

Concentrations of dioxin and related chemicals in blood and breast milk collected from 125 mothers in Hokkaido, Japan

Kajiwara J¹, Todaka T², Hirakawa H¹, Hori T¹, Yasutake D¹, Onozuka D¹, Washino N³, Konishi K³, Sasaki S³, Yoshioka E³, Yuasa M³, Kishi R³, Iida T^{1*}, Yoshimura T¹, and Furue M²

¹Fukuoka Institute of Health and Environmental Sciences, Mukaizano 39, Dazaifu-city, Fukuoka 818-0135, Japan; ²Department of Dermatology, Graduate School of Medical Sciences, Kyushu University, Maidashi 3-1-1, Higashi-ku, Fukuoka-city 812-8582, Japan; ³Department of Public Health, Hokkaido University Graduate School of Medicine, Kita 15, Nishi 5, Kita-ku, Sapporo-city, 060-8638, Japan

* Kitakyushu Life Science Center, 1-4 Nakabarushinmami, Tobata-ku, Kitakyushu-city, 804-0003, Japan

Introduction

Dioxin and related chemicals, including polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), non-*ortho* coplanar polychlorinated biphenyls (non-*ortho* PCBs), and mono-*ortho* coplanar polychlorinated biphenyls (mono-*ortho* PCBs) are known as endocrine disrupters and widespread environmental contaminants. They are accumulated in the human body through the food chain¹ and are present in the blood and breast milk. The effects of dioxin and related chemicals present in the blood of pregnant women and breast milk 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 and mono-*ortho* PCBs in the blood of pregnant women and in breast milk from the same mothers collected between 2002 and 2005 from 125 mothers living in Hokkaido, Japan. We also investigated the relationship between concentrations of PCDDs, PCDFs, and dioxin-like PCBs in the blood and the breast milk.

Materials and Methods

The blood and breast milk samples were collected between 2002 and 2005 from 125 mothers who had given their informed consent. The blood samples were collected from the maternal peripheral vein after the second trimester during their last pregnancy. The maternal milk specimens were collected one month after delivery. The mother's ages ranged from 21 to 47 (mean: 31.3). After collection, the blood and breast milk samples were stored at -30°C until analyses for 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}. 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 total toxic equivalents (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.

Results and discussion

The arithmetic mean total TEQ concentrations of PCDDs, PCDFs, non-*ortho* PCBs, and mono-*ortho* PCBs of the blood and breast milk were 16.1 (median: 14.7) and 10.6 (median: 9.6) pg TEQ/g lipid, respectively, and the concentrations were in the range of 3.4-42.9 and 2.7-41.1 pg TEQ/g lipid, respectively (Table 1). The breast milk mean total TEQ concentration was about 34% lower than that of the blood. The TEQ concentrations of PCDDs, PCDFs, non-*ortho* PCBs, and mono-*ortho* PCBs in the blood were 7.8, 2.8, 5.1, and 0.2 pg TEQ/g lipid, and in the breast milk were 4.5, 1.9, 3.8, and 0.4 pg TEQ/g lipid, respectively. The TEQ concentrations of PCDDs, PCDFs, and non-*ortho* PCBs in the breast milk were 43, 33, and 23 % lower than those in the blood, while the TEQ concentration of mono-*ortho* PCBs in the breast milk was similar to that in the blood. Dominant congeners of PCDDs, PCDFs, non-*ortho* PCBs, and mono-*ortho* PCBs in the blood were similar to those in the breast milk. Significant positive correlations between concentrations of PCDDs, PCDFs, non-*ortho* PCBs, and mono-*ortho* PCBs in the blood and breast milk were observed (Fig.1).

