

## PCBs CONCENTRATIONS IN BLOOD OF YUSHO PATIENTS: 2006 YUSHO ANNUAL INSPECTION IN FUKUOKA, JAPAN

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### Abstract

In this study, we determined concentrations and characteristics of 68 PCB isomers in blood samples collected during the annual Yusho inspection in 2006 in Fukuoka prefecture, Japan. Blood samples were collected from Yusho patients ( $n=15$ ) and Yusho-suspected patients ( $n=43$ ) in 2006 and control group of Fukuoka prefecture residents in 2004 ( $n=127$ ). As a result of the study, 4 persons were classified into pattern A (typical Yusho pattern), and their mean total PCBs concentrations were obviously higher than that of the controls. Among PCB isomers, blood concentrations of PCB#157, #156, #189, #170 and #99 were higher than those of the controls, while levels of PCB#118, #74 and #105 were lower than those of the controls. These results demonstrated that, despite over 35 years after the Yusho incident, pattern A subjects (Yusho patients) had higher concentrations of total PCBs and distinct PCB isomers pattern in the blood when compared with the controls.

### Introduction

The Yusho (oil disease) incident, mass food poisoning, occurred in northern Kyushu of Japan in 1968 and involved more than 1,800 people. It was caused by ingestion of cooking rice oil contaminated with polychlorinated biphenyls (PCBs) and various dioxins such as polychlorinated dibenzofurans (PCDFs). Many studies reported that the Yusho patients have been suffering from various symptoms over 35 years after the incident<sup>1</sup>.

Ratios of PCB isomer concentrations were used for Yusho diagnosis and classification of the following four patterns (pattern A: characteristic of Yusho; pattern C: the pattern commonly observed in general people; pattern B or BC: intermediate pattern between A and C)<sup>2,3</sup>. Hence, it is important that in the blood of Yusho patients concentrations of individual PCB isomers, in addition to total PCBs, are measured.

In the present investigation, we analyzed 68 PCB isomers in the blood of Yusho patients and Yusho-suspected patients obtained from Fukuoka Prefecture in 2006, and checked PCB characteristics in the blood.

### Materials and Methods

The blood samples of 15 Yusho patients (age: 41–81 years old; authorized by the Yusho medical team) and 43 Yusho-suspected patients (age: 10–84 years old; patients suspected to have ingested PCBs contaminated rice oil, their children, though unauthorized by the medical team according to the diagnostic criteria for Yusho disease) were collected during the annual Yusho inspection in 2006 in Fukuoka prefecture, Japan. In addition, the blood samples of 127 residents were collected in Fukuoka prefecture in 2004 and used in this study as control. The age of the controls was 68–86 years, which matches the age of the Yusho patients. Ten mL of blood were collected using a vacuum blood-collecting pipe containing heparin and stored at 4°C until PCBs analysis. The details of the methods for blood lipid extraction, purification and mass-spectrometric measurements have been described elsewhere<sup>3</sup>. PCB concentrations were expressed on a whole blood basis (pg/g) in the present study.

Table 1. PCBs concentrations in the blood of Yusho patients, Yusho-suspected patients and normal controls (Fukuoka pref. Residents).

