INDIVIDUAL PCB CONGENERS AS MARKER SUBSTANCES FOR TEQ CONCENTRATIONS OF PCBs, PCDDs AND PCDFs IN BREAST MILK

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Introduction

Breast milk contains a complex mixture of polychlorinated biphenyls (PCBs), dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) with similar physical properties. The concentrations of PCBs are considerably higher than the PCDD/DF concentrations, making the analysis of PCBs less time consuming and less expensive. A few studies indicate that there are positive associations between concentrations of PCB/DD/DFs in breast milk[1,2,3]. Therefore, the possibility of using single PCB congeners as marker substances for PCDD/DF concentrations in breast milk should be considered, in efforts to simplify the exposure assessment in epidemiological studies on pregnant and nursing women, and their infants. In search for single "marker substances" for dioxin-like PCB and PCDD/DF concentrations in breast milk, we studied the associations between concentrations of single PCB congeners and concentrations of groups of PCDD/DFs and dioxin-like PCBs (expressed as toxic equivalents, TEQs). Breast-milk samples from 27 women (22-35 years) living Uppsala County, Sweden were analyzed.

Materials and Methods

From January 1996 to May 1999, 953 pregnant women from the general population in Uppsala County were recruited as controls in a case-control study of risk factors for early miscarriages. All primiparous women recruited from early fall 1996 and onwards (n=376) were in late pregnancy asked to participate in the breast milk study. Another ten primiparous women from the city of Uppsala, recruited for a special study of concentrations of PCB and chlorinated pesticides in serum during pregnancy, were in late pregnancy also asked to participate in the breast milk study. Finally, at the prenatal clinic in Östhammar, located at the coast of the Baltic Sea, all primiparous women were in late pregnancy asked to participate in the breast milk study (23 women between fall of 1997 to spring of 1999). Of the in all 409 women that were asked to participate, 215 women agreed to sample breast milk during the third week after delivery. PCB was analyzed in all breast milk samples. Twenty-nine samples, which had low or high PCB concentrations, were selected for PCDD/DF analysis.

The procedures for extraction of samples, sample clean-up, separation of the PCBs from the chlorinated pesticides, and quality control were basically the same as described in Atuma et al.[3]. The PCDD/DF analysis was carried out at RIVM, Bilthoven, The Netherlands, using the method described by van der Velde et al.[4]. In the calculation of concentrations of groups PCDD/DFs and dioxin-like PCBs, WHO's toxicity equivalent factors (TEFs) were used[5].

Among the 29 samples selected for PCDD/DF analyses, one sample was omitted because of technical problems during analysis. The results from another sample were not used because the woman had only recently moved to Sweden (a refugee from Bosnia). Therefore, the final statistical analysis included samples from 27 women. Spearman's rank correlation coefficients were calculated for the correlations between serum concentrations of single PCB congeners and PCB/DD/DF TEQ. When correlations between concentrations of single PCB congeners and TEQ were high ($r>0.85$), simple linear regression was performed between the concentrations of the potential marker substance and TEQ. In multiple regression analyses, the influence of age on the associations between concentrations of marker substances and TEQ was studied. The level of significance was in all tests set to $p<0.05$.

Table 1. Concentrations of PCDD/DFs in breast milk collected during the third week after birth of the first child

Compound	Median (pg/g lipid)	range	TEQ median (pg/g lipid)	TEQ range
2,3,7,8-TCDD	0.92	0.28-1.81	0.92	0.28-1.81
1,2,3,7,8-PeCDD	2.55	1.20-4.56	2.55	1.20-4.56
1,2,3,4,7,8-HxCDD	1.25	0.52-2.33	0.13	0.05-0.23
1,2,3,6,7,8-HxCDD	10.05	4.86-21.48	1.01	0.49-2.15
1,2,3,7,8,9-HxCDD	2.24	1.21-6.07	0.22	0.12-0.61
1,2,3,4,6,7,8-HpCDD	18.26	7.09-54.00	0.18	0.07-0.54
OCDD	91.95	33.97-316.52	0.009	0.003-0.032
2,3,7,8-TCDF	0.43	0.15-1.12	0.04	0.02-0.11
1,2,3,7,8-PeCDF	0.20	0.11-0.48	0.010	0.006-0.024
2,3,4,7,8-PeCDF	6.74	2.88-15.55	3.37	1.44-7.78
1,2,3,4,7,8-HxCDF	1.49	0.64-2.69	0.15	0.06-0.27
1,2,3,6,7,8-HxCDF	1.23	0.50-2.38	0.12	0.05-0.24
1,2,3,7,8,9-HxCDF	<0.1	<0.1	<0.01	<0.01
2,3,4,6,7,8-HxCDF	0.61	0.21-1.25	0.06	0.02-0.13
1,2,3,4,6,7,8-HpCDF	1.94	0.72-9.88	0.02	0.01-0.10
1,2,3,4,7,8,9-HpCDF	<0.1	<0.1-0.2	<0.001	<0.001-0.002
OCDF	0.26	0.13-0.97	0.00003	0.00001-0.0001
PCDD/DF TEQ			8.7	4.7-17.4
ΣTEQ			18.9	9.6-35.0

