

Relative Contribution of PCBs, PCDFs and PCDDs to Toxic Equivalent in the Blood of Yusho Patients

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1. Introduction

A mass poisoning, called Yusho, occurred in Western Japan in 1968. Yusho was caused by ingestion of rice oil which was contaminated with polychlorinated biphenyls (PCB), polychlorinated dibenzofurans (PCDF), polychlorinated quaterphenyls, and a small amount of polychlorinated dibenzo-p-dioxin (PCDD)¹⁾. PCBs and PCDFs have been separately analyzed in the adipose tissue and blood of Yusho patients after the incidents. This time, we quantified various congeners of PCBs, PCDFs and PCDDs in identical samples of Yusho blood which were collected in 1990 and 1991, more than 20 years after the incident. TEQ, Toxic equivalent quantity estimated to 2,3,7,8-tetrachlorodibenzo-p-dioxin, in the blood was calculated using the International toxic equivalent factors (TEF) for PCDDs and PCDFs²⁾ and the TEFs by WHO European Centre for Environment and Health for PCBs³⁾.

2. Materials and Methods

Whole blood samples were collected from 2 Yusho patients (TAH and NOH) of a family in 1990 and 1991. Pooled serum was obtained from 2 clinical laboratories in Fukuoka in 1991 and 1992. The samples were kept frozen until analyses. The analytical method used for PCDDs and PCDFs was previously reported⁴⁾, involving chemical cleanup and extraction followed by high-resolution gas chromatography mass spectrometry analysis.

3. Results and Discussion

Measured concentrations of PCDDs, PCDFs and PCBs in Yusho blood and control serum are listed in Table 1. The Table also shows the concentrations of these congeners in Yusho oil, causal rice oil for Yusho in 1968. The data were obtained by Tanabe et al⁵⁾ in 1989. Concentrations of individual congeners are compared between Yusho blood and control serum in lipid basis. Concentrations of 2,3,4,7,8-penta-CDF and 1,2,3,4,7,8-hexa-CDF in Yusho blood were 12-14 times higher than those in control serum. The high concentrations have persisted for 23 years after the incident. Iida et al⁶⁾ observed that

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Table 1 Concentrations of PCDDs, PCDFs, and PCBs in Yusho oil, Yusho blood and Control serum

