BLOOD SERUM LEVELS OF PCDFS AND PCBS IN YUCHENG WOMEN 14 YEARS AFTER EXPOSURE TO A TOXIC RICE OIL

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Introduction

Polychlorinated biphenyls (PCBs), polychlorinated dibenzofurans (PCDFs), and polychlorinated dibenzodioxins (PCDDs) are ubiquitous environmental contaminants in most industrialized countries[1)]. Despite the ban on PCBs, the PCBs, and the PCDFs and PCDDs will be found in the environment for decades to come due to their long half life in the environment[2)]. In 1979, a massive poisoning of PCBs and their heat-degraded products due to consumption of contaminated rice-bran oil occurred in Central Taiwan involving more than 2000 people. Exposed victims developed skin, eye, and other symptoms, and most of them had serum levels measured[3)]. This episode was later called Yucheng (oil-disease in Chinese). The authors studied the serum levels of PCB/PCDF congeners to determine the residual levels of toxicants in victims exposed to the toxic oil 14 years ago.

Subjects and Methods

A group of children born to mothers exposed to PCBs and related compounds (Yucheng children) were followed regularly for cognitive and physical development since 1985, along with a group of control children matched by sex, age, maternal age, residential area, and parents' education and socioeconomic status[4,5,6)]. In February 1992, Yucheng children were examined in the local health offices or their homes by our *investigators. Blood samples* were collected from Yucheng children's mothers who were previously exposed to contaminants, and control children's mothers who had no

known previous exposure to PCBs and related chemicals. Serum levels of PCB/PCDF/PCDD congeners were analyzed by high resolution gas chromatography-high resolution mass spectrometry (HRGC/HRMS) using sample enrichment and isotope dilution as described recently[7]. In short, a mixture of C13-compounds, i.e., six 2,3,7,8-chlorinated PCDD congeners, six 2,3,7,8-chlorinated PCDF congeners plus 1,2,7,8-TCDF, and 3,3'4,4'-TCB, 3,3'4,4'5-PnCB, 3,3'4,4'5,5'-HxCB (IUPAC #'s 77, 126, 169) were added to the weighted samples. All non-polar organochlorine compounds in the serum were extracted with a mixture of ethanol, saturated aqueous ammonium sulfate, hexane. The weighed residue was used to estimate the serum lipid content after evaporation of the organic solvents. The samples were defatted with concentrated sulfuric acid, and purified by column chromatography on acid-base silica. The pPCBs/PCDFs/PCDDs were separated from the non-planar PCBs and other common organochlorines by chromatography on Florisil (second fraction; dichloromethane), followed by further fractionation on activated carbon. On the same purified extract, identification and measurement of pPCBs/PCDFs/PCDDs was carried out simultaneously by HRGC/HRMS. The non-planar PCBs (up to 16 congeners were monitored) were separated in the first Florisil fraction (1% dichloromethane in hexane). After evaporation at room temperature and addition of internal standard (PCB #128) these PCB congeners were determined on a non-polar methyl silicone capillary GC column with electron capture (EC) detection. For these subjects with rice oil poisoning, congeners of interest were those present in relatively high concentration in the oil and persist in human, 2,3,4,7,8-PnCDF and 1,2,3,4,7,8-HxCDF being the most important congeners.

For Yucheng mothers, measurements of PCBs/PCDFs/PCDDs were done for each individual whose blood was available. For controls, the serum samples were pooled, and analysis of serum levels were performed for the pooled sample. Relation between serum levels at the time of exposure, the total duration of breast feeding, and serum levels in 1992 was determined by regression analysis. Serum levels of toxicants were compared in Yucheng mothers of children who had and had not nail deformities by examination in 1992[8].

Results

Blood samples from a total of 56 of the 68 Yucheng mothers were obtained. In most of the samples, detectable levels of PCDFs and PCBs could be determined with average values of 2,3,4,7,8-PnCDF and 1,2,3,4,7,8-HxCDF of 1,625 and 3,820 ng/kg serum lipid, respectively. The average of the total PCBs on a whole weight basis was 11,590 ng/kg. The PCDF concentrations were still 60 to 190 times higher than control

level, and PCB concentrations were 7 times higher than the controls (Table). Concentrations of PCB levels were correlated positively with previous measurement of PCB levels in these mothers (p=0.0001) and negatively with total duration of breast feeding (p=0.005). Mothers of Yucheng children with nail deformity had higher serum levels of 2,3,4,7,8-PnCDF and 1,2,3,4,7,8-HxCDF in 1992 compared with those whose children had no nail deformity by examination (Figure).

