',5-PeCB (PCB 126)	0	2.40	0.912	2.25	3.84	0.971
3,3',4,4',5,5'-HxCB (PCB 169)	0	0.248	0.136	0.250	0.414	0.0829
Total non-ortho PCB		2.65	0.749	2.53	5.09	1.03
2,3,3',4,4'-PeCB (PCB 105)	0	0.125	0.044	0.110	0.208	0.0627
2,3,4,4',5-PeCB (PCB 114)	0	0.240	0.066	0.196	0.714	0.159
2,3',4,4',5-PeCB (PCB 118)	0	0.447	0.120	0.413	0.765	0.212
2',3,4,4',5-PeCB (PCB 123)	26	0.0032	<MDL	<MDL	0.017	0.0057
2,3,3',4,4',5-HxCB (PCB 156)	0	1.12	0.399	1.07	2.06	0.511
2,3,3',4,4',5'-HxCB (PCB 157)	0	0.253	0.097	0.244	0.516	0.116
2,3',4,4',5,5'-HxCB (PCB 167)	0	0.006	0.002	0.006	0.012	0.002
2,3,3',4,4',5,5'-HpCB (PCB 189)	0	0.022	0.003	0.022	0.039	0.011
Total mono-ortho PCB		2.22	0.880	2.25	4.23	0.963
Total WHO-TEq PCB		4.87	1.729	4.87	9.40	8.04

[a] <MDL meant lower than MDL.
[b] Values below the MDL were set to 0 (zero) in calculation of mean and SD.

on comparable ages and analytical technique (Table 3). On the other hand, the total non-ortho (coplanar) PCB-TEqs in the Japanese study (Iida et al. 1999) were higher (3.70 times) than those in our study. However, the distribution and characteristics of TEq levels or concentrations of non-ortho PCB congeners in our study was similar with Japanese study. A comparison between Taiwanese, Korean and Japanese studies in human breast milk, the PCB-TEq levels was summarized in Table 3. Among the substitutant chlorine numbers of polychlorinated biphenyls, five (PCB 105, 114, 118, 123, 126) and six (PCB 156, 157, 167, 169) chlorine numbers contributed 66.0% and 33.4% of the total PCB-TEqs, respectively (Table 2).

Table 3. Residues (pg-TEq /g-lipid) of non-ortho and mon-ortho PCBs in human milk from Taiwan compared to Korea (Yang et al. 2002) and Japan (Iida et al. 1999).

Congener	Taichung Taiwan n=30	Seoul and Inchon Korea n=12	Western Japan Japan n=51
Non-ortho PCBs	2.65	4.74	9.8
PCB 77	<MDL	0.07	0.002
PCB 81	0.00016	NA[a]	NA
PCB 126	2.40	4.65	9.4
PCB 129	0.248	0.03	0.44
Mono-ortho PCBs	2.22	1.96	NA
Total TEq	4.87	6.70	NA

[a]NA is not available.

Six prevalent indicator PCBs, mainly as PCB 28, 52, 101, 138, 153, and 180, were included in our study. These six compounds were considered to be primary indicators of biological PCB burdens (Glynn et al. 2001). In our study, the concentrations of total indicator PCBs varied from 22.1 μg/kg-lipid to 85.5 μg/kg-lipid with a mean of 54.2 μg/kg-lipid (Table 4). Our result showed that indicator PCB concentrations exceeded the dioxin-like PCB concentrations by 3.5 to 8.25 folds and PCB 138, 153 and 180 consisted 97.0% of the total indicator PCBs concentrations in this study. This finding was similar to that reported in the Swedish study (97.3%) (Glynn et al. 2001). The concentrations of six indicator PCB congeners in Taiwanese human milk was similar to those in Swedish human milk, but the total indicator PCBs level (150 ng/g-lipid) of Swedish study (Glynn et al. 2001) was 2.77 times of our study.

Furthermore, high correlation ($r=0.845$, $P<0.001$) was found between total TEq levels and the total concentrations of indicator PCBs in the breast human milk of Taiwanese women (Figure 1). PCB TEq level can be predicted by the concentration of indicator PCB through a linear function.

