

A STUDY ON PESTICIDE RESIDUES IN UMBILICAL CORD BLOOD AND MATERNAL MILK

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A survey on pesticide residues in umbilical cord blood and maternal milk was made from August 1974 to January 1975 in Taipei. All samples were extracted with normal hexane and analyzed by a gas chromatography using an electron capture detector.

This paper is a report on the concentration of seven compounds, α -BHC, β -BHC, γ -BHC, δ -BHC, o.p'-DDT, p.p'-DDT and malathion, in the cord blood of 100 subjects. In a separate study, 12 samples of maternal milk collected from among the above 100 subjects were analyzed for the same compounds. Our observations indicated that the levels of DDT residues were low and only detected in a few samples, but the levels of BHC residues were high and detected in all samples. The results showed that people living in this city were heavily exposed to BHC, moderately exposed to malathion, and only slightly exposed to DDT.

Another significant finding in this study was that the extent of the exposure to pesticides was related to the favorite food and residential location of subject. The residual levels in cord blood of those mothers who lived in the downtown area of Taipei city were higher than those who lived in Taipei suburban area. The differences in the pesticide residual levels may be attributed to dietary differences. Significant differences were found between fish-favoring group and fruit-favoring group, and between fish-favoring group and vegetable-favoring group.

The findings of this study suggest that pesticides, especially BHC, should be used with caution.

Key words: *pesticide residues, umbilical cord blood, maternal milk.*

After World War II, pesticides such as organochlorine insecticides, organophosphorus insecticides and organomercury fungicides were used effectively for the controls of injurious insects and diseases of agricultural crops. In 1968, Wurster Jr. and Wingate reported that DDT residues could affect reproduction of birds.⁽¹⁾ One year later, a paper, titled "Transmission of dieldrin

from insects to their progeny" was published by Watts.⁽²⁾ Recently, papers concerning organochlorine residues were published successively. It was found that organochlorine residues could persist in various tissues, maternal milk, blood and umbilical cord blood of human body, and even pass the placental barrier into amniotic fluid and fetus.⁽³⁾⁻⁽⁸⁾ This situation presented the

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serious concern that organochlorine pesticide residues would be harmful to the human body and our offspring.⁽⁹⁾

In Taiwan, huge quantity of organochlorine pesticides was sprayed for public health and agricultural purposes. Before 1970, DDT had been used for the malaria eradication project for a long time and adrin, dieldrin, endrin and lindane were employed for the protection of various crops against insects. The practice of domestic spraying of insecticides, including BHC, was not uncommon. No information is yet available as to the occurrence of pesticides in the body tissue of the general population in our country. As we were concerned about preventions of chronic diseases caused by pesticides, studies on pesticide residues in maternal milk and cord blood were made at first to provide informations for accumulation of these chemicals, and then to compare them with the corresponding residual levels of other countries.

METHODS AND MATERIALS

All samples were collected from obstetric patients at Taipei Ho-Ping Hospital from August 1974 to January 1975. A total of 100 samples of umbilical cord blood were obtained and treated with mixture of potassium oxalate and ammonium oxalate.

The procedures used in the analysis of blood samples were described by Tanabe H. in his book titled "Analyses of residual pesticides."⁽¹⁰⁾ Five grams of blood sample was treated with acetonitrile and centrifuged. The supernatant layer was decanted, treated with 2% sodium chloride solution and extracted with normal hexane. The extract was chromatographed over a florisol column with a mixture of ether and n-hexane (30:170) as the eluting solvent. Then, the elute was analyzed by a gas chromatography using an electron capture detector.

Twelve samples of maternal milk were collected from among the above 100 mothers at two or three days post partum and were analyzed by the same method as on blood.

RESULT AND DISCUSSION

The chronic influence of malathion will be neglected in this paper since metabolism and degradation of organophosphorus insecticides, such as malathion, in plants and animals are generally faster than those of organochlorine insecticides, such as BHC and DDT.⁽¹¹⁾ With the characteristics of high stability in environment and accumulation in living bodies, organochlorine insecticide residues will be discussed here.

