CONGENER-SPECIFIC COMPARISON OF 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 234 mothers living in Hokkaido, Japan. We also investigated the relationship between the total toxic equivalent (TEQ) concentration and total PCB concentration in the umbilical cord blood.

Materials and Methods

Umbilical cord blood samples were collected from 234 mothers who had given their informed consent. After collection, the blood samples were stored at -30°C until measurement of the concentrations of PCDDs, PCDFs, and dioxin-like PCBs. 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 5.7, 3.1, 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 maternal 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 maternal 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 concentration of PCBs in the umbilical cord blood was 49 ng /g lipid. The total PCB concentration in the umbilical cord blood was about 30% lower than that in the maternal blood[6]. 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 61.9%. The hexaCBs ratio in the umbilical cord blood was 34.3%, which was the highest value among the congeners. Among the hexaCB congeners, hexaCB-153, the most abundant congener in the umbilical cord blood, contributed 16.4% to the total concentrations of PCB congeners. Significantly positive correlations were observed between the hexaCB-153 and the total PCBs concentration in the umbilical cord blood (Fig. 1). We previously reported our observation of positive correlations between the total TEQ and the total PCB concentration in the umbilical cord blood (Fig. 2). In the present study, we also observed positive correlations between the total TEQ and the hexaCB-153 concentration in the umbilical cord blood (Fig. 3).

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

	Umbilical cord blood (n=234, pg/g lipid)				
Congeners	Mean	Median	SD	Min	Max
2,3,7,8-TCDD	0.57	0.5	0.3	0.5	3.8
1,2,3,7,8-PeCDD	1.5	1.4	1.1	0.5	8.0
1,2,3,4,7,8-HxCDD	1.0	1.0	0.2	1.0	3.3
1,2,3,6,7,8-HxCDD	4.6	4.1	2.6	1.0	15
1,2,3,7,8,9-HxCDD	1.1	1.0	0.4	1.0	3.7
1,2,3,4,6,7,8-HpCDD	21	19	11.0	5.1	64
OCDD	327	289	180	76	1466.2
Total PCDD	357	321	190	92	1533.4
2,3,7,8-TCDF	0.56	0.5	0.4	0.5	5.6
1,2,3,7,8-PeCDF	0.5	0.5	0.2	0.5	2.0
2,3,4,7,8-PeCDF	2.2	2.0	1.2	0.5	6.7
1,2,3,4,7,8-HxCDF	1.1	1.0	0.3	1.0	3.1
1,2,3,6,7,8-HxCDF	1.2	1.0	0.6	1.0	4.5
2,3,4,6,7,8-HxCDF	1.0	1.0	0.0	1.0	1.0
1,2,3,7,8,9-HxCDF	1.0	1.0	0.0	1.0	1.0
1,2,3,4,6,7,8-HpCDF	1.8	1.0	3.7	1.0	51.2
1,2,3,4,7,8,9-HpCDF	1.0	1.0	0.0	1.0	1.0
OCDF	2.0	2.0	0.0	2.0	2.0
Total PCDF	12.4	11.3	4.7	9.5	69
344'5-TCB(#81)	5.1	5.0	0.9	5.0	18.3
33'44'-TCB(#77)	7.2	5.0	11.8	5.0	179.8
33'44'5-PenCB(#126)	12	10.3	10	5	94.3
33'44'55'-HxCB(#169)	6.5	5	3.5	5	24.5
Total Non-ortho PCBs	31	26	22	20	307.3
2'344'5-PeCB(#123)	42	31	46	5	407.1
23'44'5-PeCB(#118)	2419	2141	1563	5	10786
2344'5-PeCB(#114)	110	96	83	5	389
233'44'-PeCB(#105)	611	517	397	5	2615
23'44'55'-HxCB(#167)	240	196	180	5	862
233'44'5-HxCB(#156)	589	503	403	5	1771
233'44'5'-HxCB(#157)	147	123	104	5	492
233'44'55'-HpCB(#189)	50	34	51	5	222
Total Mono-ortho PCBs	2621	2091	2011	40	11939
PCDDs-TEQ	3.1	2.8	1.4	1.4	10.3
PCDFs-TEQ	1.2	1.1	0.4	0.6	3.0
PCDDs/PCDFs-TEQ	4.3	3.9	1.7	2.0	12.5
Non-ortho PCBs-TEQ	1.4	1.2	1.1	0.7	9.9
Mono-ortho PCBs-TEQ	0.1	0.1	0.1	0.0	0.4
Coplanar PCBs-TEQ	1.5	1.3	1.1	0.7	10.1
Total TEQ	5.7	5.2	2.5	2.7	19.4
Lipid(%)	0.19	0.19	0.02	0.13	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

