CONCENTRATIONS AND DISTRIBUTION OF PCDDs, PCDFs AND COPLANAR PCBs IN VARIOUS HUMAN TISSUES

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INTRODUCTION

Certain isomers of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) and coplanar polychlorinated biphenyls (PCBs) have been reported to induce the toxic symptoms characteristic of 2,3,7,8-TCDD, including a wasting syndrome, hepatic damage, reproductive toxicity and immunotoxicity. PCDDs, PCDFs and coplanar PCBs have been detected in various biological samples including human adipose tissue, human milk, and such wild-life as fish, and marine and terrestrial mammals.

In this study, specimens of the liver, blood, adipose tissue and brain obtained from seven people (5 males and 2 females; average age, 39 years) who died accidentally were analyzed for concentrations of PCDDs, PCDFs and coplanar PCBs.

METHODS

The human tissue sample: Liver, blood, adipose and brain tissue specimens were collected at autopsy at the Department of Legal Medicine, Faculty of Medicine, Kyushu University, from seven individuals who had died from unnatural cases between 1988 and 1990 in Fukuoka, Japan.

Chemicals: All solvents used were of pesticide reagent grade.

Internal Standard: $^{13}C_{12}$-labeled coplanar PCB isomers including 3,4,3',4'-tetrachlorobiphenyl (TeCB), 3,4,5,3',4'-pentachlorobiphenyl (PeCB) and 3,4,5,3',4',5'-hexachlorobiphenyl (HxCB), $^{13}C_{12}$-labeled PCDD isomers, including 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), 1,2,3,7,8-pentachlorodibenzo-p-dioxin (PeCDD), 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin (HxCDD), 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin (HpCDD) and OCDD, $^{13}C_{12}$-labeled PCDF including 2,3,7,8-tetrachlorodibenzofuran (TCDF), 1,2,3,7,8-pentachlorodibenzofuran (PeCDF), 1,2,3,4,7,8-hexachlorodibenzofuran (HxCDF), 1,2,3,4,6,7,8-heptachlorodibenzofuran (HpCDF) and OCDF, were obtained from Cambridge Isotope Laboratories Inc., USA.

Procedure: The samples were extracted with hexane/acetone using a Polytron homogenizer. The hexane extract was filtered, and after the addition of distilled water, $^{13}C_{12}$-labelled PCDD, PCDF and coplanar PCB

isomers were added to the extract as internal standards for calculation of the recovery rates of PCDDs, PCDFs and coplanar PCBs. After the hexane extract was concentrated to the appropriate volume, the extract was washed with concentrated sulfuric acid, purified on a $AgNO_3$-silica gel column chromatography, and then separated into coplanar PCBs and PCDDs/PCDFs fractions by using activated carbon column chromatography and Florisil column chromatography. The details of this procedure have been reported elsewhere[1].

Gas chromatography-mass spectrometry: The PCDDs, PCDFs and coplanar PCBs were analyzed with using a Finnigan MAT-90 mass spectrometer (Bremen, Germany) directly interfaced with a Varian model 3400 gas chromatograph equipped with a splitless injector and a capillary column bonded with 50% methyl phenyl silicon, OV-17 (0.25mm x 25m; film thickness, 0.1μm). The GC column temperature was maintained at 120°C for 1 min, then programmed to 170°C at the rate of 10°C/min, followed by programmed to 260°C at the rate of 10°C/min. The mass resolution (5% valley) was 7000 to 10000. Two ions of molecular cluster were recorded.

RESULTS AND CONCLUSION

In our previous study, we focused mainly on the concentration and distribution of coplanar PCBs in samples of various human tissues. In this study, we also analyzed the concentrations of PCDDs and PCDFs in human tissue samples in more detail. Table 1 shows the concentrations of PCDDs, PCDFs and coplanar PCBs in human liver, blood, adipose and brain tissue expressed as pg per g of fat (ppt).

The liver: The mean total concentration and the mean total TCDD eq. (TCDD equivalents were calculated as TCDD Toxic Equivalent Factors[2]) of PCDDs was 4154.0 and 32.8 ppt, respectively, and that of PCDFs was 518.9 ppt and 86.8 ppt, respectively, that of coplanar PCBs was 356.8 ppt and 31.0 ppt, respectively. The total TCDD eq. of PCDDs, PCDFs and coplanar PCBs in the liver was 150.5 ppt.

The blood: The mean total concentration and total TCDD eq. of PCDDs was 639.9 ppt and 12.7 ppt; that of PCDFs was 125.8 ppt and 11.2 ppt; and that of coplanar PCBs was 119.9 ppt and 8.6 ppt. The total TCDD eq. of PCDDs, PCDFs and coplanar PCBs in the blood was 32.4 ppt.