In Table 1, it can be found that the percentages of cord blood samples in which organochlorine insecticide residues could be detected decreased in the following order: α -BHC, γ -BHC, δ -BHC, o.p'-DDT, β -BHC and p.p'-DDT, and the levels of these persistent residues: γ -BHC, α -BHC, δ -BHC, β -BHC, o.p'-DDT and p.p'-DDT. The data show that in cord blood, DDT residues which were in very low concentration were detected only in a few samples, but the BHC residues in high concentration were detected in all samples.

Table 2 shows that the residual levels in cord blood were high in the downtown area of Taipei city and low in Taipei suburbs. E. C. Tabor pointed out that the organochlorine residual level in the air of the urban area was even about five times higher than that of a rural area.⁽¹²⁾ John E. Davies reported that the residual level in home dust was about fifteen times of that in the dust outside the door.⁽¹³⁾ In the urban area, the conveniences of modern life made people tend to live indoor more than outdoor. Thus, the hustle and bustle of the indoor life in urban area may result in the higher con-

Table 1. The Levels of Various Pesticide Residues in Cord Blood. (ppm)

Statistical value	BHC Residues					DDT Residues			Malathion Residue
	α -BHC	β -BHC	γ -BHC	δ -BHC	total BHC	o. p'-DDT	p. p'-DDT	total DDT	
	Range	0-0.1026	0-0.0503	0-0.1892	0-0.0895	tr.-0.2195	0-0.2170	0-0.0700	
Mean	0.0150	0.0016	0.0343	0.0072	0.0582	0.0056	0.0007	0.0063	0.9339
Standard deviation	0.0161	0.0073	0.0375	0.0175	0.0520	0.0257	0.0069	0.0028	1.1317
Detected %	97	7	94	18	100	13	1	13	73

Table 2. Comparison of Pesticide Residual Levels in Cord Blood in Accordance with Different Maternal Residences. (ppm)

Residence area	No. of Subjects	BHC Residues					DDT Residues			Malathion Residue
		α -BHC	β -BHC	γ -BHC	δ -BHC	total BHC	o. p'-DDT	p. p'-DDT	total DDT	
		Taipei city*	0.0167 ± 0.0192	0.0026 ± 0.0092	0.0366 ± 0.0258	0.0078 ± 0.0193	0.0637 ± 0.0550	0.0045 ± 0.0238	***	
Taipei suburbs**	0.0154 ± 0.0104	0.0000	0.0211 ± 0.0159	0.0040 ± 0.0097	0.0405 ± 0.0242	0.0000	0.0000	0.0000	0.5705 ± 0.8951	
The others	0.0104 ± 0.0064	0.0002 ± 0.0012	0.0295 ± 0.0321	0.0091 ± 0.0203	0.0492 ± 0.0417	0.0088 ± 0.0195	0.0000	0.0088 ± 0.0195	0.9772 ± 1.2127	
Total	100	0.0150 ± 0.0161	0.0016 ± 0.0073	0.0343 ± 0.0375	0.0072 ± 0.0175	0.0582 ± 0.0520	0.0056 ± 0.0257	***	0.0056 ± 0.0257	0.9339 ± 1.1317

* Taipei city included the old city area.

** Taipei suburbs included Ging-mei (景美), Moo-tzah (木柵), Nan-kang (南港), Neh-hoo (內湖), Hsin-lin (士林), and Pei-tou (北投).

*** one case only and neglected.

tamination.

The data presented in Table 3 were arranged according to the different food favored by mothers. From the figures shown in Table 3, the fish-favoring group had higher levels of BHC isomers than the fruit-favoring group and the vegetable-favoring group. The residual level ratios of fish-favoring group to vegetable-favoring group were 0.0563 ppm: 0.0281 ppm ($P < 0.05$) and 0.0838 ppm: 0.0493 ppm ($P < 0.05$) for γ -BHC and total BHC respectively. In the same manner, the residual level ratios of fish-favoring group to fruit-favoring group were 0.0054 ppm: 0. ppm ($P < 0.05$), 0.0563 ppm: 0.0271 ppm ($P < 0.05$) and 0.0838 ppm: 0.0511 ppm ($P < 0.05$) for β -BHC, γ -BHC and total BHC, respectively. These statistically significant differences may be resulted from the fact that pesticide residues in polluted water could be stored and concentrated in the fish body due to the food chain, respiration and absorption. Therefore, men who favored fish would store more residues than other people. In other respects, although the organochlorine pesticide residues remained only under 0.1 ppm in rice grains and could be removed partially by polishing, washing and cooking also,⁽¹¹⁾ the levels of the pesticide residues of rice and flour still need further survey, since rice and flour are two main kinds of food of the Chinese.