Congener	Concentration (pg/g whole blood basis)								
	Yusho patients (n=15)			Yusho-suspected patients (n=43)			Normal controls (n=127)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
245-triCB(#29)	nd	nd	nd	nd	nd	nd	nd	0.29	0.079
244-triCB(#28)	2.6	18	5.7	nd	26	6.4	2.3	43	8.5
344-triCB(#37)	nd	nd	-	nd	nd	-	nd	nd	-
22'55'-tetraCB(#52)	1.3	9.4	3.9	0.11	19	3.4	1.3	16	4.1
22'45'-tetraCB(#49)	0.54	2.9	1.5	0.47	4.2	1.8	0.33	2.3	1.0
22'44'-tetraCB(#47)	0.71	4.3	2.7	nd	5.7	1.7	0.81	4.6	1.9
22'35'-tetraCB(#44)	nd	3.1	1.2	nd	2.8	0.93	0.35	3.3	1.5
23'46'-tetraCB(#71)	nd	1.7	0.63	nd	1.6	0.50	nd	1.2	0.61
23'45'-tetraCB(#63)	nd	1.1	0.35	nd	1.6	0.39	0.057	2.0	0.47
244'5'-tetraCB(#74)	6.8	150	53	1.8	190	48	12	240	64
23'45'-tetraCB(#70)	0.17	2.2	0.99	nd	1.4	0.49	0.17	2.2	0.83
23'44'-tetraCB(#66)	1.37	15	5.5	nd	25	5.7	1.4	40	7.7
23'3'4'-/2344'-tetraCBs(#56/60)	0.87	6.4	2.4	nd	10	2.6	0.52	16	2.9
22'355'-pentaCB(#95)	nd	4.9	2.7	nd	8.7	2.9	0.86	9.5	2.7
22'355'-pentaCB(#92)	nd	6.3	1.7	nd	8.9	1.5	0.50	16	2.8
22'455'-pentaCB(#101)	2.8	13	6.1	0.70	21	5.2	1.3	26	6.1
22'445'-pentaCB(#99)	7.7	350	74	2.0	100	30	10	120	40
23'456'-pentaCB(#117)	nd	27	4.1	nd	8.9	1.9	0.63	14	3.0
22'345'-pentaCB(#87)	nd	6.0	2.5	nd	4.0	1.1	0.63	8.2	2.2
22'344'-pentaCB(#85)	nd	0.70	0.30	nd	1.4	0.27	0.16	2.8	0.70
23'3'4'6'-pentaCB(#110)	nd	1.9	1.2	nd	1.8	0.97	0.39	2.9	1.3
23'3'4'5'-pentaCB(#107)	nd	4.8	2.0	nd	9.2	2.0	0.56	17	3.2
23'44'5'-pentaCB(#123)	nd	2.7	0.95	nd	4.6	1.1	0.24	8.0	1.5
23'44'5'-pentaCB(#118)	9.2	120	54	3.8	200	50	16	360	79
23'44'5'-pentaCB(#114)	0.63	23	7.4	nd	16	3.8	1.6	17	5.5
23'3'44'-pentaCB(#105)	2.3	26	11	0.87	37	10	3.0	78	17
22'355'6'-hexaCB(#151)	nd	14	3.5	nd	9.2	2.1	0.83	18	4.0
22'33'56'-hexaCB(#135)	nd	2.6	1.0	nd	3.4	0.52	0.43	6.3	1.5
22'34'56'-hexaCB(#147)	nd	5.1	1.2	nd	4.9	0.77	0.14	6.1	1.6
22'344'6'-hexaCB(#139)	nd	7.7	2.9	nd	5.8	1.1	0.44	9.5	2.6
22'33'56'-hexaCB(#134)	nd	nd	-	nd	nd	-	nd	0.55	0.090
23'355'6'-hexaCB(#165)	nd	nd	-	nd	nd	-	nd	nd	-
22'34'55'-hexaCB(#146)	5.2	190	50	1.2	100	27	15	150	44
22'33'46'-hexaCB(#132)	nd	3.0	0.77	nd	3.1	0.33	0.044	3.7	0.91
22'44'55'-hexaCB(#153)	35	1100	360	6.5	650	190	93	880	290
22'345'5'-hexaCB(#141)	nd	1.2	0.30	nd	2.4	0.13	0.12	4.9	1.1
22'344'5'-hexaCB(#137)	1.3	140	23	nd	20	6.9	2.9	33	9.6
22'33'45'-hexaCB(#130)	nd	92	14	nd	23	5.7	1.9	35	8.4
23'3'45'6'-hexaCB(#164)	7.3	340	76	1.8	120	37	nd	190	62
22'344'5'-hexaCB(#138)	14	870	200	5.3	280	85	41	420	130
22'33'44'-hexaCB(#128)	0.59	3.9	1.9	nd	5.1	1.4	0.43	9.2	2.8
23'44'55'-hexaCB(#167)	1.5	16	8.7	0.41	25	6.5	3.4	47	12
23'344'5'-hexaCB(#156)	2.9	670	92	0.49	58	18	8.9	92	26
23'3'44'5'-hexaCB(#157)	1.3	170	24	nd	16	4.8	2.3	21	6.5
22'33'566'-heptaCB(#179)	nd	2.3	0.88	nd	2.5	0.54	0.13	3.0	0.67
22'33'55'6'-heptaCB(#178)	3.1	50	22	nd	45	14	7.4	62	20
22'344'56'-heptaCB(#182)	14	210	110	1.89	210	63	32	280	90
22'344'5'6'-heptaCB(#183)	2.0	93	33	nd	50	15	6.5	59	20
22'344'56'-heptaCB(#181)	nd	12	1.6	nd	2.3	0.47	nd	0.8	0.23
22'33'45'6'-heptaCB(#177)	4.0	83	27	0.73	65	15	5.1	60	18
22'33'455'-heptaCB(#172)	1.4	65	14	nd	19	6.0	3.4	31	9.5
22'344'55'-heptaCB(#180)	30	830	250	4.2	460	120	74	650	190
23'344'5'6'-heptaCB(#191)	1.0	32	5.9	nd	10	1.8	0.85	7	2.4
22'33'44'5'-heptaCB(#170)	9.9	550	110	1.6	140	39	22	180	55
23'344'55'-heptaCB(#189)	0.77	84	12	nd	8.6	2.5	1.3	11	3.3
22'33'55'66'-octaCB(#202)	1.4	16	7.3	nd	20	5.1	nd	130	9.0
22'33'45'66'-octaCB(#200)	0.47	3.0	1.7	nd	2.9	0.88	nd	39	2.2
22'33'45'5'6'-/22'33'455'6'-octaCBs(#201/198)	5.0	91	34	nd	67	20	12	130	32
22'344'55'6'-octaCB(#203)	3.0	130	33	nd	48	15	8.9	91	25
22'33'44'56'-octaCB(#195)	1.5	53	13	nd	20	5.6	1.9	21	5.8
22'33'44'55'-octaCB(#194)	5.5	150	39	nd	58	19	8.6	130	27
23'344'55'6'-octaCB(#205)	nd	7.4	1.6	nd	2.3	0.49	0.33	2.7	0.99
22'33'455'66'-nonaCB(#208)	1.3	8.5	3.5	nd	9.2	2.0	0.44	7.4	2.5
22'33'44'566'-nonaCB(#207)	nd	6.5	2.0	nd	3.3	0.99	0.18	3.2	1.1
22'33'44'55'6'-nonaCB(#206)	1.9	33	8.6	nd	12	4.5	2.2	20	6.3
22'33'44'55'66'-decaCB(#209)	1.9	7.3	4.0	nd	8.0	3.0	1.6	12	4.4
Total triCBs	2.6	18	5.7	nd	26	6.5	2.4	43	8.6
Total tetraCBs	20	170	73	7.1	230	65	18	320	85
Total pentaCBs	29	460	170	13	400	110	41	680	170
Total hexaCBs	69	3600	860	16	1300	390	200	1900	600
Total heptaCBs	67	2000	580	8.6	990	280	160	1290	410
Total octaCBs	17	440	130	0.66	200	66	38	420	100
Total nonaCBs	3.8	48	14	0.045	23	8	2.8	29	9.8
Total PCBs	210	6600	1800	52	3200	920	520	4600	1400

