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DDT and PCBs in Human Milk: Implication for Breast Feeding Infants

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The presence of organochlorine compounds (OCCs) in human milk has been reported in studies from various countries during recent years (Wickstrom et al., 1982; Baluja et al., 1982; Fytianos et al., 1985; Ramakrishnan et al., 1985). Significant levels of pp'-DDT, pp'-DDE and polychlorinated biphenyls (PCBs) were found in cord blood (Krauthacker et al., 1980; Roncevic et al., 1987). It is known these compounds are transferred to infants from their mothers across the placenta and via lactation (Kodama and Ota, 1980; Siddiqui et al., 1981). Milk secretion is the most important route of excretion of OCCs in women. In most reported studies the milk was collected once from each subject. The amount of pp'-DDT, pp'-DDE and PCBs in human milk at different time intervals after birth was reported earlier (Curley and Kimbrough, 1969; Kodama and Ota, 1980), but data concerning the time course are sparce in the literature. Many researchers collected samples of mother's milk during the first week of lactation, but mature milk (beginning two to six weeks after delivery) is most relevant concerning OCC intake by breast-fed infants.

Our previously published paper (Roncevic et al., 1987) showed significant correlation between maternal and cord blood concentration of OCls and PCBs. This paper reports levels of pp'-DDT, pp' -DDE, op'-DDE and PCBs in human colostrum and milk. This study was performed in order to investigate the relationship of OCC concentrations in colostrum and milk and the infant intake of these chemicals during 8 months of breast-feeding.

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MATERIALS AND METHODS

Samples of colostrum and milk were obtained in the winter of 1984/85 from women, who were urban residents of South Bachka (Northern Yugoslavia). These 14 women were members of the group for which blood data were reported in Roncevic et al. (1987). Breast milk samples were collected starting one to two months post-partum from 7 women. Four women gave more than two samples at various lactating periods. Samples were stored at -20°C until analyzed.

The infants food source during the first month of life was only milk from their mothers. Additional food was diluted lemon juice. The daily consumption of milk was determined by weighing the infant before and after feeding during 24 hours.

Gas chromatographic analysis was performed using a Varian Model 3700 gas chromatograph equiped with a 63-Ni electron capture detector. Determination of OCls was carried out using a 2 m x 2 mm glass column packed with 1.5% 0V-17 and 1.95% QF-I. The column temperature was 200°C, the injector 240°C and the detector 270°C. The determination of PCBs employed a 30 m x 0.3 mm capillary column coated with SE-30 (Supelco). The initial column temperature was 55° C, held for 1.5 min, after the injection (splitless) and programmed from 55° to 190°at 15° C/min and from 190° C to 220° C at 2° C/min. Standard curves from 0.01 to 0.1 ng/µl were used for quantitation of OCls. Concentrations of PCBs were calculated by summation of components 28, 52, 101, 118, 138, 153, 170, 180 (IUPAC) from a 1:1 mixture of Arochlor 1254 and 1260. Statistical evaluation was carried out using linear regression analysis.

RESULTS AND DISCUSSION

The results of linear regression analysis of OCC levels in 14 maternal blood samples (Roncevic et al., 1987) and colostrum are shown in Table 1.

Table 1. Relation of OCC concentration (µg/kg) in maternal blood serum and colostrum examined by linear regression analyses for four components

Chemical	Intercept	Slope	r-squared	P-value
op'-DDE	0.51	0.22	0.21	0.10
pp'-DDE	6.95	0.04	0.60	0.40
pp'-DDT	3.02	0.11	0.10	0.29
PCBs	5.14	0.64	0.05	0.67

There was no significant correlation between maternal blood and colostrum levels in this study. Sidiqui et al. (1981) found a significant correlation between DDT levels in the maternal blood and milk, while Krauthacker et al. (1980) did not find such a correlation.

The data in Table 2, expressed in micrograms per kilogram of milk (μg/kg), show individual concentrations of DDT and metabolites, and PCBs in colostrum and breast milk samples collected at different periods of lactation. The concentration of PCBs in almost all analyzed colostrums and milks is of the same order of magnitude as those of pp'-DDT.

