XENOBIOTIC REDUCTION AND CLINICAL IMPROVEMENTS IN CAPACITOR WORKERS: A FEASIBLE METHOD

Key words: Occupational, polychlorinated biphenyls, detoxification, congener profiles, body burdens, adipose, serum, treatment, Hubbard method, follow-up.

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ABSTRACT

Eleven capacitor workers, occupationally exposed to PCBs and other industrial chemicals, were treated with the detoxification method developed by Hubbard while thirteen co-workers served as controls. The mean pretreatment PCB levels were 28.0 mg/Kg in adipose and 188.0 ;ig/L in serum. At post treatment, PCBs were reduced in serum by 42% ($p<0.05$) and in adipose by 30% for the six patients without concurrent disease. Patients with concurrent disease had a 10% reduction in adipose levels, while serum levels remained unchanged.

Both adipose and serum PCB levels increased in controls. These differences were maintained at a 4-month follow-up examination, though the mean adipose PCB values in all groups were higher than at post-treatment. Changes in cholesterol, triglycerides, serum AST, ALT, and gGT did not correlate with changes of PCB values. Clinically, at post-treatment all patients reported a marked improvement in symptoms, with most of these improvements retained at follow-up. No such improvements were noted in controls. This approach appears to be a feasible treatment modality for symptomatic workers exposed to persistent lipophilic chemicals.

INTRODUCTION

Literally thousands of chemicals are mined, manufactured, and used in modern industry. In using these chemicals, some escape while others are deliberately released into the environment. The amount of chemicals contaminating the environment is estimated to be in the range of millions of pounds per year[1] Although some of them are very short-lived, others persist for a considerable time. Through a variety of processes these chemicals may be transported from the point of release to a site where they become an exposure hazard

A large number of industrial chemicals are lipid soluble and are not readily eliminated from the body. They are generally transformed into more polar metabolites before being excreted by natural routes. For many chemicals the rate of this metabolic process is high while for some, notably aromatic hydrocarbons, the rate is quite slow, leading to bioaccumulation.

Polychlorinated biphenyis (PCBS) comprise a group of synthetic aromatic hydrocarbons which have been commercially produced since the 1930's. The use of PCBs in the production line in Slovenia, a N.W. Republic of Yugoslavia, was banned in 1985. This followed the discovery, in 1983, of a major environmental pollution with PCBs arising from a condenser factory in Semic.[2] In twenty-three years of operation it is estimated that some 70 tons of PCBs were dumped in a region of approximately 20 square miles, exposing about 3000 inhabitants of the region. [3]

From 1962, PCBs of the Aroclor 1242 (42% chlorine content) and 1254 (54% chlorine content) types had been used in the production line of this factory. PCBs, however, were not the only toxic chemicals present at this site. Periodic job transfers and inappropriate handling of compounds resulted in heightened occupational

exposures. In addition, PCB wastes were regularly incinerated on the factory premises, potentially enabling exposure to PCDDs and PCDFs .[4,5]

An increasing number of symptomatic residents from Semic led to an onsite field study, initiated in 1984. Symptoms similar to those reported herein (Table 2) were present in children, adult residents, and particularly in the occupationally exposed workers. Biochemical abnormalities found were derangements of carbohydrate and lipid metabolism, and elevated levels of serum AST, ALT and gGT. Abnormalities in liver biopsies were also noted. Previous and renewed medical treatments alleviated neither the symptoms nor the biochemical abnormalities. This led to the suggestion that long-term exposure to industrial chemicals was the basis for these derangements. [6]

We present our findings of a group of 24 workers, 11 of whom were treated with the detoxification method developed by Hubbard.[7] This treatment had previously been reported to reduce body burdens of lipophilic chemicals in humans.[8-10] It also improved the symptoms consequential to exposure to chemicals. [11,12] Therefore, we were requested to assess the possible benefits of this procedure for symptomatic workers from Semic. As it is difficult to monitor the levels of most chemicals to which these workers were exposed, PCBs were chosen as a marker for evaluation of body burden reductions, while symptom surveys and medical evaluations assessed clinical improvements arising from this treatment regimen.