The adipose: The mean total concentration and mean total TCDD eq. of PCDDs was 684.3 ppt and 19.1; that of PCDFs was 43.8 ppt and 11.9 ppt; and that of coplanar PCBs was 250.2 ppt and 19.3 ppt. The total TCDD eq. of PCDDs, PCDFs and coplanar PCBs in adipose tissue was 50.4 ppt.

The brain: The mean total concentration and mean total TCDD eq. of PCDDs was 21.2 ppt and 0.9 ppt; That of PCDFs was 19.4 ppt and 4.9 ppt; and that of coplanar PCBs was 12.3 ppt and 0.9 ppt. The total TCDD eq. of PCDDs, PCDFs and coplanar PCBs in the brain was 6.8 ppt.

Fig. 1 shows the concentration of TCDD eq. in each tissue expressed as pg per g of fat (ppt). The liver showed the highest TCDD eq., and a main component was PCDFs. The adipose tissue showed the second highest TCDD eq., which was about one-third of the TCDD eq. of the liver. The brain showed the lowest TCDD eq., which was considered to probably be due to the blood-brain barrier. Fig. 2 shows the total TCDD eq. of PCDDs, PCDFs and coplanar PCBs in each tissue expressed as pg per g (wet weight; ppt). The adipose tissue showed the highest TCDD eq., as it has the highest lipid content of the tissues examined. The liver showed the second highest TCDD eq., which was about one-fifth of that of the adipose tissue. The blood showed the

Table 1 Concentrations of PCDDs, PCDFs and coplanar PCBs in human liver, blood, adipose and brain tissue as pg/g fat

Samples	Liver	Blood	Adipose	Brain
2,3,7,8-TCDD	2.5 ± 1.4	1.9 ± 1.2	2.8 ± 1.6	0.3 ± 0.1
1,2,3,7,8-PeCDD	9.5 ± 6.4	8.6 ± 5.7	12.6 ± 4.5	0.6 ± 0.3
1,2,3,4,7,8-HxCDD	17.1 ± 16.4	1.7 ± 2.1	4.0 ± 1.6	0.2 ± 0.1
1,2,3,6,7,8-HxCDD	141.7 ±109.1	54.9 ± 33.2	80.4 ± 35.5	2.3 ± 1.4
1,2,3,7,8,9-HxCDD	32.9 ± 21.5	0.0 ± 0.0	7.0 ± 4.6	0.7 ± 0.3
1,2,3,4,6,7,8-HpCDD	274.0 ±293.0	38.8 ± 19.4	39.0 ± 19.9	4.9 ± 4.7
OCDD	3635.0 ± 3132	517.9 ±345.8	532.6 ±390.9	10.3 ± 5.1
Total PCDDs	4154.0 ± 3504	639.9 ±375.9	684.3 ±406.3	21.2 ± 7.6
2,3,7,8-TCDF	11.9 ± 9.5	4.7 ± 2.0	2.5 ± 1.8	0.9 ± 0.3
1,2,3,7,8-PeCDF	5.3 ± 4.8	1.6 ± 1.4	0.9 ± 1.3	0.4 ± 0.2
2,3,4,7,8-PeCDF	109.6 ± 88.6	16.9 ± 8.7	20.1 ± 9.8	7.9 ± 7.7
1,2,3,4,7,8-HxCDF	109.3 ± 99.1	8.6 ± 3.9	6.6 ± 3.7	6.4 ± 6.4
1,2,3,6,7,8-HxCDF	184.8 ±171.4	9.3 ± 6.9	8.3 ± 5.4	1.7 ± 1.7
1,2,3,4,6,7,8-HpCDF	79.6 ± 73.7	14.3 ± 13.7	4.3 ± 0.3	0.7 ± 0.8
1,2,3,4,7,8,9-HpCDF	9.3 ± 8.6	0.1 ± 0.3	0.3 ± 0.3	0.1 ± 0.1
OCDF	NA	NA	NA	NA
Total PCDFs	518.9 ±441.0	125.8 ±152.9	43.8 ± 21.2	19.4 ±17.2
3,3',4,4'-TeCB	16.7 ± 8.7	15.8 ± 4.4	6.1 ± 1.7	2.8 ± 1.2
3,3',4,4',5-PeCB	275.4 ±188.7	63.9 ± 32.8	141.4 ± 79.3	8.3 ± 2.9
3,3',4,4',5,5'-HxCB	64.7 ± 32.9	40.1 ± 21.0	102.7 ± 48.3	1.4 ± 0.6
Total coplanar PCBs	356.8 ±218.0	119.9 ± 52.9	250.2 ±122.2	12.3 ± 4.0
Total DD (TCDD eq.)	32.8 ± 23.0	12.7 ± 18.8	19.1 ± 6.0	0.9 ± 0.4
Total DF (TCDD eq.)	86.8 ± 71.9	11.2 ± 5.1	11.9 ± 5.9	4.9 ± 4.6
Total CoPCB(TCDD eq.)	31.0 ± 20.6	8.6 ± 4.4	19.3 ± 10.4	0.9 ± 0.3
Total TCDD eq.	150.5 ±109.0	32.4 ± 12.8	50.4 ± 18.0	6.8 ± 5.0
Lipid content (%)	6.41 ± 3.7	0.45 ± 0.06	76.7 ± 19.3	10.3 ± 2.5