Table 2. Individual concentrations of OCC (μg/kg) in colostrum and milk taken from 7 mothers at various times during lactation

		Time of lactation (Months post partum)							
Sub.	OCC	Col.	Mo.1-2	Mo.3	Mo.4	Mo.5	Mo.6	Mo.7	Mo.8
1.	op'-DDE	1.1	0.6		0.7	0.3	0.1		0.6
	pp'-DDE	79.0	83.1		89.6	62.0	59.3		66.2
	pp'-DDT	5.7	22.8		30.9	25.0	25.1		27.3
	PCB's	9.8	15.6		15.0	10.5	8.9		11.8
2.	op'-DDE	1.0		0.5	0.2			0.3	0.3
	pp'-DDE	15.0		53.9	46.2			43.6	51.3
	pp'-DDT	7.0		5.7	5.6			7.0	7.5
	PCB's	3.3		4.6	4.8			5.1	13.1
3.	op'-DDE	2.0	0.3	0.3	0.8	2.4	2.1		
	pp'-DDE	75.5	56.3	63.5	63.8	46.6	54.8		
	pp'-DDT	20.7	6.4	7.8	5.3	10.3	13.8		
	PCB's	9.3	12.5	9.7	17.1	13.9	16.5		
4.	op'-DDE	0.7	0.4	1.1	0.2	0.2			
	pp'-DDE	40.2	61.8	49.8	69.1	54.5			
	pp'-DDT	3.6	6.5	5.9	6.3	3.5			
	PCB's	6.2	6.3	7.4	9.3	7.3			
5.	op'-DDE	1.5	0.7	1.5					
	pp'-DDE	33.2	37.5	44.3					
	pp'-DDT	5.5	4.8	5.5					
	PCB's	5.0	12.8	13.5					
6.	op'-DDE	1.2	1.3						
	pp'-DDE	17.3	35.4						
	pp'-DDT	4.1	4.9						
	PCB's	4.1	8.1						
7.	op'-DDE	0.5	0.3						
	pp'-DDE	40.0	59.1						
	pp'-DDT	5.3	13.5						
	PCB's	7.9	11.2						

Comparison of the results for colostrum in this study with the published data from 1982/83 study in same region (Vukavic et al., 1986), indicates that both pp'-DDT and pp'-DDE levels have been decreased in the last few years. The average pp'-DDE (52.84) and pp'-DDT (9.94) levels in human milk reported herein are very close to those (pp'-DDE=53 and pp'-DDT=10) reported by Krauthacker et al. (1980) from Croatia (North-West Yugoslavia). This similarity of DDT and DDE concentrations in milk collected several years apart, could mean that residents of South Bachka were more exposed to DDT in past than residents of the North-West region of Yugoslavia. The use of DDT in Yugoslavia was restricted in 1972.

The relation of pp'-DDT, pp'-DDE, op'-DDE and PCB concentrations in milk and colostrum examined by linear regression is given in Table 3. The geometric mean of two or more milk samples per donor was related to the colostrum values.

Table 3. Relationship of OCC concentration (µg/kg) in colostrum and milk examined by linear regression analyses for seven individuals (data from Table 2.)

Chemical	Intercept	Slope	r-squared	P-value
op'-DDE	0.57	0.076	0.01	0.815
pp'-DDE	39.64	0.34	0.69	0.02
pp'-DDT	9.71	0.034	0.0008	0.952
PCBs	5.70	0.75	0.53	0.062

It can be seen that colostrum and milk levels are related. The P value for pp'-DDE (p=0.02) is statistically significant and the P value for PCB's (p=0.062) is close to significance. These two compounds are dominant in colostrum and milk because of their significant accumulation in the body. When colostrum is secreted, 2-4 days after delivery, women have limited food intake. Probably all the pp'-DDE and PCBs in colostrum are coming from previously accumulated amounts in body fat. Adamovic et al. (1978) reported that the amount of excreted pp'-DDE in milk is 11-14 times higher than intake by food, which can be the explanation for the significant correlation between colostrum and milk values of pp'-DDE.

The individual levels of pp'-DDT, pp'-DDE and PCBs show variation at the different time intervals tested. Table 4, shows the relationship of OCC concentration in milk to the period of lactation between 2 and 8 months after delivery. It is clear that the concentration of pp'-DDE decreases somewhat (3% per month) during lactation (p=0.08). However, this is only marginally statistically significant since the individual variation was pronounced. DDT and PCBs show increases of 3% and 6% a month, respectively.

