DIOXIN AND PCB CONCENTRATIONS IN UMBILICAL CORD BLOOD COLLECTED IN HOKKAIDOU, JAPAN

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Introduction

Dioxins including polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), non-ortho coplanar polychlorinated biphenyls (non-orthoPCBs), mono-ortho coplanar polychlorinated biphenyls (mono-ortho PCBs) and PCBs are widespread environmental contaminants. They are accumulated in the human body through the food chain[1]. The effects of dioxins and PCBs present in pregnant women have been of great concern in the field of public health, and there is strong interest in determining the influence of these chemicals on the health of fetuses and infants. In this study, we determined the concentrations of PCDDs, PCDFs, non-ortho PCBs, mono-ortho PCBs and PCBs in umbilical cord blood from 132 mothers living in Hokkaido, Japan. We also investigated the relationship between the total toxic equivalents (TEQ) concentration and total PCB concentration in the umbilical cord blood.

Materials and methods

Umbilical cord blood samples were collected from 132 mothers who had given their informed consent. After collection, the blood samples were stored at -30°C until analyses for concentrations of PCDDs, PCDFs, and dioxin-like PCBs were performed. The extraction of PCDDs, PCDFs, and dioxin-like PCBs from the samples was performed using a previously reported method[2,3]. The concentrations of the PCDDs, PCDFs and dioxin-like PCBs were measured using high-resolution gas chromatography/high-resolution mass spectrometry with a solvent cut large-volume injection system[2,3]. To estimate the TEQ concentration, we introduced ND (less than the detection limit) values to half values of the detection limit and the estimates based on the toxic equivalency factor (TEF) values proposed by the World Health Organization (WHO) in 2005.

The extraction of PCBs from the samples was performed using a previously reported method[3,4]. The PCB concentrations were measured using high-resolution gas chromatography/high-resolution mass spectrometry [4]. To estimate the total concentrations of PCBs, we introduced ND (less than the detection limit) values to half values of the detection limit.

Results and discussion

The arithmetic means of the total TEQ, PCDD, PCDF, non-*ortho* PCB, and mono-*ortho* PCB concentrations of the umbilical cord blood were 5.6, 2.9, 1.2, 1.4, and 0.1 pg TEQ/g lipid, respectively (Table 1). The mean total TEQ concentration of the umbilical cord blood was about 34% lower than that of the blood[5]. The dominant congeners of PCDDs, PCDFs, non-*ortho* PCBs, and mono-*ortho* PCBs in the umbilical cord blood were similar to those in the blood[5]. Of the 209 PCB congeners, 66 were identified in the umbilical cord blood in the present study (Table 2). The arithmetic mean of the total PCB concentration in the umbilical cord blood was 41 ng /g lipid (Table 1). The sum of the ratios of the concentrations of pentaCBs, hexaCBs, and heptaCBs to the total concentrations of PCB congeners in the umbilical cord blood was 82.9%. The hexaCBs ratio in the umbilical cord blood was 46.3%, which was the highest value among those of the other congeners. Among the hexaCB congeners, hexaCB-153, the most abundant congener in the umbilical cord blood, contributed 20.7% to the total concentrations of PCB congeners. Among the PCB congeners measured in the present study, pentaCB-118, hexaCB-138, hexaCB-153, heptaCB-164, and heptaCB-180 also showed high ratios to total concentrations of these PCBs congeners in the umbilical cord blood. The total concentrations of these five congeners in the umbilical cord blood contributed approximately 53.6% of the total concentration of PCB congeners. Other PCB congeners contributed less than 5% of the total concentration of PCB congeners. The total PCB concentration in the umbilical cord blood was about 30% lower than that in the blood[6]. In addition, positive correlations between the total TEQ and the total PCB concentration in the umbilical cord blood were observed (Fig. 1).

Table 1. Concentrations of PCDDs, PCDFs, and dioxin-like PCBs in the umbilical cord blood.