The comparison of pesticide residual levels in blood of people of this country with those of other countries is listed in Table 4. The level of total BHC residues, especially γ -BHC, in this country was higher than that in England, America and Japan, but the level of total DDT was not except Japan. Although the percentage of β -isomer in total BHC residues in Japan (54.1%) was higher than that in this country (2.7%) and the chronic toxicity of β -BHC was about five times more potent than that of the other isomers,⁽¹²⁾⁽¹⁴⁾ the

total chronic toxicity of all BHC isomers in this country was still higher than that in Japan. This may be the result of the consecutive application of tremendous amount of lindane (γ -BHC) for the control of injurious insects of rice plants, vegetables and fruits in Taiwan.

The 12 samples of maternal milk collected from among the above 100 subjects were compared with those of cord blood using t-test statistics. The average pesticide residual levels in cord blood vs that in maternal milk are shown in Table 5. The levels of some isomers of pesticide residues in maternal milk were slightly higher than those in cord blood, namely, the differences in α -BHC and β -BHC were significant.

The comparison of pesticide residual levels in maternal milk between our country and the foreign countries is shown in Table 6. In this country, the level of total BHC residue in maternal milk was higher than in England and America.

From the data shown in Tables 1, 4 and 6, it could be concluded that the pesticide residual levels were affected by the elapsed time after application of pesticides. It could be found that the residual DDT in Taiwan has been reduced gradually since the use of DDT was banned in 1970, but the levels of the residual BHC is still high, therefore the control of the BHC residues must be emphasized. In 1975, the application of BHC was prohibited by our government for the agricultural purpose, and hence a decrease of BHC residual level would be expected in the near future.

Owing to the persistence of organochlorine pesticide residues in the human body, it seems to be meaningful to do further study in this field.

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Table 3. Comparison of Pesticide Residual Levels in Cord Blood in Accordance with Different Food Favored by Mothers. (ppm) ($\bar{x} \pm S.D.$)

Favored Food	No. of Subjects	BHC Residues						DDT Residues		Malathion Residue
		α -BHC	β -BHC	γ -BHC	δ -BHC	total BHC	o, p' -DDT	p, p' -DDT		
Meat	29	0.0128 \pm 0.0094	0.0006 \pm 0.0025	0.0337 \pm 0.0470	0.0098 \pm 0.0218	0.0569 \pm 0.0602	0.0041 \pm 0.0150	0.0000	0.7804 \pm 0.9822	
Fish	16	0.0163 \pm 0.0162	0.0054 \pm 0.0139	0.0563 \pm 0.0379	0.0058 \pm 0.0126	0.0838 \pm 0.0456	0.0000	0.0000	1.0993 \pm 1.1955	
Vegetable	30	0.0163 \pm 0.0029	0.0021 \pm 0.0080	0.0281 \pm 0.0346	0.0022 \pm 0.0104	0.0493 \pm 0.0541	0.0027 \pm 0.0103	0.0000	0.9624 \pm 1.4023	
Fruit	24	0.0147 \pm 0.0135	0.0000	0.0271 \pm 0.0236	0.0092 \pm 0.0214	0.0511 \pm 0.0394	0.0150 \pm 0.0476	**	0.9762 \pm 1.0809	
t Value		0.93	1.82	1.65	0.72	1.56	1.09	**	0.97	
		0.00	1.02	2.54*	1.05	2.17*	1.04	**	0.33	
		0.34	7.67*	3.03*	0.58	2.43*	1.27	**	0.34	

* significant difference ($p < 0.05$).

