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Partitioning Coefficients of Organochlorine Pesticides Between Mother Blood Serum and Umbilical Blood Serum

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The use of persistent organochlorine insecticides in tropical countries has particular implications with regard to environmental quality and human exposure. DDT and Lindane have been recommended by WHO in tropical countries for the control of the spread of vector-borne diseases (WHO 1984; Tomlin 1997; Trigg et al. 1998). Public health programs in Mexico have utilized these insecticides of choice to control disease-transmitting organisms (CICOPLAFEST 1998).

The environmental contamination caused by persistent organochlorine insecticides, used especially in tropical countries in vector control campaigns and in combat of ectoparasites, has led many researchers to study the extent and magnitude of their spreading. Since human beings are the most exposed, it is not surprising, that high levels of organochlorine pesticide residues have been found in human adipose tissue and human milk fat (Kohlmeier et al. 1995; Waliszewski et al. 1998; 1998). The lipid-rich human tissues have proven to be good indicators of exposure originating from environmental and food contamination (Kohlmeier et al. 1995; Goldman et al. 1995). Therefore, they are also indicators of the extent of population exposure to these pollutants (Bailar 1995; Ezzati-Rice et al. 1995) and of the existing hazards (Lee et al. 1995; Lopez-Carrillo et al. 1996). In tropical countries, where they are used to combat the vector-transmitting diseases, higher levels of their residues have been observed in human fat-rich tissues, as a result of the widespread contamination caused by their drift from sprayed areas (Waliszewski et al. 1998).

Recently in Mexico, the persistent organochlorine pesticides, such as DDT, which was the most extensively used in sanitary actions, were replaced by the less persistent pyrethroids. This change has been immediately reflected by a decrease of DDT and its metabolites observed in recent years in human adipose tissue and human milk fat (Waliszewski et al. 1998). The aim of this study was to establish the coefficients of partitioning most important organochlorine pesticides between mother blood serum and umbilical blood serum expressed on fat basis, as a

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consequence of environmental exposure in tropical areas of Mexico, where the organochlorine pesticides are sprayed to combat vector–transmitted diseases.

MATERIALS AND METHODS

Mother's blood serum and umbilical blood serum samples from ninety volunteer mothers were obtained during the period from October 1997 to December 1998 among patients admitted for cesarean delivery. A requirement for participants was that they must have resided in Veracruz or its suburban area for at least the previous 12 months. The blood samples, approximately 10 ml, were obtained from fasting mothers one hour before cesarean and umbilical cord blood was taken after the umbilical cord was cut.

The blood samples were analyzed according to the previously described method (Waliszewski and Szymczynski 1991). The qualitative and quantitative determinations were done by gas chromatography on Varian 3400CX apparatus equipped with a ^{63}Ni electron capture detector. A volume of 1 µl was injected in splitless mode into a PTE-5 QTM 15 m x 0.53 mm id. 0.5 µm film capillary column, using nitrogen as carrier gas with a 6.7 ml/min flow rate and the following temperature program: 140°C (3 min) to 250°C at 10°C/min, hold 10 min. The temperatures of the detector and injector were 320°C and 220°C respectively.

All blood samples were analyzed for the presence of: HCB, α–, β–, γ–HCH, pp'DDT, op'DDT and pp'DDE. The minimum detection limits expressed on fat basis for the organochlorine pesticides studied were: 0.001 mg/kg for HCB and HCH isomers, 0.002 mg/kg for pp'DDE and 0.003 mg/kg for pp'DDT and op'DDT.

To determine the quality of the method, the recovery study was performed on ten overspiked replicates of a blank cow blood serum sample, which revealed contamination levels below the detection limits. The fortification study, done at 0.005 to 0.020 mg/kg levels, depending on the pesticide, showed mean recovery values form 89% to 95%. Standard deviation and coefficient of variation were below 10 which indicated excellent repeatability of the employed method.

The total serum lipids were determined colorimetrically using phosphovanillin according to the method recommended by Wiener Lab for clinical laboratories.

Differences between organochlorine pesticide levels in mothers blood serum and umbilical blood serum were examined using multi-way analysis of variance. The paired Pearson correlation factors *(r)* and coefficient of

partitioning (Kp) were calculated between both paired samples by the statistical software Minitab 12.

RESULTS AND DISCUSSION

Chemicals that are highly lipophilic are usually considered to transfer very readily through placental membranes. The equilibrium model for persistent organochlorine pesticides in the human body during pregnancy can describe the partitioning rate of these compounds between maternal and fetal tissues (Juchau 1983; Russel et al. 1999; Rhainds et al. 1999). When the organochlorine pesticide levels are expressed on fat basis, the equilibrium model permits the determination of internal distribution within the organism, which can be assumed to be uniform among lipid-rich tissues (Mes 1992; Parham et al. 1997). Persistent lipophilic compounds reside largely in lipids and the solubility of organochlorine pesticides does not differ importantly among different lipids (Noren et al. 1999; Longnecker et al. 1999). Thus, their equilibrium between maternal and fetal organisms is defined as chemical fugacities in maternal and fetal tissues. The apparently equal concentrations assumed for both sizes of organisms, therefore depends on the lipid content of the tissues and liposolubility of the pesticide. Pregnancy involves the transfer of lipids and lipoproteins from maternal tissues through the placenta to the developing fetus, a process which results in transfer of dissolved organochlorine pesticides through the placenta and their presence in lipid - rich tissues of the fetus. Xenobiotics with molecular weights greater than 100 would normally pass through placental membranes principally via simple passive diffusion (Juchau 1983). The metabolization of accumulated residues in the fetus is low due to the poor detoxification mechanisms of the developing organism. The rate of transfer could be enhanced as the result of the tendency to maintain a concentration gradient for the diffusible form.