	Umbilical cord blood (n=132, pg/g lipid)				
Congeners	Mean	Median	SD	Min	Max
2,3,7,8-TCDD	0.6	ND	0.3	ND	3.8
1,2,3,7,8-PeCDD	1.4	1.1	1.1	ND	5.0
1,2,3,4,7,8-HxCDD	ND				
1,2,3,6,7,8-HxCDD	4.8	4.1	2.8	ND	15
1,2,3,7,8,9-HxCDD	1.1	ND	0.4	ND	3.7
1,2,3,4,6,7,8-HpCDD	17	16	7.9	5.1	52
OCDD	270	232	142	76	739.2
Total PCDD	296	259	147	92	792.6
2,3,7,8-TCDF	0.6	ND	0.5	ND	5.6
1,2,3,7,8-PeCDF	0.6	ND	0.2	ND	1.9
2,3,4,7,8-PeCDF	2.2	2.0	1.2	ND	6.7
1,2,3,4,7,8-HxCDF	1.0	ND	0.2	ND	2.7
1,2,3,6,7,8-HxCDF	1.2	ND	0.6	ND	4.5
2,3,4,6,7,8-HxCDF	ND				
1,2,3,7,8,9-HxCDF	ND				
1,2,3,4,6,7,8-HpCDF	2.0	ND	4.7	1.0	51.2
1,2,3,4,7,8,9-HpCDF	ND				
OCDF	ND				
Total PCDF	12.6	11.3	5.7	9.5	69
344'5-TCB(#81)	5.1	ND	1.2	ND	18.3
33'44'-TCB(#77)	7.9	ND	15.5	ND	179.8
33'44'5-PenCB(#126)	12	7.5	11	ND	94.3
33'44'55'-HxCB(#169)	6.6	ND	3.7	ND	24.5
Total Non-ortho PCBs	31	26	27	20	307.3
2'344'5-PeCB(#123)	662	572	429	ND	2615.0
23'44'5-PeCB(#118)	119	105	85	ND	380
2344'5-PeCB(#114)	2651	2323	1653	546	10786
233'44'-PeCB(#105)	41	30	42	ND	254
23'44'55'-HxCB(#167)	662	564	392	107	1771
233'44'5-HxCB(#156)	160	130	105	ND	492
233'44'5'-HxCB(#157)	247	204	178	ND	862
233'44'55'-HpCB(#189)	57	40	50	ND	198
Total Mono-ortho PCBs	4598	4043	2715	1164	16651
PCDDs-TEQ	2.9	2.5	1.4	1.4	6.9
PCDFs-TEQ	1.2	1.1	0.4	0.6	3.0
PCDDs/PCDFs-TEQ	4.1	3.5	1.7	2.0	9.3
Non-ortho PCBs-TEQ	1.4	1.0	1.1	0.7	9.9
Mono-ortho PCBs-TEQ	0.1	0.1	0.1	0.0	0.5
Coplanar PCBs-TEQ	1.5	1.1	1.2	0.7	10.4
Total TEQ	5.6	5.0	2.6	2.8	19.7
Lipid(%)	0.19	0.19	0.02	0.14	0.26

CB: chlorinated biphenyl; CDD: chlorinated dibenzo-p-dioxins; CDF: chlorinated dibenzofurans; Hx: hexa; Hp: hepta; ND: less than the determination limit; OCDD: octachlorodibenzo-p-dioxin; OCDF: Octachlorodibenzofurans; PCB: polychlorinated biphenyl; PCDD:polychlorinated dibenzo-p-dioxin;PCDF:polychlorinated dibenzofuran;Pe:penta;TCB:tetrachlorobipheny;TCDD:tetrachlorodibenzo-p-dioxin;TCDF:tetrachlorodivenzofuran;TEQ:toxic equivalent quantity.

TEQconcentrations were computed by using 2005 WHO toxic equivalency factor (TEF) values.