MATERIALS AND METHODS

Exposure Opportunities

Both small and large capacitors were assembled at the plant in Semic. Exposure opportunities occurred at several steps of the production cycle. Preassembly involved indirect exposure to PCBs, and direct exposure to trichloroethylene (TCE) and the by-products of welding. For impregnation, the preassembled devices were submerged in vessels filled with impregnating fluid (usually PCBs) maintained at 120' C. Impregnated capacitors were manually sorted for soldering. Soldered products were immersed in TCE to remove excess impregnating fluid. TCE in large, open kettles was also used to degrease tools, hands, and the work space. Final degreasing

and testing were performed before painting and packing. Further opportunities for exposure occurred during product inspection and equipment maintenance.

Daily burning of industrial wastes had occurred for over two decades on factory premises. As open-fire waste incineration of PCBs promotes formation of PCDDs and PCDFS, [4,5,13,14] there was at least a potential exposure opportunity to these compounds.

TABLE I

Number of Workers Reporting Direct
Exposure to Chemicals at the Factory

Chemical	Patients (n=10)	Controls (n= 1 2)
Impregnators:		
PCBs (Pyralene; Arociors; Clophene 30)	8	10
Terphenyls and Naphthalenes	10	8
Castor oil	8	9
Other substances:		
PCDFs and dibenzo-*p*-dioxins*	10	12
Trichloroethylene	10	9
Epoxides	10	5
Pump oils	8	0
Neoprene	1	0
Metal spraying	1	0
Welding (gas/arc)	7	2

* Inferred from occupational duties involving waste burning.

Work was often performed barehanded due either to the quick deterioration or the inadequate replacement of protective equipment. In addition, only provisional walls separated the impregnating halls from other production areas so that the space could be adjusted according to production demands.

A complete listing of chemicals utilized at the plant was considered classified information and was unavailable to researchers, thereby precluding verification of exposure histories. Consequently, the compilations of exposure opportunities listed in Table I were derived from patient reports. For the purpose of this study, particular chemical exposures were considered to be direct whenever they involved hands-on work for

at least six consecutive months of employment. Other work stations were considered to involve only indirect exposure.

Patient Selection

Available resources limited the number of the participants to twenty-four male factory workers who volunteered to participate in this study following circulation of a written description of the study including potential side effects. Each participant had a detailed explanatory interview before obtaining an informed consent.

Following the initial medical interview, eleven workers with a history of distinct symptoms, and unsuccessful medical treatment thereof, were selected for treatment. Dominating symptoms in this group included frequent chloracne eruptions, skin rashes, a history of slow healing of wounds, irritative, unproductive cough, chronically stuffed nose, sore throat, frequent 'common cold" episodes, nonexertional dyspnoe, headaches, muscular pains and general malaise (Table 2).

The remaining thirteen workers volunteered as a control group for the period of observation. Four asymptomatic individuals who had not been exposed to PCBs volunteered as an unexposed group.

All workers had a complete medical examination, the standard chemical panel at a fasting state, and tissue sampling done before, at the end of treatment, and five months after the initial evaluation. All clinical findings were doublechecked by a second physician. Participants rated the severity of their signs and symptoms on a scale from zero to five at each examination. Of these, chloracne eruptions, some dermatological complaints, respiratory changes and eye symptoms, were also assessed at medical examinations. Previous scoring was not disclosed to the participants at subsequent evaluations.

Occupational histories obtained from the workers were cross-checked with employment records. All reported symptoms were validated from records compiled during the previous cross-sectional survey. [6] Neither the interviewer nor the physician were blinded with respect to either the jobs held by the participants or the aim of the study.

Detoxification

This procedure is designed to mobilize and enhance the elimination of' lipophilic xenobiotics from the body. It is a medically supervised regimen, pursued individually until a stable clinical improvement is achieved. It consists of daily aerobic exercise, followed by frequent periods of low-heat (60-80' (') sauna. Niacin and polyunsaturated oil are administered to sustain the mobilization and elimination. Vitamins and minerals are supplemented and the daily liquid losses are replaced. Body weight is kept constant throughout the program. A detailed description is provided elsewhere. [7]