\*nd : not detected (&lt; 0.03 pg/g whole blood basis)

## Results and Discussion

Table 1 shows the concentrations of total PCBs and individual isomers in the blood of Yusho patients, Yusho-suspected patients and controls. The mean concentrations of total PCBs in the blood were 1,800 pg/g (range: 210–6,600 pg/g) in Yusho patients, 920 pg/g (52–3,200 pg/g) in Yusho-suspected patients and 1,400 ng/g (520–4,600 pg/g) in controls, respectively. The mean total PCBs concentration in the blood of Yusho-suspected patients was lower than that of the controls. This might be due to age difference between the groups (Yusho-suspected patients: 10–84 years old; controls: 68–86 years old).

Among the Yusho patients and Yusho-suspected patients, 4, 6, 8 and 40 persons were classified into groups of pattern A, B, BC and C, respectively. All pattern A subjects were Yusho patient. Mean total PCBs concentration in the blood was 2,800 pg/g (range: 730–6,600 pg/g) in pattern A, 1,300 pg/g (480–2,400 pg/g) in pattern B, 1,200 pg/g (220–2,300 pg/g) in pattern BC and 970 pg/g (52–3,200 pg/g) in pattern C subjects. The mean total PCBs concentration in the blood of pattern A subjects was comparable to that observed in previous study in 2004 (mean; 2,900 pg/g)<sup>4</sup>. These results indicated that concentration of total PCBs in the blood of pattern A subjects was clearly higher than that of the other pattern subjects and the controls.