During the study, blood serum samples from 90 volunteer mothers and blood serum from the umbilical cords were analyzed to determine the organochlorine pesticide residue concentrations in both paired samples. The results obtained expressed on fat basis (mg/kg) and the statistical calculations are presented in Table 1 as frequency of residue presence, ranges of values obtained, means and standard deviation of means, median, mean of partitioning coefficient and their standard deviation and quartiles. The greatest residue frequency reveals the most persistent and lipophilic compounds such as pp'DDE and HCB, followed by β-HCH and pp'DDT. The pesticides γ-HCH, α-HCH and op'DDT express minor frequencies in both types of analyzed samples. The comparison of mean and median values for specific organochlorine pesticides between both sample groups (mother blood serum and umbilical blood serum) indicates the highest values for umbilical blood serum determined for all pesticides. The results verify the existence of previously mentioned phenomena, free

Table 1. Frequency, ranges, mean (x), standard deviation (SD), median, quartiles (Q1 - Q3) and coefficient of partitioning (Kp) of organochlorine pesticides (mg/kg on fat basis) between blood serum and umbilical blood serum from 90 mothers living in Veracruz .

Pesticide	Frequency	Ranges	X ± SD	Median	Q1 - Q3	Kp X ± SD
HCB-serum	90/90	0.016 – 1.160	0.191 ± 0.152	0.167	0.115 - 0.219	0.650 ±0.243
HCB-umbilical	89/90	0.000 – 1.518	0.273 ± 0.229	0.259	0.159 - 0.376	
α-HCH-serum	10/90	0.59 – 0.152	0.046 ± 0.042	0.032	0.022 - 0.052	0.818 ± 0.262
α-HCH-umbilical	9/90	0.000 – 0.180	0.059 ± 0.051	0.042	0.025 - 0.077	
β-HCH-serum	60/90	0.000 - 0.857	0.287 ± 0.251	0.251	0.161 - 0.390	0.849 ±0.308
β-HCH-umbilical	51/90	0.000 - 0.976	0.366 ± 0.303	0.303	0.184 - 0.489	
γ-HCH-serum	22/90	0.74 – 0.084	0.045 ± 0.236	0.042	0.029 - 0.068	0.692 ± 0.428
γ-HCH-umbilical	10/90	0.000 – 0.137	0.074 ± 0.046	0.072	0.026 - 0.117	
pp'DDE-serum	90/90	0.242 - 20.856	4.378 ± 3.846	3.627	1.549 5.966	0.943 ± 0.286
pp'DDE-umbilical	90/90	0.250 -17.716	4.676 ± 3.501	4.001	1.703 - 6.221	
op'DDT-serum	10/90	0.000 - 0.918	0.300 ± 0.290	0.212	0.100 - 0.458	0.796 ± 0.326
op'DDT-umbilical	9/90	0.000 - 0.814	0.354 ± 0.293	0.266	0.117 - 0.635	
pp'DDT-serum	52/90	0.800 – 11.264	1.848 ± 2.469	0.826	0.478 - 2.162	0.875 ± 0.308
pp'DDT-umbilical	44/90	0.000 – 15.929	2.800 ± 1.225	1.225	0.759 - 3.614	

transfer of organochlorine pesticides and poor enzymatic fetus activity to metabolize accumulated compounds, that results in the formation of concentration gradients according to the partitioning capacity.

A partitioning coefficient of 1.0 indicates equal concentrations of compounds studied among both compartments. Of the organochlorine pesticides, pp'DDE indicates the highest partitioning coefficient Kp mean value of 0.943, which is very near to equal concentrations determined in mother blood serum and umbilical blood serum samples. The pp'DDE value is followed by Kp 0.875 for pp'DDT and Kp 0.849 for β-HCH, pesticides which visually reveal major concentrations in umbilical cord blood serum. Minor partitioning coefficients were calculated for HCB and γ-HCH. It seems that the capacity for pesticide accumulation in specific compartments of the human body depends on the proper physical-chemical properties of each pesticide. This permits the formation of an equilibrium pattern between both compartments, their specific accumulation caused by inability of rapid metabolic transformation and detoxification processes.

The calculated Pearson correlation factors for organochlorine pesticide studied in paired mother blood serum and umbilical blood serum, presented in Table 2, indicate very effective correlation, as well as an equilibrium pattern between these body compartments during pregnancy.

In summary, it can be concluded that organochlorine pesticides absorbed from contaminated food or inhaled contaminated air and stored by pregnant women are distributed among all body compartments, including mother blood serum and umbilical cord serum to a degree dependent on their individual physical-chemical properties and the capacity for their metabolization.

Table 2. Pearson correlation factors calculated for pesticide studied in mother blood serum and umbilical blood serum from 90 volunteers

Pesticide	Pearson correlation
HCB serum - HCB umbilical	0.834 very effective
α-HCH serum - α-HCH umbilical	0.955 very effective
β-HCH serum - β-HCH umbilical	0.875 very effective
Σ-HCH serum - Σ-HCH umbilical	0.849 very effective
DDE serum - DDE umbilical	0.854 very effective
pp'DDT serum - pp'DDT umbilical	0.799 very effective
Σ-DDT serum - Σ-DDT umbilical	0.874 very effective

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