Congeners	Umbilical cord blood (n=234, pg/g lipid) Mean	Median	SD	Min	Max
245-TrCB(#29)	21	5.0	26.59	5	146
244'-TrCB(#28)	818	733.7	607.03	5	5471
344'-TrCB(#37)	617	99.4	1302.51	5	9185
22'55'-TeCB(#52)	510	403.8	386.49	5	2021
22'45'-TeCB(#49)	133	95.9	134.47	5	665
22'44'-TeCB(#47)	167	136.8	141.22	5	706
22'35'-TeCB(#44)	259	190.8	241.10	5	1155
23'4'6-TeCB(#71)	46	21.1	54.49	5	330
234'5-TeCB(#63)	38	36.0	30.40	5	193
244'5-TeCB(#74)	1495	1381.8	773.32	237	4343
23'4'5-TeCB(#70)	212	159.1	191.76	5	1312
23'44'-TeCB(#66)	494	421.0	351.18	48	3842
233'4'-/2344'TeCBs(#56/60)	120	107.3	106.50	5	1005
22'35'6-PeCB(#95)	316	272.7	213.91	5	1497
22'355'-PeCB(#92)	148	126.9	114.95	5	808
22'455'-PeCB(#101)	442	394.2	274.06	5	2021
22'44'5-PeCB(#99)	1503	1294.1	809.06	107	4404
234'56-PeCB(#117)	158	137.1	100.63	5	727
22'345'-PeCB(#87)	153	141.0	115.42	5	775
22'344'-PeCB(#85)	49	38.4	41.51	5	235
233'4'6-PeCB(#110)	175	137.7	173.20	5	1830
233'4'5-PeCB(#107)	146	119.8	116.03	5	853
2'344'5-PeCB(#123)	44	33.6	46.82	5	435
23'44'5-PeCB(#118)	2589	2279.4	1507.77	528	10786
2344'5-PeCB(#114)	119	105.9	81.64	5	389
233'44'-PeCB(#105)	647	568.1	386.36	5	2615
22'355'6-HxCB(#151)	173	145.9	148.69	5	1467
22'33'56'-HxCB(#135)	71	63.5	54.88	5	312
22'34'56-HxCB(#147)	39	29.0	36.91	5	183
22'344'6-/22'34'5'6-HxCB(#139/149)	20	10.5	30.93	5	256
22'33'56-HxCB(#134)	7	5.0	9.33	5	79
233'55'6-HxCB(#165)	5	5.0	2.60	5	29
22'34'55'-HxCB(#146)	1178	980.5	703.34	19	3649
22'33'46'-HxCB(#132)	74	58.3	90.78	5	907
22'44'55'-HxCB(#153)	8065	7009.0	4359.16	416	22984
22'3455'-HxCB(#141)	43	30.8	48.62	5	321
22'344'5-HxCB(#137)	328	292.2	182.02	10	1030
22'33'45'-HxCB(#130)	265	225.4	178.08	5	952
233'4'5'6-HxCB(#164)	2105	1827.2	1183.37	358	6218
22'344'5'-HxCB(#138)	4654	4103.3	2470.04	303	12860
22'33'44'-HxCB(#128)	115	93.3	100.60	5	632
23'44'55'-HxCB(#167)	267	232.5	179.85	5	862
233'44'5-HxCB(#156)	648	545.2	378.83	58	1771
233'44'5'-HxCB(#157)	161	138.2	100.78	5	492
22'33'566'-HpCB(#179)	24	13.2	25.82	5	140
22'33'55'6-HpCB(#178)	425	362.8	268.61	5	1318
22'344'56-HpCB(#182)	1742	1479.6	986.10	368	6497
22'344'5'6-HpCB(#183)	461	409.4	266.32	5	2036
22'344'56-HpCB(#181)	14	5.0	61.28	5	838
22'33'4'56-HpCB(#177)	447	387.7	287.97	5	1525
22'33'455'-HpCB(#172)	170	160.8	109.78	5	504
22'344'55'-HpCB(#180)	3607	3150.6	2045.09	376	10726
233'44'5'6-HpCB(#191)	38	26.4	35.81	5	185
22'33'44'5-HpCB(#170)	1270	1109.3	714.07	82	3795
233'44'55'-HpCB(#189)	53	37.8	49.55	5	222
22'33'55'66'-OcCB(#202)	133	109.0	96.84	5	488
22'33'45'66'-OcCB(#200)	17	5.0	16.89	5	85
22'33'45**-OcCB(#201/198)	354	284.7	257.25	13	1544
22'344'55'6-OcCB(#203)	238	207.8	168.25	5	802
22'33'44'56-OcCB(#195)	94	72.6	80.62	5	463
22'33'44'55'-OcCB(#194)	389	327.5	246.83	5	1433
233'44'55'6-OcCB(#205)	13	5.0	13.97	5	84
22'33'455'66'-NoCB(#208)	38	23.8	40.32	5	230
22'33'44'566'-NoCB(#207)	20	10.7	21.59	5	116
22'33'44'55'6-NoCB(#206)	101	76.6	93.23	5	450
22'33'44'55'66'-DeCB(#209)	35	22.6	39.32	5	216
Total TriCBs	1338	961.1	1511.14	15	10537
Total TetraCBs	3032	2833.7	1582.85	140	10061
Total PentaCBs	5999	5419.3	3325.58	282	19748
Total HexaCBs	16882	14951.0	10328.88	175	49144
Total HeptaCBs	7613	6744.8	4859.81	123	26155
Total OctaCBs	1117	918.0	816.61	35	4510
Total NonaCBs	153	120.2	134.54	15	701
Total DecaCBs	35	22.6	39.32	5	216
Total PCBs	49237	42994.5	31104.40	1747	166629
Lipid (%)	0.19	0.19	0.02	0.13	0.26