Among PCB isomers, average concentrations of individual PCB isomers in the blood of pattern A subjects ( $n=4$ ) were compared with those in the blood of the controls ( $n=127$ ). Concentrations of PCB#157, #156, #189, #170 and #99 in blood of pattern A subjects were obviously higher than those in blood of the controls, while levels of PCB#118 were evidently lower than those of the controls (Fig. 1). These trends were characteristic of the patients reported by previous study<sup>4</sup>. In addition, PCB #74 and #105 concentrations in pattern A subjects were clearly lower than those of the controls. These results suggest that PCB #74 and #105 might be also used in Yusho diagnosis.

A positive correlation was found between the age of pattern A subjects and concentrations of both total PCBs and significant PCB isomers above-mentioned (#157, #156, #189, #170, #99, #118, #74 and #105) in the blood. These results indicate that the Yusho patients might have ingested these PCB isomers mainly from foodstuff.

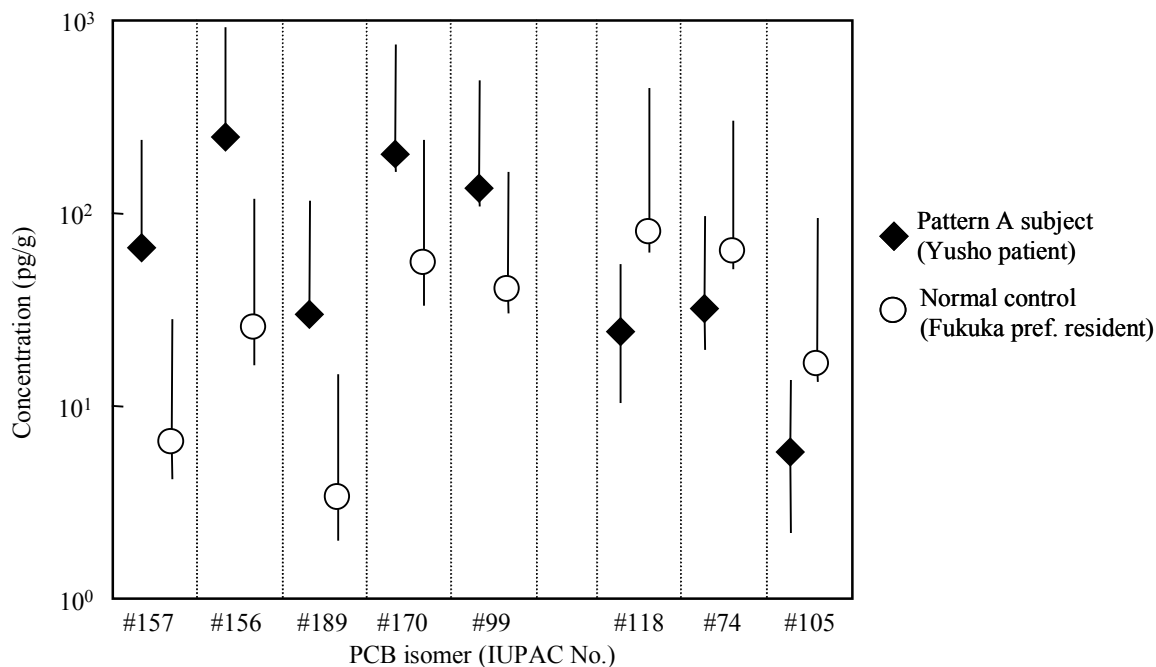


Fig. 1. Concentrations of PCBs (#157, #156, #189, #170, #99, #118, #74 and #105) in blood of pattern A subjects (quarry) and normal control (circle). Bars indicate the range.

In conclusion, over 35 years have passed since the incident, however, pattern A subjects (Yusho patients) had high concentrations of total PCBs and a specific PCB isomer pattern in the blood compared with the controls. In view of our investigation, we suggest that further research is necessary to determine the PCBs levels and their isomer patterns in the blood of Yusho patients and Yusho-suspected patients, and assess health risk in future.

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