TABLE 2
Severity of Symptoms in Participating Workers

	Severity Score (mean)*								
	Group A (n=6)			Group B (n=4)			Controls (n=12)		
Symptom	Pre	Post	F-up	Pre	Post	F-up	Pre	Post	F-up
A. Chloracne eruptions§	2.2	0.3	1.0	1.5	0	1.3	1.2	1.2	1.2
B. Dermatological Rashes§ Slow healing of wounds Dry and thickened skin§	3.0	0.3	1.5	2.8	0	1.3	1.3	1.3	1.1
C. Respiratory Stuffed nose§ Sore throat§ "Common cold"§ Irritative, unproductive cough§ Nonexertional dyspnoe Bronchopneumonia	0.8	0	0.3	1.8	2.0	1.0	1.9	1.8	1.6
D. Eye symptoms Irritation Conjunctivitis§ Blurred vision Eyelid swelling§	2.2	0.8	1.3	2.8	0	0.3	0	0	0
E. Headaches	3.6	0.3	2.3	3.3	0	1.0	1.8	1.8	1.6
F. Nervous system Paresthesias Memory impairment Nervousness Emotional instability Lassitude Decreased acuity	3.2	0.3	1.3	4.0	0.3	0.8	1.0	1.0	1.1
G. Gastrointestinal Nausea and vomiting Abdominal pains and bloating Changed bowel habits Copious mucus discharge	2.7	0.5	1.3	2.3	0	0.3	2.0	1.0	1.6

H. Sleep disturbances Inability to initiate Inability to maintain	3.0	0.2	1.3	3.3	0.5	1.8	0	0	0
I. Musculoskeletal Joint pains and swellings Muscular pains and weakness General malaise	3.2	0	1.7	2.8	0	0.8	0.9	0.9	0.8

Patient self scoring on a scale of 0 (absent) to 5 (very severe).
§ Verified by medical evaluation.

The treatment was delivered at a medical facility outside the polluted area. The patients (11) resided there for the duration of their programs, resuming their usual working schedules immediately after program completion. Four patients presented complaints compatible with coexistent medical disease. At pretreatment, the patient group was therefore subdivided into group A, comprising seven patients without additional medical problems, and group B, comprised of the four patients having a concurrent disease.

The control group (13) remained at home, without changing their usual schedules, except for the days of medical examinations. This study had not been designed as a double blind study because the potential for mobilizing stored compounds in the control group without enhanced elimination was determined to pose an unnecessary risk.

PCB Determination

Adipose tissue was aspirated subcutaneously in the gluteal region according to the method described by Daum et al.[15] Approximately 1 gram of adipose tissue was obtained by this procedure. In three workers, selected at random, pretreatment samples were split for precision testing of the laboratory results.

Blood (20 cc) was drawn at a fasting state. Samples were centrifuged for 15 minutes at 2,250 rpm, and serum was decanted for analysis.

Samples were collected and stored in vials precleaned according to the standards set by the US EPA, assigned a number code, and frozen until analysis. The vials and the analyses were provided by Pacific Toxicology Laboratories, Los Angeles, California. Samples were delivered for analysis in two batches. The first contained the initial and post-treatment specimens. The follow-up samples were analyzed separately.

For analysis, PCBs were extracted from the tissue samples, deproteinized with hexane/ethyl ether, and separated from co-extracted biogenic material and organochlorine pesticides. Samples were anal zed b the Varian 3500 hi h-resolution gas-chromatographer with electron capture detector and a 30 M non-polar bonded phase DB-1 capillary column. Qualitative results were confirmed by gaschromatography/mass-spectrography in approximately 10 % of the samples. [16,17] Aroclor 1242, 1254, and 1260 in iso-octane served as external standards.[18,19]

PCBs were reported as the sum total of eighteen congeners. Peak assignments were made from Ballschmitter and Zell.18 Their numbering follows that proposed by the International Union for Pure and Applied Chemistry (IUPAC). No attempt was made to determine the levels of other industrial chemicals.

Statistical Analyses

Data were analyzed by ANOVA (F-test; p - 0.05) and block designed ANOVA (F-test). A block consisted of pre-, post- and follow-up data for each person. Student's two-tail 't" test for paired data was used for PCB data at post treatment, and linear regression analysis was used to correlate serum to adipose PCB values and for intra-group changes in symptom severity scores. Analyses were performed on Statgraphics program Ver. 4.0 STSC, Inc., Rockville, MD 20852.