CB:chlorinated biphenyl, SD:standard deviation

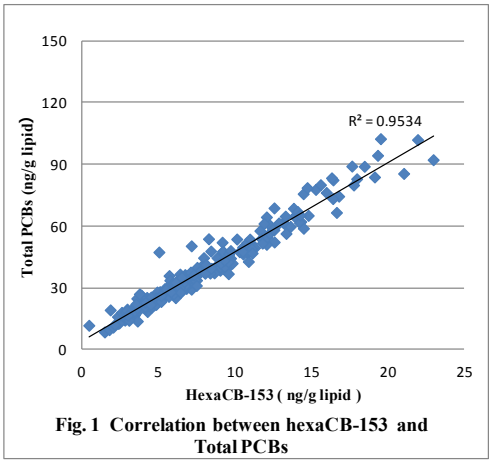

Fig. 1 Correlation between hexaCB-153 and Total PCBs

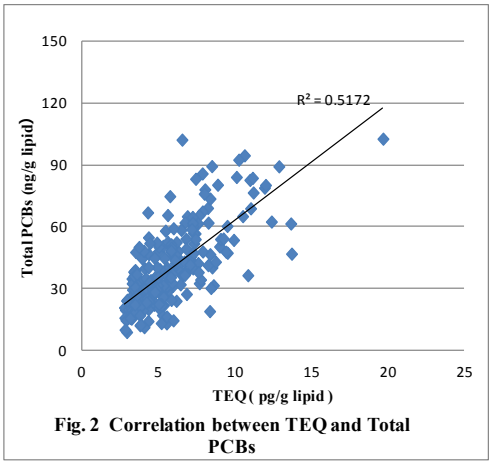

Fig. 2 Correlation between TEQ and Total PCBs

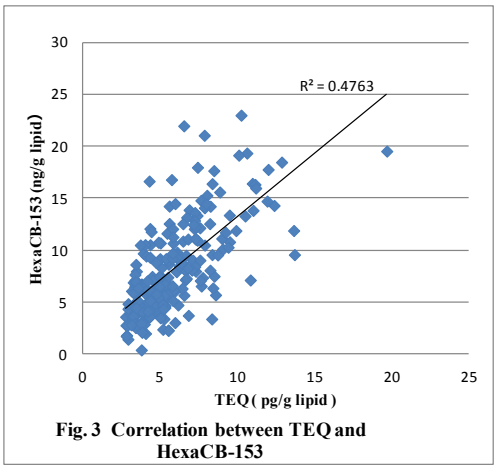

Fig. 3 Correlation between TEQ and HexaCB-153

Acknowledgements
This work was supported in part by a Grant-in-Aid for Scientific Research from the Ministry of Health Labour and Welfare, Japan.

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