Table 1. Concentrations of PCDDs, PCDFs, and dioxin-like PCBs in the blood of pregnant women and breast milk.

| Congeners | Blood (n=125, pg/g lipid) | | | | | Breast milk (n=125, pg/g lipid) | | | | | Ratio (milk/blood) |
|-----------------------|---------------------------|------|-------|------|--------|---------------------------------|------|-------|------|--------|-----------------------|
| | Mean | SD | Max | Min | Median | Mean | SD | Max | Min | Median | |
| 2,3,7,8-TCDD | 1.0 | 0.6 | 3.1 | ND | 1.0 | 0.6 | 0.3 | 2.8 | ND | ND | 0.61 |
| 1,2,3,7,8-PeCDD | 4.5 | 1.9 | 12 | ND | 4.3 | 2.7 | 1.3 | 8.9 | ND | 2.6 | 0.60 |
| 1,2,3,4,7,8-HxCDD | 1.8 | 1.0 | 5.8 | ND | ND | 1.1 | 0.3 | 3.2 | ND | ND | 0.60 |
| 1,2,3,6,7,8-HxCDD | 15 | 7.5 | 44 | 2.4 | 14 | 8.3 | 4.0 | 25.3 | ND | 7.3 | 0.55 |
| 1,2,3,7,8,9-HxCDD | 2.2 | 1.4 | 7.4 | ND | 2.1 | 1.2 | 0.5 | 3.8 | ND | ND | 0.53 |
| 1,2,3,4,6,7,8-HpCDD | 27 | 11 | 71 | 9.6 | 24 | 5.7 | 3.4 | 23.5 | 2.1 | 5.0 | 0.21 |
| OCDD | 476 | 187 | 1392 | 189 | 432 | 43 | 33 | 251 | 8.2 | 34 | 0.09 |
| Total PCDD | 528 | 204 | 1500 | 211 | 481 | 63 | 40 | 308 | 19.3 | 52 | 0.12 |
| 2,3,7,8-TCDF | 0.8 | 0.4 | 2.5 | ND | ND | 0.5 | 0.2 | 1.9 | ND | ND | 0.70 |
| 1,2,3,7,8-PeCDF | 0.6 | 0.3 | 2.2 | ND | ND | 0.5 | 0.1 | 1.1 | ND | ND | 0.88 |
| 2,3,4,7,8-PeCDF | 6.4 | 3.1 | 20 | ND | 5.8 | 4.5 | 2.3 | 18.5 | ND | 4.2 | 0.71 |
| 1,2,3,4,7,8-HxCDF | 2.6 | 1.5 | 12 | ND | 2.5 | 1.1 | 0.5 | 3.8 | ND | ND | 0.43 |
| 1,2,3,6,7,8-HxCDF | 2.8 | 1.5 | 7.0 | ND | 2.6 | 1.2 | 0.6 | 5.5 | ND | ND | 0.42 |
| 2,3,4,6,7,8-HxCDF | 1.1 | 0.4 | 3.7 | ND | ND | 1.0 | 0.1 | 2.5 | ND | ND | 0.90 |
| 1,2,3,7,8,9-HxCDF | ND | | | | | ND | | | | | |
| 1,2,3,4,6,7,8-HpCDF | 3.0 | 2.9 | 20 | ND | 2.5 | 1.2 | 0.9 | 6.8 | ND | ND | 0.40 |
| 1,2,3,4,7,8,9-HpCDF | ND | | | | | ND | | | | | |
| OCDF | 2.1 | 0.8 | 11.4 | ND | ND | ND | | | | | |
| Total PCDF | 21 | 7.8 | 52 | 9.5 | 20 | 15 | 3.6 | 38 | 10 | 14 | 0.68 |
| 344'5'-TCB(#81) | ND | | | | | ND | | | | | |