Table 2. Concentrations of PCBs in the umbilical cord blood

	Umbilical cord blood (n=132, ng/g lipid)				
Congeners	Mean	Median	SD	Min	Max
245-TrCB(#29)	0.019	ND	0.023	ND	0.12
244'-TrCB(#28)	0.94	0.89	0.61	ND	5.5
344'-TrCB(#37)	0.97	0.39	1.6	ND	9.2
22'55'-TeCB(#52)	0.53	0.50	0.32	ND	1.7
22'45'-TeCB(#49)	0.13	0.11	0.11	ND	0.56
22'44'-TeCB(#47)	0.16	0.15	0.11	ND	0.53
22'35'-TeCB(#44)	0.28	0.21	0.23	ND	1.2
23'4'6-TeCB(#71)	0.055	0.038	0.058	ND	0.33
234'5-TeCB(#63)	0.041	0.040	0.036	ND	0.19
244'5-TeCB(#74)	1.6	1.5	0.81	0.38	4.0
23'4'5-TeCB(#70)	0.22	0.18	0.18	ND	1.3
23'44'-TeCB(#66)	0.51	0.43	0.41	0.048	3.8
233'4'-/2344'TeCBs(#56/60)	0.13	0.11	0.13	ND	1.0
22'35'6-PeCB(#95)	0.28	0.25	0.18	ND	0.99
22'355'-PeCB(#92)	0.14	0.11	0.12	ND	0.81
22'455'-PeCB(#101)	0.42	0.37	0.27	0.073	1.8
22'44'5-PeCB(#99)	1.5	1.3	0.84	0.27	4.4
234'56-PeCB(#117)	0.16	0.14	0.11	ND	0.73
22'345'-PeCB(#87)	0.15	0.14	0.12	ND	0.77
22'344'-PeCB(#85)	0.051	0.044	0.044	ND	0.23
233'4'6-PeCB(#110)	0.18	0.15	0.19	ND	1.8
233'4'5-PeCB(#107)	0.15	0.12	0.12	ND	0.85
2'344'5-PeCB(#123)	0.041	0.03	0.042	ND	0.25
23'44'5-PeCB(#118)	2.7	2.3	1.65	0.55	11
2344'5-PeCB(#114)	0.12	0.10	0.085	ND	0.38
233'44'-PeCB(#105)	0.66	0.57	0.43	ND	2.6
22'355'6-HxCB(#151)	0.17	0.15	0.16	ND	1.5
22'33'56'-HxCB(#135)	0.067	0.058	0.055	ND	0.31
22'34'56-HxCB(#147)	0.038	0.027	0.037	ND	0.18
22'344'6-/22'34'5'6-HxCB(#139/149)	0.017	ND	0.037	ND	0.26
22'33'56-HxCB(#134)	0.007	ND	0.006	ND	0.041
233'55'6-HxCB(#165)	0.005	ND	0.001	ND	0.016
22'34'55'-HxCB(#146)	1.2	1.1	0.76	0.019	3.6
22'33'46'-HxCB(#132)	0.074	0.054	0.11	ND	0.91
22'44'55'-HxCB(#153)	8.5	7.1	4.7	1.8	23
22'3455'-HxCB(#141)	0.039	0.027	0.045	ND	0.32
22'344'5-HxCB(#137)	0.33	0.29	0.19	0.063	1.0
22'33'45'-HxCB(#130)	0.26	0.21	0.20	ND	0.95
233'4'5'6-HxCB(#164)	2.2	1.9	1.3	0.36	6.2
22'344'5'-HxCB(#138)	4.9	4.2	2.6	0.66	13
22'33'44'-HxCB(#128)	0.13	0.12	0.11	ND	0.63
23'44'55'-HxCB(#167)	0.25	0.20	0.18	ND	0.86
233'44'5-HxCB(#156)	0.66	0.56	0.39	0.11	1.8
233'44'5'-HxCB(#157)	0.16	0.13	0.10	ND	0.49
22'33'566'-HpCB(#179)	0.025	0.013	0.028	ND	0.14
22'33'55'6-HpCB(#178)	0.43	0.36	0.28	0.026	1.3
22'344'56-/22'34'55'6-HpCB(#182/187)	1.8	1.5	1.1	0.41	6.5
22'344'5'6-HpCB(#183)	0.47	0.41	0.29	ND	2.0
22'344'56-HpCB(#181)	0.019	ND	0.081	ND	0.84
22'33'4'56-HpCB(#177)	0.42	0.38	0.29	ND	1.5
22'33'455'-HpCB(#172)	0.16	0.15	0.11	ND	0.50
22'344'55'-HpCB(#180)	3.7	3.2	2.1	0.77	11
233'44'5'6-HpCB(#191)	0.032	0.025	0.031	ND	0.15
22'33'44'5-HpCB(#170)	1.3	1.15	0.75	0.26	3.8
233'44'55'-HpCB(#189)	0.057	0.040	0.050	ND	0.20
22'33'55'66'-OcCB(#202)	0.13	0.11	0.097	ND	0.49
22'33'45'66'-OcCB(#200)	0.017	0.008	0.017	ND	0.078
22'33'45**-OcCB(#201/198)	0.26	0.22	0.18	0.013	0.91
22'344'55'6-OcCB(#203)	0.23	0.19	0.16	ND	0.79
22'33'44'56-OcCB(#195)	0.10	0.08	0.085	ND	0.46
22'33'44'55'-OcCB(#194)	0.39	0.33	0.25	ND	1.1
233'44'55'6-OcCB(#205)	0.013	0.005	0.013	ND	0.073
22'33'455'66'-NoCB(#208)	0.044	0.027	0.044	ND	0.23
22'33'44'566'-NoCB(#207)	0.024	0.016	0.024	ND	0.12
22'33'44'55'6-NoCB(#206)	0.11	0.10	0.091	ND	0.45
22'33'44'55'66'-DeCB(#209)	0.039	0.022	0.045	ND	0.22
Total TriCBs	1.9	1.5	1.7	0.16	11
Total TetraCBs	3.6	3.3	1.6	1.3	10
Total PentaCBs	6.6	5.6	3.4	1.9	20
Total HexaCBs	19	16	10	4.7	49
Total HeptaCBs	8.4	7.3	4.8	1.8	26
Total OctaCBs	1.1	0.92	0.71	0.19	3.3
Total NonaCBs	0.18	0.15	0.13	0.015	0.70
Total DecaCBs	0.039	0.022	0.045	ND	0.22
Total PCBs	41	36	20	13	102
Lipid (%)	0.19	0.19	0.02	0.14	0.26

CB:chlorinated biphenyl, SD:standard deviation

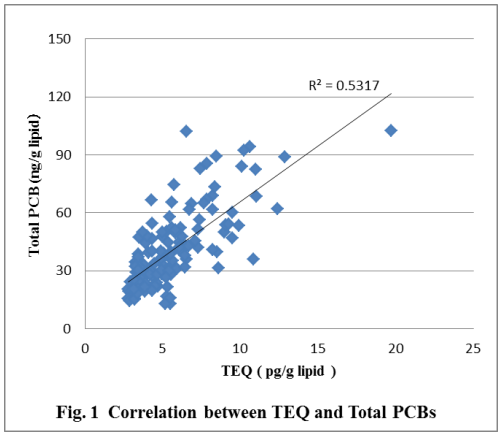

Fig. 1 Correlation between TEQ and Total PCBs

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