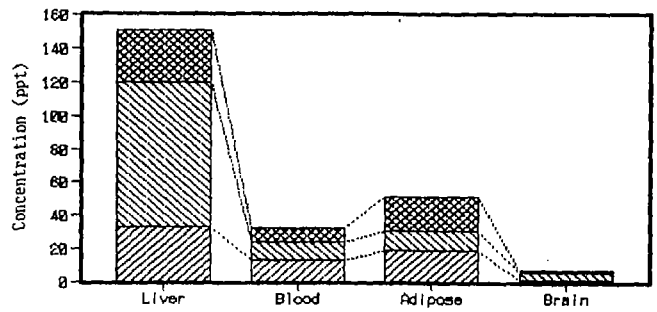

Fig.1 Total TCDD eq. in various tissues (Fat bases).

PCDD PCDF CoPCB

lowest TCDD eq., as it has the lowest lipid content[3] of the tissues analyzed. Fig. 3 shows the component ratio of total TCDD eq.in each tissue. The main component in the liver was PCDFs, the adipose tissue coplanar PCBs, and the brain PCDFs. The blood contained almost the same proportion of each of the three components.

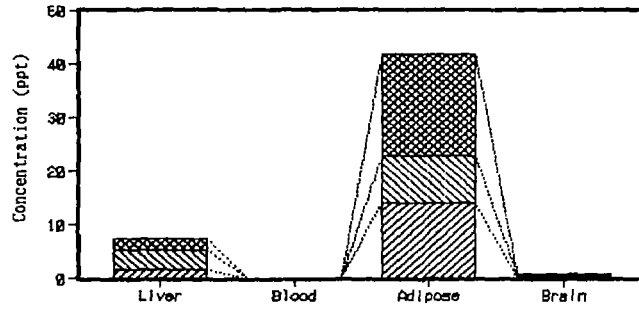

Fig.2 Total TCDD eq. in various tissues (Wet bases).

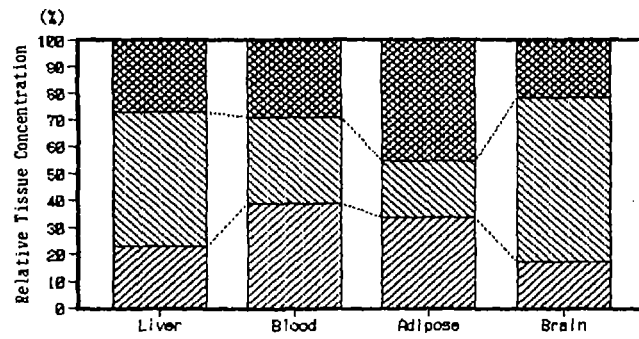

Fig.3 Compornent ratio of distribution.

PCDD PCDF CoPCB

REFERENCES

1 Iida T, Hirakawa H, Matsueda T, Nakagawa R, Takenaka S, Morita K, Narazaki Y, Fukamachi K, Takahashi K. Levels of Polychlorinated Biphenyls and Polychlorinated Dibenzofurans in the blood, subcutaneous adipose tissue and stool of Yusho patients and normal subjects. Toxicol. Environ. Chem. 1992; in press.

2 Eric Dewailly, Jean-Philippe Weber, Suzanne Gingras, and Claire Laliberte. Coplanar PCBs in human milk in the province of Quebec, Canada: Are they more toxic than Dioxin for breast fed infants? Bull. Environ. Contam. Toxicol. 1991; 47: 491-498.

3 D.G Patterson, Jr. ,P.Furst,L.o.Henderson, S.G. Isaacs, L.R. Alexander, W.E Turner, L.L Needham, and H. Hannon. Partitioning of in vivo bound PCDDS/PCDFS among various compartments in whole blood. Chemosphere, 1989; 19: Nos.1-6, pp 135-142.