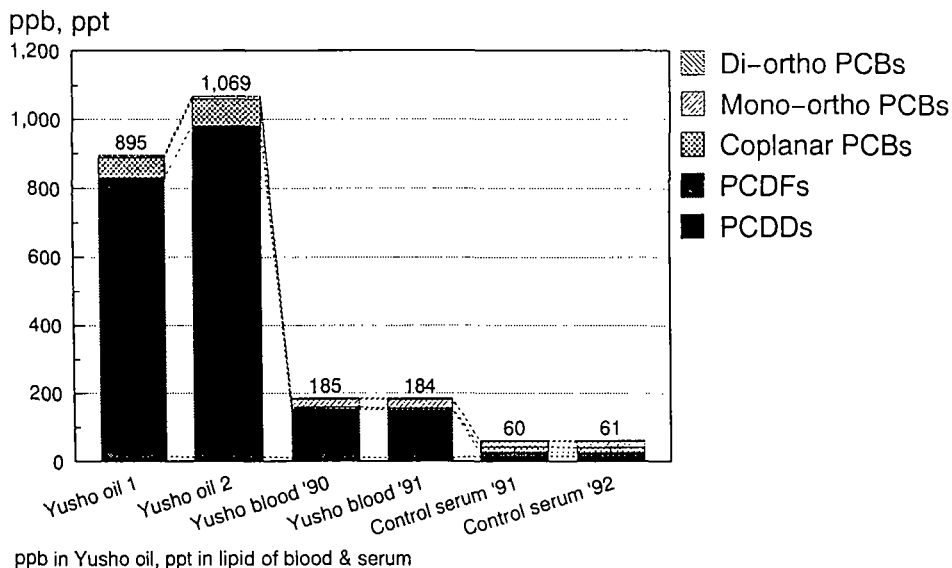
TEF	Yusho Oil		Lipid basis, ppt				
	Yusho Oil 1 (ppb)	Yusho Oil 2 (ppb)	Yusho Blood 1990	Yusho Blood 1991	Control Serum 1991	Control Serum 1992	
Total sample amount (g)	1	1	10.1	10.17	40	35.41	
Total lipid amount (g)	1	1	0.052	0.052	0.202	0.214	
2,3,7,8-Tetra-CDD	1	nd	nd	2.3	2.2	3.3	2.9
1,2,3,7,8-Penta-CDD	0.5	7.1	7.5	7.4	7.0	9.4	8.9
1,2,3,4,7,8-Hexa-CDD	0.1	11	5.7	2.4	3.4	5.0	3.5
1,2,3,6,7,8-Hexa-CDD	0.1	42	38	34.0	37.3	38.0	39.6
1,2,3,7,8,9-Hexa-CDD	0.1	24	22	5.9	4.9	7.9	8.7
1,2,3,4,6,7,8-Hepta-CDD	0.01	180	190	16.8	17.0	49.0	43.2
Octa-CDD	0.001	130	110	537	516	1220	1054
Total PCDDs		394.1	373.2	605.8	587.8	1332.6	1160.8
2,3,7,8-Tetra-CDF	0.1	630	690	<5.0	<5.0	4.4	5.0
2,3,4,7,8-Penta-CDF	0.5	1300	1400	243.0	240.0	17.4	17.4
1,2,3,7,8-Penta-CDF	0.05	290	760	1.7	1.5	<1.5	1.5
1,2,3,4,7,8-Hexa-CDF	0.1	580	1200	157.0	148.0	12.1	11.7
1,2,3,6,7,8-Hexa-CDF	0.1	110	230	34.5	34.3	8.7	7.8
1,2,3,7,8,9-Hexa-CDF	0.1	nd	nd	<1.1	<1.4	<0.8	<1.0
2,3,4,6,7,8-Hexa-CDF	0.1	170	160	4.0	4.4	3.3	3.4
1,2,3,4,6,7,8-Hepta-CDF	0.01	310	200	16.6	16.7	10.4	6.8
1,2,3,4,7,8,9-Hepta-CDF	0.01	12	11	2.9	3.8	<1.7	<1.6
Octa-CDF	0.001	76	76	na	na	nd	<5.4
Total PCDFs		3478.0	4727.0	459.7	448.7	56.3	53.6
3,3',4,4'-Tetra-CB	0.0005	11000	12000	44*	48*	25*	24*
3,3',4,4',5-Penta-CB	0.1	530	730	46	44	149	134
3,3',4,4',5,5'-Hexa-CB	0.01	23	31	127	125	84	99
Total Coplanar PCBs		11553	12761	217	217	258	257
2,3,3',4,4'-Penta-CB	0.0001	24000	32000	3326	3717	11304	8603
2,3,4,4',5-Penta-CB	0.0005			3279	2952	2745	2756
2,3',4,4',5-Penta-CB	0.0001	27000	37000	15040	13081	43599	41021
2',3,4,4',5-Penta-CB	0.0001			<400	<400	676	789
2,3,3',4,4',5-Hexa-CB	0.0005	2700	3200	31976	34795	13962	18216
2,3,3',4,4',5'-Hexa-CB	0.0005			8533	9002	3131	4092
2,3',4,4',5,5'-Hexa-CB	0.00001			4545	4845	8325	8455
2,3,3',4,4',5,5'-Hepta-CB	0.0001			2058	2696	850	925
Total Mono-ortho PCBs		53700	72200	68757	71088	84592	84857
2,2',3,3',4,4',5-Hepta-CB	0.0001	1900	2100	22710	27060	17531	20820
2,2',3,4,4',5,5'-Hepta-CB	0.00001	1800	3300	51611	61453	84082	79759
Total Di-ortho PCBs		3700	5400	74321	88513	101613	100579
Total PCBs		68953	90361	143295	159818	186463	185693