** one case only and neglected.

Table 4. Comparison of Pesticide Residual Levels in R. O. C. and Other Countries. (ppm)

Country	Sample	No. of Cases	BHC Residues				DDT Residues				Reported by	
			α -BHC	β -BHC	γ -BHC	δ -BHC	total BHC	o, p' -DDT	p, p' -DDT	p, p' -DDE		total DDT
England 1967	whole blood	20	—	0.0041	0.0015	—	0.0056	—	0.0189	0.0133	0.0322	W. E. Dale
America 1969	cord blood	30	0.0004	0.0026	—	—	0.0030	—	0.0046	0.0062	0.0108	A. Curley
Japan 1971	cord blood	30	0.0033	0.0072	0.0028	—	0.0133	—	0.0003	0.0023	0.0026	Yamagishi
R. O. C. 1975	cord blood	100	0.0150	0.0016	0.0343	0.0072	0.0582	0.0056	0.0007	—	0.0064	this paper

Table 5. The Pesticide Residual Levels in Umbilical Cord Blood and Maternal Milk. (ppm)

Sample and Statistical Value	Organochlorine Pesticides							Organophosphorus Pesticides		
	BHC Residues			total BHC		DDT Residues				
	α -BHC	β -BHC	γ -BHC	δ -BHC	total BHC	o, p' -DDT	p, p' -DDT	total DDT	malathion	DDVP
Cord blood	0.0159	0.0004	0.0499	0.0115	0.0777	0.0167	0.0047	0.0214	1.3479	0.0000
Maternal milk Δ	0.0272	0.0228	0.0334	0.0008	0.0842	0.0165	0.0191	0.0356	1.8818	0.0995
$\bar{x} \pm SE\bar{x}$	0.0157 \pm 0.0048	0.0243 \pm 0.0110	0.0061 \pm 0.0073	-0.0155 \pm 0.0083	0.0280 \pm 0.0163	-0.0071 \pm 0.0226	0.0023 \pm 0.0112	0.0054 \pm 0.0325	0.9748 \pm 0.4935	**
t Value	3.27*	2.21*	0.84	1.87	1.72	0.31	0.21	0.17	1.98	**

* significant difference ($p < 0.05$).

** one case only and neglected.

Δ ppm per whole milk.

Table 6. Comparison of Pesticide Residual Levels in Maternal Milk in R. O. C. and Other Countries. (ppm)

Time and Area Investigated	No. of Samples	Total BHC		Total DDT		Remark
		the highest value	mean	mean	mean	
Japan { Akita Tokyo Takashi Osaka	14	0.097	0.047	—	—	DDT and BHC were banned in November 1971, for both agricultural and hygienic purposes.
	7	0.117	0.057	0.055	0.055	
	27	0.225	0.122	0.076	0.076	
Osaka	3	0.293	0.185	—	—	
England	19	—	0.013	0.128	0.128	DDT was banned in 1965.
America	5	—	0.008	0.063	0.063	DDT was banned in 1970.
this paper	12	0.105	0.084	0.035	0.035	DDT was banned in 1970 and BHC was banned in 1975.

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臍帶血液及母乳中殘留農藥之調查研究

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於民國63年8月至民國64年1月在臺北市立和平醫院生產的產婦中，取得100名產婦生產時臍帶血液樣本及其中12名之初乳，經採用日本國立衛生試驗所食品部長田邊弘也所著「殘留農藥之分析」一書中所載之方法，利用Varian 1,800型及600型氣相層析儀器進行檢驗分析。並依產婦之住址、食物嗜好等分類比較之。其結果如下：

1. 殘留農藥在臍帶血液中之平均濃度為總 DDT 0.0064 ppm，總 BHC 0.0582 ppm，malathion 0.9339 ppm；檢出率以 BHC 最高為 100%，malathion 次之 73%，DDT 最低 13%。

2. 市區內的樣本，其殘留 BHC 的平均濃度比市郊的樣本略高。

3. 嗜食魚類的產婦，其臍帶血液中 BHC

之殘留比嗜食蔬菜或水果者為多，且為有意義之差異。

4. 與國外之報告比較，本報告之臍帶血液 BHC 中殘留量均較他國為高，而 DDT 殘留量則否；而由初乳內 DDT 殘留量的比較可以看出，本報告於 DDT 禁用四年後才作調查，其數值較低，而他國所作的調查均於禁用前，其數值較高，故此 DDT 的殘留量與其禁用之早晚有關。

5. 綜觀所得數據，臍帶血液及初乳中農藥之殘留，DDT 已因我國於1970年禁用而顯示蓄積程度小且不普遍，但 BHC 及 malathion 的殘留量仍高，尤以 BHC 特具有蓄積性，應予注意管制，我國在1975年開始禁用於農業，應可避免污染之加深。

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