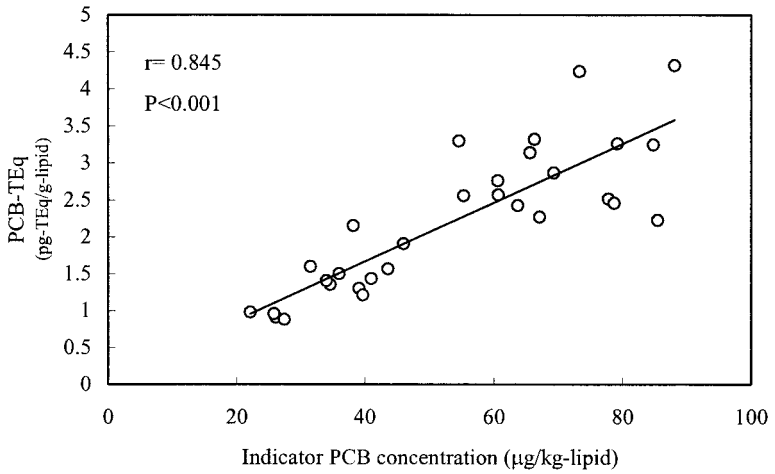

Figure 1. Correlation was between TEq levels of WHO-PCB and concentrations of indicator PCBs.

Table 4. Indicator PCB levels (μg/kg-lipid) of human milk in Taiwan (n=30).

PCB Item	N<MDL	Mean	Min	Median	Max	SD
PCB 28[a]	7	0.843	<MDL	0.900	2.11	0.602
PCB 52[a]	24	0.040	<MDL	<MDL	0.700	0.140
PCB 101[a]	16	0.333	<MDL	<MDL	2.10	0.491
PCB 138	0	17.7	6.90	19.9	30.5	6.42
PCB 153	0	21.2	9.61	21.9	32.4	7.59
PCB 180	0	14.1	5.23	12.2	31.5	7.01
Total		54.2	22.1	55.7	85.5	20.6

[a]Values below the MDL were set to 0 (zero) in calculation of mean and SD.

The linear regression model was "Total PCB TEq level = Indicator PCB concentration * 0.0398 + 0.0775". Similar observation was reported by Glynn et al. (2001) and Koopman-Essebom et al. (1994) for Northern European. It is suggested that the indicator PCB levels may appropriately represent the level of the total PCB-TEqs in Taiwan.

Total PCB-TEqs of dioxin-like PCBs (r=0.475, $p<0.01$) were found to be positively correlated with mother's age, but negatively with pre-pregnant, perinatal and increment of BMI (Table 5). Total indicator PCBs concentrations were also positively correlated with mother's age (r=0.625, $p<0.001$), but negatively with perinatal BMI at 38 week (r=-0.372, $p<0.05$). However, there was no significant association between the percent of lipid

content and the total indicator PCB levels or PCB-TEqs. Similarly, there was no correlation between total PCB-TEqs or indicator PCB concentrations and infant's birth weight, birth length, head and chest circumferences. It is of interest to note that total indicator PCB concentrations were inversely correlated with the pre-pregnant BMI after adjustment of mother's age (r=0.701, $p< 0.001$, β=-2.875). Our study demonstrated that the PCB levels in human milk of normal mothers living in Taiwan were similar to East Asian reports (Japanese and Korean). Infants exposure to dioxin-like PCBs and PCDD/Fs via human milk and body burden of dioxin-like compound mothers will need to be evaluated in the future for Taiwan.

Table 5. Spearman correlation between anthropometrical parameters of mothers or infants and PCB-TEqs or indicator PCBs.

Subject characteristics	PCB-TEqs	*p*	Indicator PCBs	*p*
Mother				
Age	0.475**	0.003	0.625***	<0.001
Pre-pregnant BMI	-0.064	0.710	-0.244	0.152
Perinatal BMI at 38 week	-0.305	0.101	-0.372*	0.043
Increment of BMI	-0.017	0.928	-0.028	0.883
Baby				
Birth weight	-0.276	0.104	-0.214	0.210
Birth length	-0.013	0.941	0.051	0.768
Head circumference	-0.058	0.738	-0.045	0.793
Chest circumference	-0.229	0.178	-0.210	0.219
Lipid content	0.065	0.705	-0.045	0.792

* $p< 0.05$ level ** $p< 0.01$ level *** $p< 0.001$ level

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