* Maximum value

these PCDFs were 30–40 times higher in adipose tissue of Yusho patients than in the corresponding control levels in 1986. Contrary to the PCDF levels, some planar congeners of PCBs such as 2,3,3',4,4'-penta-CB, 2,3',4,4',5-penta-CB and 3,3',4,4',5-penta-CB were in lower concentrations in Yusho blood compared to the corresponding control levels, although total PCB levels were comparable in both of the cases. The lower concentrations of 2,3,3',4,4'-penta-CB and 2,3',4,4',5-penta-CB in Yusho blood were already observed in 1977⁷⁾ and 1992⁸⁾. The decrease of the congeners in the blood of Yusho patients was probably caused by enzyme induction of long-retaining strong enzyme inducers such as 2,3,4,7,8-penta-CDF.

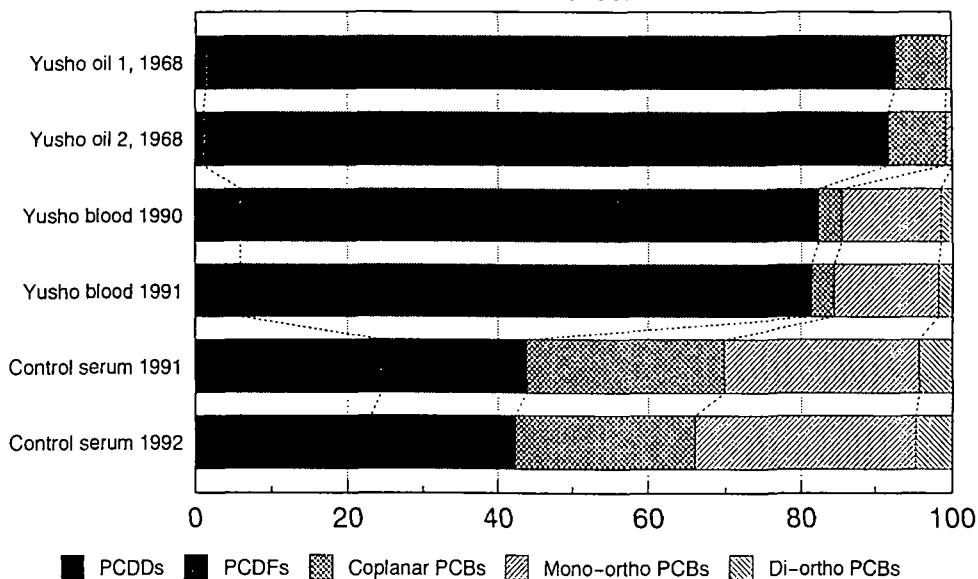
TEQs were estimated in Yusho blood and control serum using the TEFs proposed by NATO for PCDDs and PCDFs and by WHO for PCBs, which are listed in Table 1. In Yusho blood, 2,3,4,7,8-penta-CDF contributed the highest toxicity (TEQ 121 ppt in lipid) among the congeners determined and 1,2,3,4,7,8-hexa-CDF and 2,3,3',4,4',5-hexa-CB contributed the following toxicity (TEQ 15 and 17 ppt in lipid, respectively). TEQ concentrations in Yusho blood and control serum are shown in Figure 1, together with TEQ concentrations in Yusho oil. A large portion of TEQ concentrations in Yusho blood is contributed by PCDFs. This contribution pattern was reflected from TEQ concentration pattern in Yusho oil, which was ingested by Yusho patients 23 years ago. Total TEQ concentrations in Yusho blood were only 3 times higher than those of control serum.

Fig. 1 TEQ levels in Yusho oil, Yusho blood and control serum



Percentage TEQ contribution in Yusho oil, Yusho blood and control serum is shown in Figure 2. Besides large PCDF toxic contribution (76%), mono-ortho PCBs (13%) and PCDDs (6%) contributed less portion of toxicity in Yusho blood. In control serum, toxicity was almost equally contributed by PCDDs, PCDFs, coplanar PCBs, and mono-ortho PCBs, and more than half the toxicity is contributed by PCBs.

Fig. 2 Percentage TEQ contribution in Yusho oil
Yusho blood and control serum



4. References

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