RESULTS

The participants did not exhibit debilitating stages of any disease. Adverse effects due to the detoxification program were not encountered. The average duration of the treatment program was 33 consecutive days. There were no drop-outs and no complications were noted due to the tissue sampling.

One worker of the control group had a recent acute exposure to PCBs from dust while cutting the concrete floor in the impregnating hall without adequate protective equipment. He had severe chloracne eruptions, general malaise with muscle aches, skin rash, 'common cold' symptoms, conjunctivitis and hepatomegaly with abnormal 'liver-function' tests. He was referred to the hospital for detailed evaluation. His PCB levels were high and, although presented, were not included in the evaluations.

The initial sample of one treated patient was reported lost and this patient was excluded from subsequent evaluations.

The list of chemicals known or inferred (i.e. PCDDs and PCDFS) to be present at the factory and the number of participants who reported exposure to them are listed in Table 1.

Clinical manifestations

Pretreatment: The patients and the controls did not differ significantly for age, height, weight, blood pressure, employment duration or years of' reported direct exposure to PCBS. Smoking was significantly lower ($p<0.03$) in the control group (Table 3). Though biochemical abnormalities were found in both groups (Table 4), these derangements did not correlate with either the clinical findings or with exposure histories.

TABLE 3

General Data of the Participants (n=22)

	Patients (n=10)	Controls (n=12)	Signif. Btwn Groups
Personal data (mean ± I S.D.)			
Age	37.4	39.3	N.S.*
Years of employment	15.7	13.7	N.S.
Years of direct PCB contact	8.3	5.3	N.S.
Smoking (packs/d)	0.8±0.7	0-3±0.3	(p=0.03)
B.P. (mm/Hg) systolic	138.0±17.8	130.8 ± 12.3	N.S.
diastolic	86.5 ± 6.7	86.0 ± 8.6	N.S.
Weight (Kg)	81.1 ± 15.9	76.5 ± 9.5	N.S.
Height (cm)	173.3 ± 4.1	173.9 ± 8.1	N.S.

* N.S. = Not Significant (t test).

All workers presented similar signs and symptoms. Eleven (50'Yo) dated the onset of their problems within the first five years of employment and nineteen (79%) had become symptomatic within eight years of employment. All symptoms persisted from their onset until this treatment but fluctuated in severity. No case of stable remission had been reported, and previous medications had failed to improve the complaints.

Our initial medical evaluation disclosed chloracne eruptions, skin rashes, dry and thickened skin, eye irritation, stuffed nose, "common cold"-like symptoms, and irritative and unproductive cough. Mean severity scores of' *these* complaints at pretreatment, post-treatment and follow-up evaluations are presented in Table 2. The treated

group (groups A and B) did have more pronounced symptoms, reflecting the original selection bias. In four patients (group B) with symptoms indicating coexistent disease, further evaluations confirmed non-insulin dependent diabetes mellitus, peptic ulcer disease, biliary stones, and prostatitis with calcifications and colonic diverticulosis, respectively. Medical therapies were initiated and maintained throughout the detoxification program, which was modified to a less strenuous, longer protocol.

The overall severity of symptoms in the control group (n = 12) was lower. This group did not report eye irritation or sleeping disorders. Although their smoking habits were significantly lower (Table 3), they had appreciable respiratory problems.

TABLE 4

Biochemical Parameters in Serum

Parameters (Normal Range)	Range of Abnormal Values	**Number of Persons with Abnormal Results** Group A (n=6) Pre	Post	F-up	Group B (n=4) Pre	Post	F-up	Controls (n= 12) Pre	Post	F-up
Cholesterol (3-6 mmot/L)	6.1-16.2	5	0	2	4	2	4	4	2	1
Triglycerides (0.4-1.5 gm/L)	1.9-13.8	5	3	4	4	1	3	4	3	4
AST (6-18 U/L)	20- 25	2	0	1	1	1	1	1	0	1
ALT (3-26 U/L)	27-38	2	2	1	1	1	0	7	5	6
gGT (4-60 U/L)	60-80	2	0	1	0	0	1	0	0	1
Glucose (3.9-6.6 mmol/L)	6.1-16.2	3	2	2	1	1	1	3	1	*2*
Iron* (12-23 umol/L)	23.6-38	5	4	5	4	2	2	4	2	2

* Serum TIBC values were normal.