| 33'44'-TCB(#77) | 13 | 5.6 | 37.2 | ND | 13.1 | 5.4 | 2.4 | 29.0 | ND | ND | 0.40 |
| 33'44'5'-PenCB(#126) | 42 | 24 | 142 | ND | 35.8 | 34 | 21 | 156 | ND | 29 | 0.81 |
| 33'44'55'-HxCB(#169) | 31 | 16 | 86 | ND | 28.5 | 19 | 10 | 64 | ND | 17 | 0.60 |
| Total Non-ortho PCBs | 91 | 40 | 270 | 27 | 86 | 63 | 31 | 254 | ND | 57 | 0.69 |
| 2'344'5'-PeCB(#123) | 134 | 77 | 459 | 24 | 115 | 113 | 72 | 531 | ND | 99 | 0.84 |
| 23'44'5'-PeCB(#118) | 7060 | 3564 | 18746 | 1325 | 6182 | 7006 | 3936 | 29091 | 1440 | 6219 | 0.99 |
| 2344'5'-PeCB(#114) | 436 | 242 | 1695 | 87 | 405 | 400 | 226 | 1708 | 94 | 361 | 0.92 |
| 233'44'-PeCB(#105) | 1732 | 880 | 5051 | 444 | 1480 | 1712 | 953 | 6952 | 303 | 1542 | 0.99 |
| 23'44'55'-HxCB(#167) | 866 | 433 | 2275 | 159 | 812 | 706 | 427 | 3184 | 169 | 629 | 0.81 |
| 233'44'5'-HxCB(#156) | 2369 | 1169 | 6428 | 441 | 2127 | 2003 | 1145 | 7839 | 419 | 1746 | 0.85 |
| 233'44'5'-HxCB(#157) | 583 | 292 | 1783 | 88 | 527 | 463 | 257 | 1858 | 102 | 406 | 0.79 |
| 233'44'55'-HpCB(#189) | 287 | 135 | 807 | 63 | 269 | 181 | 103 | 671 | 47 | 162 | 0.63 |
| Total Mono-ortho PCBs | 13480 | 6393 | 36266 | 3231 | 12651 | 12583 | 6872 | 51833 | 2762 | 11603 | 0.93 |
| PCDDs-TEQ | 7.8 | 3.2 | 20.8 | 1.7 | 7.2 | 4.5 | 2.0 | 15.0 | 1.3 | 4.1 | 0.57 |
| PCDFs-TEQ | 2.8 | 1.2 | 7.8 | 0.6 | 2.6 | 1.9 | 0.8 | 7.0 | 0.6 | 1.7 | 0.67 |
| PCDDs/PCDFs-TEQ | 10.6 | 4.3 | 27.8 | 2.6 | 9.9 | 6.3 | 2.7 | 22.1 | 2.0 | 5.9 | 0.59 |
| Non-ortho PCBs-TEQ | 5.1 | 2.8 | 16.8 | 0.7 | 4.6 | 3.9 | 2.3 | 17.5 | 0.7 | 3.4 | 0.77 |
| Mono-ortho PCBs-TEQ | 0.4 | 0.2 | 1.1 | 0.0 | 0.4 | 0.4 | 0.2 | 1.6 | 0.1 | 0.3 | 0.99 |
| Coplanar PCBs-TEQ | 5.5 | 2.9 | 17.8 | 0.8 | 4.9 | 4.3 | 2.5 | 19.0 | 0.7 | 3.7 | 0.78 |
| Total TEQ | 16.1 | 6.7 | 42.9 | 3.4 | 14.7 | 10.6 | 4.9 | 41.1 | 2.7 | 9.6 | 0.66 |
| Age | 31.3 | 5.13 | 47 | 21 | 32 | 31.3 | 5.13 | 47 | 21 | 32 | |
| Lipid(%) | 0.38 | 0.08 | 0.72 | 0.26 | 0.37 | 4.26 | 1.39 | 8.37 | 0.85 | 4.14 | |

