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Concentrations of organochlorine pesticides in cord serum of newborns in Wuhan, China

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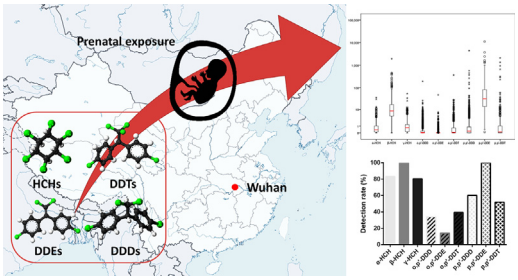
HIGHLIGHTS

- Cord serum is a reliable non-invasive tool for monitoring prenatal exposure.
- β-HCH and *p,p′*-DDE were the dominant OCPs in cord serum samples.
- There was a positive relationship between the exposure levels of two DDT isomers.

GRAPHICAL ABSTRACT



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ABSTRACT

Organochlorine pesticides (OCPs) had been widely used in China before they were banned decades ago due to the concern of the toxicology to human. Previous reports showed that OCPs were still often detectable in human bodies. However, there is limited study concerning the body burden of OCPs in infants and fetus in China. In this study, the prenatal exposure to OCPs was evaluated by measuring OCPs in cord serum. A total of 1046 cord serum samples were collected in Wuhan during 2014 and 2015, and analyzed for the concentrations of hexachlorocyclohexanes (HCHs), dichlorodiphenyltrichloroethanes (DDTs), dichlorodiphenyldichloroethanes (DDDs) and dichlorodiphenyldichloroethylenes (DDEs) by using gas chromatography-tandem mass spectrometry (GC–MS/MS). The median levels of ∑HCHs and ∑DDTs were 10.1 ng/g lipid (with the range from <LOD to 1910 ng/g lipid) and 35.5 ng/g lipid (with the range from 0.18 to 11,100 ng/g lipid), respectively. β-HCH and *p,p′*-DDE were found to be the major OCPs presenting in the cord serum samples. A minor positive association between the serum levels of α-HCH and β-HCH was observed, and the concentrations of o,p′- and *p,p′*-DDT isomers were found positively associated. The OCP exposure levels obtained in this study were comparable to those data from other areas in China and much lower than some of highly polluted countries. The prenatal exposure to OCPs would be of concern since fetuses were more vulnerable than adults and the cord serum is an accurate non-invasive matrix for monitoring of prenatal exposure.

1. Introduction

Organochlorine pesticides (OCPs), regarded as persistent organic pollutions, mainly consist of hexachlorocyclohexanes (HCHs) and dichlorodiphenyltrichloroethanes (DDTs). DDT could be metabolized to dichlorodiphenyldichloroethane (DDD) and

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dichlorodiphenyldichloroethylene (DDE). OCPs were widely used in agriculture, industry and the control of vector-borne diseases. Despite being banned for decades, OCPs may still be detected in the environment, animals and human bodies through the food chain (Turusov et al., 2002). Due to the resistance to degradation and persistence in the environment, OCPs have a half-life of years. It has been reported that OCPs could be accumulated in human bodies through food intake (Lee et al., 2007; Mcgraw et al., 2009).

OCPs are endocrine disrupting chemicals (EDCs) and may induce estrogenic response by interfering estrogen-controlled pathways and altering the development of endocrine systems. OCPs could act like androgen receptor antagonists with other endocrine disrupting environmental pollutants. The association of reproductive disorders and the exposure to OCPs has been suggested by epidemiology studies (Araki et al., 2018). The elevated OCP levels in woman bodies may increase the risk of preterm birth and spontaneous abortion (Korrick et al., 2001; Longnecker et al., 2001). In fast-growing stages of life, developing fetuses would be at higher risks than adults to EDCs because the fetuses are more vulnerable to the potentially adverse effects. Prenatal exposure to the EDCs was reported to be associated with increased risk of diseases in neonates, such as adverse birth outcomes and allergic diseases (Ren et al., 2011; Robledo et al., 2015; Rosenquist et al., 2017; Valvi et al., 2017).

The ability of OCPs to pass through the placental barrier has been reported, and the high correlation coefficients between maternal and cord serum concentration indicated that the levels of OCPs in cord serum could be used to estimate the maternal and neonatal burden both (Grimalt et al., 2010; Sala et al., 2001). The extent of OCPs passing through the placenta could be reflected by the concentrations in cord serum. Opposed to the maternal serum, cord serum levels of OCPs provide more direct evaluation of prenatal exposure. Moreover, the cord serum is a non-invasive type of sample, which allows more convenient and safer sample collection during the delivery compared to the collection of neonatal blood.