Post-treatment: No new signs and symptoms appeared during the course of the study. All participants had a steady body weight and blood pressure- The symptoms improved markedly in all treated patients. In the control group, the

symptom severity score did not vary appreciably during this time period (Table 2).

There were fewer incidents of biochemical abnormalities in both the treated and control groups at post-treatment (Table 4). Those abnormalities present were not limited to the same patients. These derangements did not correlate with the clinical improvements and did not appear to be related to the treatment procedure.

Follow-up: Four months after treatment, the body weight, blood pressure and smoking habits of the participants were within the range of pretreatment values.

The ten treated patients presented a borderline deterioration in their symptom severity scores compared to past treatment, though still improved relative to pretreatment values. The scores in the control group remained within the range of previous evaluations (Table 2). Biochemical derangements were again found in all groups (Table 4). They did not correlate with the clinical changes.

PCB Levels

The 18 PCB congeners measured, ordered according to their respective retention times, are listed in Table 5, and PCB levels are reported in Table 6.

Pretreatment: The mean PCB levels in the unexposed persons were in agreement with other reports for the unexposed population.[20,21] Analysis of the split adipose tissue samples for three workers had a good degree of precision (Table 6).

The patients (n = 10) and the controls (n = 12) did not differ significantly in their initial adipose and serum PCB values (Table 6), with the range of- I)C[3 levels in both groups being extremely wide (from 2 to 77 mg/Kg in adipose and from 22 to 562 1g/L in serum). The correlation of adipose to serum values for the mean concentration of the eighteen PCB congeners was linear (r = 0.917). is was the correlation of the adipose to serum total PCB for the 22 workers (r = 0.993).

Neither the total PCB levels nor the PCB congener levels correlated with any of the following: blood pressure, height, weight, the derived indices for the lean body mass, the body surface area, the biochemical abnormalities, or the symptom severity scores.

TABLE5

Chemical Structure of PCB Congeners
Eluted from the Samples

IUPAC N$^{\Omega}$	Structure	Type
Low chlorinated:		
28/31	2,5,4'/2,4,4'	Trichlorobiphenyl
74	2,4,5,4'	Tetrachlorobiphenyl

66	2,4,3',4'	
60	2,3,4,4'	
High chlorinated:		
99	2.4,5,2',4'	Pentachlorobiphenyl
144	2,3,4,6.2',5'	Hexachlorobiphenyl
153	2,4,5,2',4',5'	
138	2,3,4,2',4',5'	
175	2,3,4,6,2',3',5'	Heptachlorobiphenyl
159	2,3,5,6,2',4',5'	
174	2,3,4,5,2',3',6'	
177	2,3,5,6,2',3',4'	
180	2,3,4,5,2',4'.5'	
170	2,3,4,5,2'.3',4'	
196	2,3.4,6,",3',4',5'	Oclachlorobiplieii@l
201	2,3,5,6,2',3',4',5'	
195	2,3,4,5,6,2',3',4'	
194	2,3,4,5,2',3',4',5'	

Post-treatment: Following treatment, PCB levels of the patient group were reduced. However, the reductions were clearly distinct for groups A and B, which had been clinically subdivided at pretreatment. (Table 6)

In group A, adipose PCB levels were lowered by 30 percent, while serum values were lowered by 42 percent ($p<0.05$; the only statistically significant change). The reductions were consistent for all PCB congeners in serum, while there appeared to be a tendency for reduction of the low chlorinated congeners from adipose (Figure la). The correlation of mean levels of PCB congeners from adipose to serum remained linear in this group ($r = 0.921$; $n = 18$).

TABLE 6

PCB Content in Adipose Tissue* and Serum

	Pre	Post	Follow-up
Patients; Group A (n=6)			
Adipose	20.9 ± 13.4	14.5 ±7.1.	16.7 ± 11.9
Serum (μg/L)	139.4 ± 117.2	80.3 ± 52.09	168.8 ±175.5
Patients; Group B (n=4)			
Adipose	40.9 ± 23.6	37.0 ± 22.0	38.2 ± 24.1
Serum	284.8 ± 204.6	292.6 ± 284.5	287.1 ± 236.2
Controls (n=12)[P]			
Adipose	22.4 ± 22.8	23.1 ± 23.3	27.4 ± 27.1
Serum	139.8 ± 169.9	179.4 ± 208.0	183.8 ± 205.1

* Values from the 3 split adipose samples were (7.8 and 7.4 mg/Kg), (18.1 and 18.3 mg/Kg), and (33.1 and 34.0 mg/Kg).