Table. Serum levels of toxicants in Yucheng mothers and their controls

	Serum of Yucheng mothers		Pooled control sera
	mean ± SE	Range	
2,3,4,7,8-PnCDF ng/kg lipid (ppt)	1,625 ± 94	580 - 3,430	28
1,2,3,4,7,8-HxCDF ng/kg lipid (ppt)	3,820 ± 250	1,300 - 10,330	20
PCBs ng/kg whole weight (ppt)	11,590 ± 1,500	2,220 - 67,800	1,670

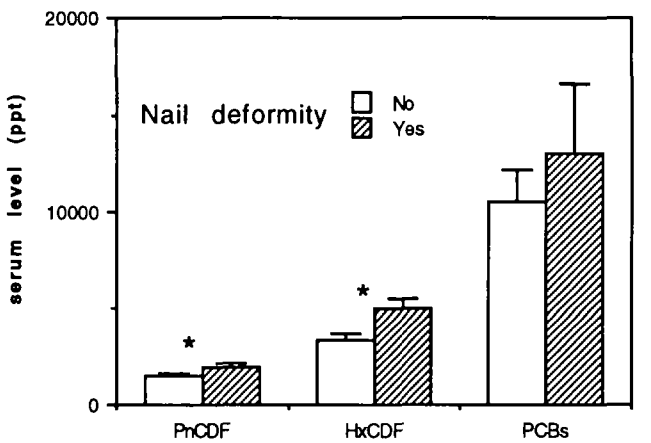

Figure. Serum levels of PnCDF, HxCDF, and PCBs in Yucheng mothers of children with and without nail deformity.
* p<0.05

Conclusion

We conclude that Yucheng victims continued to have detectable serum levels of PCB/PCDF congeners which were many times higher compared to the unexposed controls. Measurement of serum levels of PCB/PCDF in exposed mothers was well

correlated with the levels of previous exposure and with clinical manifestation in children who were exposed to the toxicants in utero from their mothers.

References

1) Jensen A.A. (1987): Polychlorinated biphenyls (PCBs), polychlorodibenzo-p-dioxins (PCDDs) and polychlorodibenzofurans (PCDFs) in human milk, blood, and adipose tissue. Sci. Total Environ. 64, 259-293.
2) Kimbrough R.D. (1985): Laboratory and human studies on polychlorinated biphenyls (PCBs) and related compounds. Environ. Health Prospect. 59, 99-106 .
3) Hsu S.-T., Ma C.-I., Hsu S. K.-H., Wu S.-S., Hsu N. H.-M., Yeh C.-C., and Wu S.-B. (1985): Discovery and epidemiology of PCB poisoning in Taiwan: A four-year followup. Environ. Health Perspect. 59, 5-10.
4) Rogan W.J., Gladen B.C., Hung K.-L., Koong S.-L., Shih L.-Y., Taylor J.S., Wu Y.-C., Yang D., Ragan N.B., and Hsu C.-C. (1988): Congenital poisoning by polychlorinated biphenyls and their contaminants in Taiwan. Science 241, 334-336.
5) Chen Y.C.J., Guo Y.L., Hsu C.C., and Rogan W.J. (1992): Cognitive development of Yu-Cheng ('oil-disease') children prenatally exposed to heat-degraded PCBs. JAMA 268, 3213-3218.
6) Guo Y.L., Lin C.J., Yao W.J., Ryan J.J., and Hsu C.C. (1994): Musculoskeletal changes in children prenatally exposed to polychlorinated biphenyls and related compounds (Yu-Cheng children). J Toxicol Environ Health 41, 83-93.
7) Ryan J.J., Levesque D., Panopio L.G., Sun W.F., Masuda Y., and Kuroki H. (1993): Elimination of polychlorinated dibenzofurans (PCDFs) and polychlorinated biphenyls (PCBs) from human blood in the Yusho and Yu-Cheng rice oil poisonings. Arch. Environ. Contam. Toxicol. 24, 504-512.
8) Hsu M. M. L., Chang J. C., and Hsu C. C. Nail changes in PCB poisoning. In: the 13th International Symposium on Chlorinated Dioxins and Related Compounds, September 24-28, 1993, Vienna, Austria.