Results and Discussion

The average concentration of PCDD/DF TEQ in the participating women (9 pg TEQ/g lipid; 1996-1999, Table 1)) was within the lower range of average concentrations found in the latest WHO-coordinated breast milk study performed in 1992/93 (4-27 pg TEQ/g lipid)[5]. When looking at ΣTEQ, which also includes the concentrations of dioxin-like PCBs, the average concentrations (19 pg TEQ/g lipid; 1996-1999) in our women was lower than the average concentrations reported from Sweden in 1994 (26 pg TEQ/g lipid)[3], the Netherlands 1990-92 (61 pg/g lipid)[1], Norway 1990 (48 pg/g lipid)[6] and Japan 1996 (28 pg/g lipid)[7].

Table 2. Concentrations of PCB congeners in breast milk collected during the second week after birth of the first child

Substance	Median (ng/g lipid)	range	TEQ median (pg/g lipid)	TEQ range
CB 77	n.q.			
CB 126	0.053	0.016-0.107	5.26	1.64-10.67
CB 169	0.022	0.007-0.054	0.22	0.078-0.54
CB 105	1.42	0.30-14.80	0.14	0.03-1.48
CB 118	12.90	4.60-64.10	1.29	0.46-6.41
CB 156	5.35	1.94-11.50	2.68	0.97-5.75
CB 167	1.36	0.30-2.90	0.014	0.003-0.029
PCB TEQ			8.95	4.25-17.93
CB 28	1.76	<0.60-25.60		
CB 52	<0.6	<0.60-18.90		
CB 101	<0.6	<0.60-29.40		
CB 138	32.4	13.7-93.5		
CB 153	69.3	33.0-186.0		
CB 180	32.4	16.2-83.8		

We found strong correlations (Spearman's rank correlation coeff:>0.85) between the concentrations of PCDD/DF TEQs and the PCB congeners CB 167 and CB 180, between PCB TEQ and CB 126, CB 118 and CB 167, and between ΣTEQ and CB 118, CB 153, CB 167 and CB 180. In linear regression analyses the strongest associations were found between CB 180 and PCDD/DF TEQ (coefficient of determination (R^2) = 0.88), between CB 167 and PCB TEQ (R^2=0.83), and between CB 167 and ΣTEQ (R^2=0.91). Age adjustement did not significantly change these associations (Table 3).

Our results show that single PCB congeners can be used as marker substances for concentrations of groups of PCDD/DFs and dioxin-like PCBs, making the chemical analysis more rapid and less expensive. The strong associations between the concentrations of TEQs and single di-*ortho* PCB congeners with no dioxin-like activity will, however, make it difficult to determine if possible health effects are caused by dioxin-like PCB/PCDD/DFs or by non-dioxin-like PCBs.

Table 3. Multiple regression analysis of the relationships between the dependent variables 'PCDD/DF TEQ concentration', 'PCB TEQ concentration' and 'ΣTEQ concentration' and the independent variables 'PCB congener concentration' and 'age'[a]

	PCB concentration		Age		
	β	p	β	p	R^2
PCDD/DF/TEQ					
CB 156	0.979±0.183	<0.001	0.142±0.124	0.261	0.80
CB 167	2.753±0.582	<0.001	0.218±0.124	0.092	0.77
CB 153	0.062±0.012	<0.001	0.245±0.113	0.040	0.79
CB 180	0.159±0.020	<0.001	0.140±0.090	0.133	0.88
PCB TEQ					
CB 126	0.118±0.017	<0.001	0.368±0.109	0.003	0.82
CB 167	4.542±0.658	<0.001	0.052±0.140	0.713	0.82
ΣTEQ					
CB 126	0.157±0.030	<0.001	0.894±0.194	<0.001	0.80
CB 156	1.913±0.412	<0.001	0.433±0.278	0.132	0.78
CB 167	7.295±0.810	<0.001	0.270±0.173	0.131	0.91
CB 153	0.131±0.025	<0.001	0.565±0.233	0.023	0.81
CB 180	0.287±0.055	<0.001	0.505±0.241	0.047	0.81

[a]Only regressions with coefficients of determination (R^2) >0.75 are presented

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