§ Statistically significant ($p<0.05$) by Student's two-tailed t-test.

[P] Values for the acutely exposed worker (not included) are: adipose = 74.3 mg/Kg (pre) & 106 mg/Kg (post); serum = 912.9 μ/L (pre) & 1,074 μg/L (post).

In contrast, the reduction in adipose PCBs for group B was only 10 percent while the serum levels increased slightly. Changes in individual congeners did not reflect a like pattern to that of group A (Figure I b).

The control group had a slight increase in adipose PCB values at this time and the serum levels were higher by 28 percent. The increases in PCB congeners in this group did not appear to follow a pattern comparable to that of either treated group (Figure 1c).

Follow-up: Samples obtained at the four-month post-treatment evaluation were analyzed for PCBs as a separate batch. Mean adipose PCB levels were slightly higher than at post-treatment for all groups. Group A levels were still lower than at pretreatment, while levels in group B were about the same and those in the control group were somewhat higher than initially found. Mean serum PCBs in all groups were higher than at pretreatment. (Table 6)

The correlation of adipose to serum values was linear in all groups for the mean concentrations of the eighteen PCB congeners (r = 0.828 for group A and r = 0.970 for controls).

DISCUSSION

Concerns about the health effects from exposure to aromatic hydrocarbons in industrial settings were expressed as early as 1936 .22 Examples of the toxicity caused by polychlorinated dibenzofuran (PCDF) and quaterphenyl (PCQ) isomers, contaminants of ingested PCBS, have since been given in the Yusho and Taiwan studies. [23-25]

Reports over the past decade on clinical findings in cases of exposure to PCBs and related substances evolved a consensus on many of the observed adverse effects. Untoward human health effects related to such exposures include chloracne,[5,23,26-29] eye irritation and swelling of eyelids,[27,30-32] skin rashes and discoloration,[23,27,32-36] gastrointestinal,[27,28,34,36] and neurological[33,36,38] symptoms. Malaise, fatigue, muscular and joint pains, and sleep disturbances[30,34,36] appeared more frequently among exposed persons. Alterations of lipid metabolism and] "liver enzyme" activities[28,30,34,35,38-40] have also been observed.

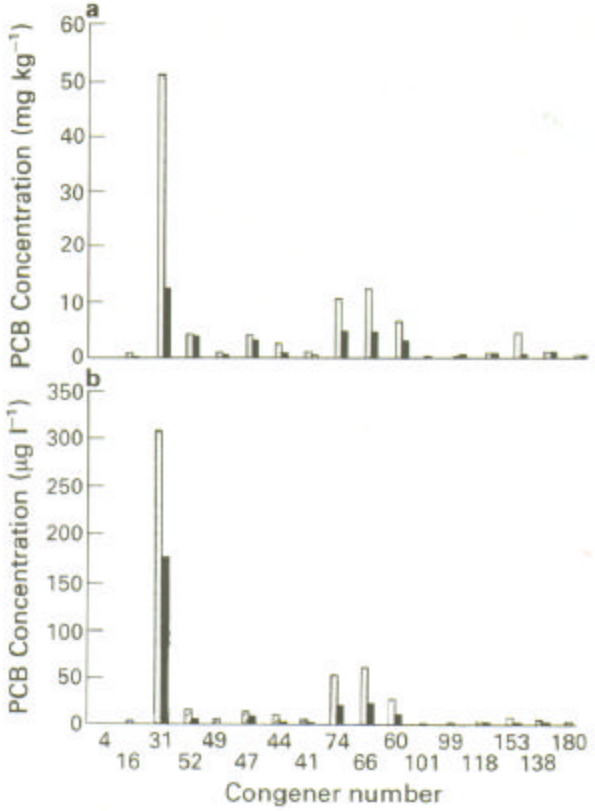

FIG 1: PCB Congener Profiles. (1) = Pretreatment; (1) = Post-treatment. Mean concentrations of congeners, listed in order of elution (IUPAC Numbering as in Table V. "28' = 28/31.) Left = Serum, right = Adipose. (a) Six patients without concurrent disease; (b) Four patients **with** concurrent disease; (c) Controls.

