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Exposure of young mothers and newborns to organochlorine pesticides (OCPs) in Guangzhou, China

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ABSTRACT

Exposure of young mothers and newborns to organochlorine pesticides (OCPs) were assessed by measuring the levels of OCPs in human milk (HM) and maternal blood (MB) and umbilical cord blood (UCB) samples from Guangzou in China. 21 OCPs were analyzed using gas chromatography/mass spectrometry (GC/MS). The results showed that the median levels (ranges) of total HCHs (four HCH isomers) in HM, MB and UBC were 54.7 (5.7–159.3), 43.7 (1.9–386.6), and 20.2 (4.0–103.2) ng/g lipid, respectively; and the median concentration of total DDTs (DDT and its metabolites) were 2114.6 (329.1–6164.6), 1676.0(283.4–6167.7), and 1287.8(189.6–3296.0) ng/g lipid, respectively. On a lipid basis, the chemical concentrations were in the order HM>MB>UCB. Comparison with literature data showed that the levels of ∑DTTs and ∑HCHs in milk and maternal blood samples were within the range reported in samples in other Chinese provinces and higher than those in developed or industrialized countries, but significantly lower than contaminated area such as in India. The predominant pollutant in the HCH family is β-HCH. *p,p′*-DDE is a predominant pollutant in all DDEs and DDDs and DDTs for all the samples tested, and accounted for more than 80% of total HCHs and DDTs.

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1. Introduction

Organochlorine pesticides (OCPs) are a group of persistent organic pollutants (POPs) and have been determined in different environment media in many countries. OCPs can cause environmental damage and human health risks because they have long half-lives of years to decades in the environment and biotics, are lipophilic, and have biological accumulation through the food chain (Laug et al., 1951; Egan et al., 1965; Torres et al., 2008). Several studies have reported that they have endocrine-disrupting activity (Botella et al., 2004; Fernàndez et al., 2004). It has been well established that OCPs can accumulate in human adipose tissue and cause chronic toxicity after long-term exposure, even if the exposure is at a relatively low dose (Dich et al., 1997). They can evoke estrogenic responses interfering with estrogen-controlled pathways and also change the development of endocrine systems (Olea and Olea-Serrano, 1996). Many organochlorine pesticides have been found to be carcinogenic in rodent studies (McConnell, 1994; Brody et al., 2004). Moreover, they can cause non-Hodgkin's lymphoma in both adults and children (Buckley et al., 2000; Meinert et al., 2000; Penelope et al., 2004); and can cause hepatotoxicity, wasting, immunotoxicity, developmental abnormalities, neurobehavioral effects, and population declines (Fox, 2001; Safe, 1993). They may more adversely affect fetal development than adults because human fetuses and infants are considered significantly more sensitive to a variety of environmental toxicants when compared with adults (Branum et al., 2004; Charnley and Putzrath, 2001; Needham and Sexton, 2000).

OCPs are extensively used in agriculture and public health for management of malaria in developing countries and have been detected in various environmental media, such as air, water, sediment, soil and biota (Bidleman and Wideqvist, 1987; Shukla et al., 2006; Strandberg et al., 1998; Hao et al., 2008; Wang et al., 2007). The presence of OCPs in human adipose tissue, blood, human milk has also been reported (Nakata et al., 2005; Poon et al., 2005; Kalantzi et al., 2004; Thomas et al., 2006). Although the manufacture and use of DTTs had been banned in China since 1983, the wide use of OCPs, particularly DTTs as insecticides in agriculture for many years, and their persistence in the environment has led to the higher environmental levels of OCPs in China than in most other countries. There are several reports of OCPs in human tissue including serum (Bi et al., 2007), adipose tissue (Nakata et al., 2002, 2005) and human

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milk (Poon et al., 2005; Kunisue et al., 2004; Wong et al., 2002) in China. However, there is no report about OCPs in maternal blood and the relationship of OCPs between mothers and fetuses in China until now. In this study, the aim was to analyze the level of OCPs in human milk (HM), maternal blood (MB) and umbilical cord blood (UCB) in Guangzhou, China, and examine the relationship of the OCPs between mothers and fetuses.

2. Materials and methods

2.1. Biological samples

In March of 2004, 90 samples including 30 HM samples, 30 MB samples and 30 UCB samples were obtained from the Guangzhou Second People's Hospital. Information such as age, diet and place of residence of the pregnant women as well as birth weight and sex of each baby was obtained. Blood samples for this study were drawn from the cubital vein of volunteers before pregnant women were parturient, and umbilical cord blood was collected from the umbilical cord vein after delivery. The serum was obtained from centrifuged blood, was transferred to 10 mL brown glass vials which had been precleaned by heating at 450 °C. Milk samples were collected at 2–8 days post partum. Serum samples and milk samples were kept at −20 °C until chemical analysis.

2.2. Instrumental analysis

Sample analysis was performed with a Hewlett-Packard (HP) 5890 gas chromatograph (GC) coupled with a 5972 mass spectrometer (MS) in the selective ion monitoring (SIM) mode. Splitless injection onto a DB-5 (30 m × 0.25 mm i.d., 0.25 μm film thickness; J&W Scientific, Folsom, CA) capillary column was used for the separation of OCPs, with helium (1 mL/min) as the carrier gas. The temperature of the injection port was set to 250 °C. The temperature of the column was programmed from 60 °C (2 min) to 200 °C (2.0 min) at a rate of 12 °C/min, to 270 °C (1.0 min) at a rate of 5 °C/min and finally to 290 °C (5 min) at a rate of 15 °C/min. Quantification of OCPs was carried out with an internal standard method.