Monitoring is valuable to assess the current exposure level and judge the susceptible exposure mode. The continuous monitoring could further investigate the kinetics of contaminants and the trend of risks. HCHs and DDTs have been detected in tissue or blood samples collected from children and adults among the general populations (Rosenquist et al., 2017; Thomas et al., 2017; Thomas et al., 2006). Prenatal exposure to OCPs could be evaluated by monitoring their concentrations in cord serum. However, there were only a limited number of studies evaluating exposures in utero in China. In the present study a total of 1046 cord serum samples were collected from Wuhan where widespread contamination of OCPs along the Yangtze River has been documented (Müller et al., 2008). HCH isomers (α-HCH, β-HCH, γ-HCH) and the total DDT (DDT isomers and metabolites) were determined. The exposure levels in cord serum samples reflect prenatal exposure and provide useful information for assessing the continuous risk of the persistent compounds although being banned for decades.

2. Material and methods

2.1. Study population and sample collection

The study population was derived from a prospective cohort study conducted at the Wuhan Women and Children Medical Care Center in Wuhan, China. The pregnant women were enrolled if they had prenatal care, intended to give birth in the study hospital, and had no communication problems. The research protocol was approved by the ethics committees of the Tongji Medical College, Huazhong University of Science and Technology (No. (2012)07), and the related hospitals (No. 2012003). The written informed consent was provided by all participants. Cord serum samples (n = 1046) were collected at delivery in 2014 and 2015, and the centrifuged serum samples were frozen at −80 °C for the further analysis.

2.2. Analysis of OCPs in cord serum

Individual standards (α-HCH, β-HCH, γ-HCH, *o,p′*-DDD, *o,p′*-DDE, *o,p′*-DDT, *p,p′*-DDD, *p,p′*-DDE and *p,p′*-DDT) were purchased from Chem Service Inc. (West Chester, PA). Internal standards ($^{13}C_6$-labeled α-HCH and $^{13}C_{12}$-labeled *p,p′*-DDT) were obtained from Dr. Ehrenstorfer (Augsburg, Germany). All solvent and reagents are HPLC grade purity provided by VWR (Dresden, Germany). The sample preparation procedure and analysis by gas chromatography-tandem mass spectrometry (GC–MS/MS) were described in our previous method with minor modifications (Fang et al., 2017). Briefly, 100 μL of serum samples were spiked with internal standards (10 pg $^{13}C_6$-labeled α-HCH and 10 pg $^{13}C_{12}$-labeled *p,p′*-DDT) and added with 20 μL of formic acid and 120 μL of isopropanol to denature the proteins. The mixture was extracted by hexane/methyl tert-butyl ether (1:1, v/v) three times. The organic phases were combined and dried with nitrogen gas. The total serum lipids were determined gravimetrically (Blight et al., 1959). The extract was then reconstituted with 50 μL of hexane. The samples were analyzed by GC–MS/MS (7000C, Agilent Technologies, Santa Clara, CA, USA). Separation was achieved on a DB5-MS capillary column (30 m, 0.25 mm inner diameter and 0.25 μm thickness) with helium as the carrier gas. The triple quadrupole MS system was operated in multiple reaction monitoring (MRM). Detailed instrumental parameters, MRM transitions and the detection limits (LODs) are provided in Table S1. The LODs of the analytes were defined as 3 times of the signal to noise ratio and ranged from 0.30 to 1.5 pg/mL for all analytes. Fetal bovine serum was used as blanks and quality control (QC) samples spiked with known amount of HCHs and DDTs. Each batch of samples consisted of 10 cord serum samples and one QC sample. The concentrations of target compounds in the blanks should not exceed the LODs.

2.3. Statistical analyses

The OCPs concentrations were expressed in the level of ng/mL and adjusted by the lipid amount. For the statistical tests, the non-detectable concentration was accounted as a value equal to the LOD divided by the square root of 2 (Hornung et al., 1990). The SPSS Statistics for Windows of version 18.0 (IBM, Armonk, NY, USA) was used for data analysis, such as Spearman correlation analysis.

3. Results

3.1. General characteristics

The socio-demographic characteristics of the pregnant women and infants in this study are presented in Table 1. The mean maternal age was 28.2 ± 3.2 years old, and the overall range of age was between 18 and 44 years old. Only 10.8% of the women had a pre-pregnancy body mass index (BMI) over 24 kg/m^2 with the average BMI value of 20.6 ± 2.7 kg/m^2. Most subjects (944 of 1046) were primiparous. All the participating mothers were Wuhan residents currently and about 96.2% of them have lived more than one year. Most mothers received the formal education (higher than high school) and 47.5% of them had a college degree. About 32.4% of participants were unemployed while the others worked before or during the pregnancy. However, none of them had the occupational exposure to the selected OCPs. Among these newborns, 549 (52.5%) were boys. The average birth weight was 3341 ± 416 (1030–5270) g, the average birth length was 50.3 ± 1.6 (40–57) cm, and the average gestational age was 39.3 ± 1.2 (31.6–41.9) weeks.

3.2. Detection rates of OCPs

As seen in Table 2, detection rates of the OCPs in the cord serum of newborns ranged from 14.1 to 100.0%. β-HCH and *p,p′*-DDE were detected in 99.8% and 100.0% of the cord serum samples, respectively. The other two HCH isomers, α-HCH and γ-HCH, were present in