The possibility that additional symptoms may arise following exposure to other industrial chemicals and organic solvents has been emphasized[23,36,41 43]. In most of these studies, however, the combined effect of long-term exposure to multiple chemicals and their individual contributions to the overall clinical picture could not be assessed.

Evaluating the influence of particular chemicals used in industrial processes on the occurrence and expression of clinical problems remains, however, only one aspect of the problem. Amelioration of the deteriorated health and efforts to reduce possible long-term consequences from accumulated chemicals has not heretofore been addressed to an appreciable extent in humans.

Oral treatment with cholestyramine, an anion exchange resin used as a bile sequestrator, was suggested as a detoxification measure. [44] In man, however, organochlorine compounds seem to appear in greater quantities in the stool than they do in bile, probably because of gut excretion. [45]

Any mobilization of chemicals from adipose tissue has the inherent risk of imposing a load to other organs, particularly to the liver. The release from adipose during treatment may pose an undue health risk if not ancillary to elimination.

Clinical improvements of some symptoms presented by 16 Taiwanese patients, intoxicated with PCB-contaminated rice oil, were reported after a fasting cure of 7 to 10 days. PCB reductions were anticipated due to the elicited weight loss of approximately 5 Kg. However, PCBs in blood of the Taiwanese patients were considerably higher at post-treatment than they had been prior to treatment. PCB content of adipose tissue was not monitored in that stud Y.[46]

In our study, both the adipose and serum levels of PCBs were reduced in those patients without concurrent disease (group A) while levels remained relatively unchanged in those with concurrent disease (group B): adjustments of the treatment program could have contributed to the latter outcome. During this same time frame, levels for the controls did not vary significantly. These findings are in agreement with prior work showing that this treatment does not result in excessive serum levels of PCBs.10 The consistent linear relationship between serum and adipose levels for the 18 PCB congeners analyzed further suggests that elimination of mobilized compounds was similar for all species of this class of compounds. This aligns with the observed excretion of unmetabolized compounds during this program. [11,47]

It may appear conjectural to extrapolate changes in PCB levels to a similar process involving other accumulated chemicals. Previously published data, however, indicate that other lipophilic chemicals have also been reduced by this treatment. [9-11,48]

Though treated patients maintained an improvement in adipose PCB levels, these levels were higher for all groups at the 4 month follow-up than had been observed at post-treatment. No unusual exposure opportunities were recorded to explain these changes, although inadvertent exposure due to ongoing clean-up activities or a persisting local contamination [49] may have contributed to the observed elevations. Alternatively, analytical problems may be relevant. Time-series data may present particular problems which are not always easy to correct.[50] In addition, a difference in analysis sensitivity between the two batches may have affected the follow-up results in this study.

All three groups had cases with biochemical abnormalities. In agreement with previous investigators,[13,21,23,29,51] we were unable to find a correlation of the PCB levels or the exposure histories to these derangements. These abnormalities did not appear to have been influenced appreciably by the treatment (Table 4).

The treated participants reported a remission of symptoms. Except for the respiratory problems, the improvements in self-rated severity scores for groups A and B were quite similar. Due to the study protocol, however, the Hawthorne effect should be taken into account in evaluating the extent of these reported improvements (Table 2). A limited influence of this effect is indicated by two observations. First, the symptoms were documented to have persisted in the past despite medical intervention. Second, and more importantly, remissions in chloracne, skin rashes, respiratory and eye symptoms were observed at medical evaluations in the treated patients, but not in the controls. We conclude that the improvements are attributable to the treatment regimen.

This study presents, to the best of our knowledge, the first attempt to monitor PCB body burden reductions in a group with such elevated initial levels. Although the high variability of PCB levels in this small group did not allow definite statements based on statistical significance, a clear reduction in PCB levels was observed in those patients without concurrent medical disease. These reductions, along with the observed improvements in the clinical picture for all treated patients, suggest that this is a method to consider in the treatment of symptomatic individuals who have accumulated persistent lipophilic chemicals.

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