Table 4. Relationship of OCC concentration (µg/kg) in milk to time of lactation for pp'-DDT, pp'-DDE and PCBs for subjects 1-4 of Tables 1 and 2*. Data normalized to the geometric mean for each individual taken as 100%.

Chemical	Slope	r- squared	P-value
pp'-DDE	-3.15	0.19	0.08
pp'-DDT	3.09	0.06	0.33
PCB's	5.99	0.11	0.20

*op'-DDE not included because levels too low

Klein et al. (1986) found a linear decrease on subsequent days from day 2 to day 10 of breast feeding in the elimination kinetics of DDE. The general tendency is a gradual decrease of OCC residue levels in milk during the first six moths of the lactation (Jensen, 1983). However, Curley and Kimbrough (1969) reported that the mean concentration for pp'-DDT decreases during 96 days of lactation while that of pp'-DDE increases, but not statistically significantly. Yakushiji et al. (1979) found a gradual and considerable decrease of PCB levels in milk fat during the first 6 months of lactation. All these studies were done at different time intervals of lactation and in different countries. However, there was no statistically significant correlation between the concentration of OCC in milk and time during the lactation period. The levels of DDT, DDE and PCBs in milk showed a great deal of individual variation, which is not case for different milk samples from the same mother. The concentrations of OCC in milk do not change markedly throughout the lactation period.

The daily intakes via breast milk by three infants of the major organochlorine contaminants, PCBs, DDT and metabolites, have been calculated from the levels in the milk samples, the daily consumption of milk and the body weight of the infant. The results are summarized in Table 5.

Almost every published paper gives the daily intake of an average child, which doesn't mean much because in reality every breast-fed infant is exposed to different amounts of OCC. Many investigators published daily intakes by neonates calculated using an assumed volume of milk consumed. Our findings are based on the daily consumption of milk obtained by weighing the infants. The average milk consumption of a one to two months old infant would be 600 g/24h. Two infants were exposed to residues of PCBs in amounts higher than the ADI (FAO/WHO,1987). The residues of DDT did not exceed the permissible daily intake level of FAO/WHO, 1985. These amounts are smaller than in India (Ramakrishnan et al., 1985) and larger than in Finland, but also different for each child. Only 10-20% of "total DDT" is pp'-DDT in the three infants reported here. The body burden of each infant depends on body burden of the mother and is increasing with time.

Table 5. Daily intake of DDT and PCB residues by three breast fed infants

	Infant 2	Infant 3	Infant 6	
Weight (kg)	5.35	4.35	5.75	
Phase of lactation(days)	70	37	61	
Milk intake (g/24h)	670	600	530	
Residues (μg/kg/day)				ADI(μg/kg/day)
op'-DDE	0.07	0.04	0.12	
pp'-DDE	10.40	7.76	3.27	
pp'-DDT	2.85	0.88	0.45	
Total DDT	13.32	8.67	3.83	0-20
PCBs	1.95	1.7	0.75	1.0

Table 6 gives an example of intake of OCC residues by one breast fed infant at different phases of lactation.

Table 6. Calculated daily intake for one breast fed infant (μg/kg/day)

Phase of lactation(days)	37	80	108
Milk intake(g)	600	(808)	(1000)
Body mass(kg)	4.35	5.60	6.15
op'-DDE	0.04	0.05	0.13
pp'-DDE	7.76	9.07	10.37
pp'-DDT	0.88	1.12	0.86
Total DDT	8.67	10.24	11.36
PCBs	1.72	1.38	2.78

Calculated milk consumption in parentheses
(Mardesic, Pedijatrija)

It was estimated using the data from Table 6 that the child consumed approximately 75 kg milk during the 108 days from the day of birth. The cumulative intake for this infant during 108 days of breast feeding would be approximately 1 mg of PCBs, 4.25 mg of pp'-DDE and 0.66 mg of pp'-DDT, which greatly exceeds, even on a per kg body weight basis, the body burden at birth, from transplacental transport.

Daily intake and cumulative intake is higher for pp'-DDE than pp'-DDT and in future this difference will be larger. It would be better that the ADI is given for pp'-DDT only, since this is an indicator of recent intake, rather than total DDT level.

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