ND: less than the determination limit; SD: standard deviation.

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

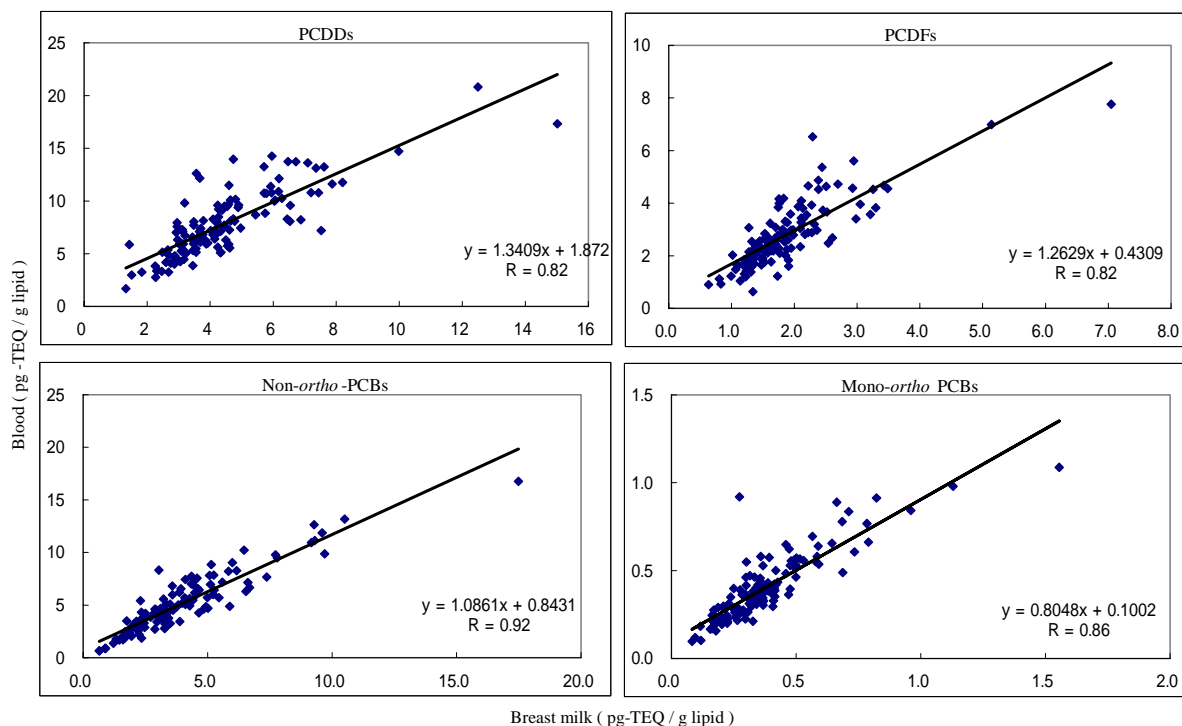


Fig. 1 Relationships between PCDDs, PCDFs, non-ortho PCBs, and mono-ortho PCBs concentrations in blood and breast milk.

These results suggest that PCDDs, PCDFs, non-ortho PCBs, and mono-ortho PCBs accumulated in the blood can be transferred to the breast milk. Mono-ortho PCBs were easily transferred from blood to breast milk, but PCDDs, PCDFs, and non-ortho PCBs were not easily transferred to breast milk. Moreover, the concentrations of 1,2,3,4,6,7,8-HpCDD and OCDD in the breast milk were 5.7 and 43 pg/g lipid (range of 2.1-24 and 8.2-251 pg/g lipid), respectively, and significantly lower than those in the blood. Concentration ratios of each congener of PCDDs, PCDFs, non-ortho PCBs, and mono-ortho PCBs in breast milk to blood tended to decrease with higher chlorinated congeners.

In this study, we measured the concentrations of PCDDs, PCDFs, non-ortho PCBs and mono-ortho PCBs in the blood of pregnant women and breast milk of the same mothers. These results will be used as basic data for the study of the influence of dioxin and related chemicals on the health of fetuses and infants.

Acknowledgment

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

Reference

1. Chen HL, Lee CC, Liao PC, Guo YL, Chen CH, Su HJ. Environ. Res. 2003; 91: 172
2. Todaka T, Hirakawa H, Tobiishi K, Iida T. Fukuoka Igaku Zasshi 2003; 94: 148
3. Hori T, Tobiishi K, Ashizuka Y, Nakagawa R, Todaka T, Hirakawa H, Iida T. Fukuoka Igaku Zasshi 2005; 96(5): 220
4. Iida T, Hirakawa H, Matsueda T, Takenaka S, Nagayama J. Chemosphere 1999; 38(15): 3497