2.3. Sample cleanup and analysis

The sample cleanup was performed following a previously described method (Qu et al., 2007) with minor modification. The surrogate standards 2,4,5,6-tetrachloro-m-xylene (TMX) and decachlorobiphenyl (PCB-209) were added to samples (serum or milk, 5 mL) in a Teflon separatory funnel. HCl (6 M) was added to the sample followed by rigorous blending. 2-propanol (12 mL) was then added and the sample was mixed again. The samples were subsequently extracted three times with hexane/dichloromethane (1:1 v/v) mixture. The combined extracts were washed with KCl aqueous solution. The organic phase was dried with anhydrous Na_2SO_4, reduced in volume to approximately 1 mL, evaporated to almost dryness under a gentle stream of nitrogen, and then dried in a silica gel desiccator. A gravimetric determination was made for the amount of extracted lipids. The lipids were dissolved with n-hexane and washed with concentrated H_2SO_4. The organic solvent was reduced to 1 mL and loaded onto a silica/sulfuric acid column (2:1 by weight; 1 g) with hexane/dichloromethane (2:1 v/v) mixture (8 mL) as the mobile phase. The eluted OCPs collection was reduced under a gentle nitrogen stream, resolubilized in hexane and transferred into a vial for GC–MS analysis. Pentachloronitrobenzene (PCNB), as an internal standard for OCPs, was added prior to GC–MS analysis.

2.4. Quality assurance and quality control (QA/QC)

Instrumental QC was performed by regular injection of solvent blanks and standard solutions, while the analyst and method QC was ensured through replicate sample analyses and procedural blanks (a procedural blank was run with each batch of six samples). Peaks were quantified only if the signal/noise was >3 and the ratio between two monitored ions was within 15% of the standard value and the concentration of the analyte was at least twice the blank sample level. The limit of detection (LOD) of individual DDTs and HCHs ranged from 0.5 to 0.8 ng/g lipid. The average recovery of the surrogate standards was 75.6%. Very low concentrations of *p,p′*-DDE were detected in procedural blanks. However the blank values were not subtracted from the sample measurements. The concentrations of analytes were not corrected for recovery efficiency.

2.5. Statistical analysis

Correlations between each OCPs and age, stature and weight of young mothers were examined using the SPSS 13.0 statistical software. Statistical significance was defined as a *p*-value less than 0.05.

3. Result and discussion

In this study, ninety samples including 30 HM samples, 30 MB samples and 30 CUB samples were analyzed for 21 OCPs (α-HCH, β-HCH, γ-HCH, δ-HCH, heptachlor, heptachlor epoxide, aldrin, dieldrin, endrin, endrin ketone, endrin aldehydes, *o,p′*-DDT, *o,p′*-DDE, *o,p′*-DDD, *p,p′*-DDT, *p,p′*-DDE, *p,p′*-DDD, endosulfan I, endosulfan II, endosulfan sulfate, and methoxychlor) in this study. Four isomers of HCH, two isomers of DDT and four metabolites are reported herein, because the other OCP compounds determined such as heptachlor, heptachlor epoxide, aldrin, dieldrin, endosulfan (I), endosulfan sulfate, endrin, endrin aldehyde and methoxychlor were only detected in less than 15% of all samples. Endosulfan (II) and endrin ketone were not detected in any sample. These young mothers lived in Guangzhou and none of them had any work-related potential for exposure to OCPs according to the information provided by them.

3.1. Concentrations of OCPs

The median and mean concentrations and ranges of α-HCH, β-HCH, γ-HCH, δ-HCH, *o,p′*-DDT, *o,p′*-DDE, *o,p′*-DDD, *p,p′*-DDT, *p,p* -DDE, *p,p*-DDD, ∑DDTs and ∑HCHs measured in the three types of samples are given in Table 1. The concentration ranges of DDTs were 329.1–6164.6, 283.4–6167.7 and 189.6–3296.0 ng/g lipid in HM, MB and UCB samples, respectively. When comparing the mean levels of total DDT in these three kinds of samples, it was observed that in the HM samples the total DDT levels were 1.6 times higher than the UCB samples (2114.6 ng/g lipid vs. 1287.8 ng/g lipid); and total DDT levels in the MB samples were1.3 times higher than in the UCB samples (1676.0 ng/g lipid vs. 1287.8 ng/g lipid). The concentration ranges of HCHs were 5.7–159.3 ng/g lipid, 1.9–386.6 ng/g lipid and 4.0–103.2 ng/g lipid in HM, MB and UCB, respectively. The mean levels of total HCH were 54.7, 43.7 and 20.2 ng/g lipid in HM, MB and UCB, respectively. It was observed that the order of OCP levels was HM>MB>UCB samples.

When comparing the OCP levels in human samples to other places in China, the level of DDTs in HM in this study was less than that in HM in Dalian of Liaoning province (2130 ng/g lipid; Kunisue et al., 2004); HM and breast tissue in Hong Kong (2870 and 2990 ng/g lipid; Poon et al., 2005); much lower than in Guangzhou in year 2000 (3550 ng/g lipid; Wong et al., 2002), and breast tissue in Shanghai (7600 ng/g lipid; tissue was from person of breast cancer; Nakata et al., 2002). However, the level of DDTs in HM is higher than in HM in Pingqiao