Persistent Organic Pollutants in 9/11 World Trade Center Rescue Workers: Reduction following detoxification

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Introduction:
Rescue workers, including firefighters present at the World Trade Center (WTC) following the September 11, 2001 terrorist attacks were exposed to large quantities of dust, smoke and fumes from the collapse and fire. The fire at the WTC site burned for months. Firefighters, paramedics, police and are among the personnel who labored for weeks and months in the immediate vicinity of the WTC. Personal Protective Equipment (PPE) use was inconsistent[1], contaminant exposure occurred in a number of ways including absorption and inhalation. Many of the rescue workers developed persistent coughs, headaches, memory disturbance and other symptoms while working on the site[2]. USEPA measurements of benzene, dioxins and polychlorinated biphenyls (PCBs) were elevated in the air in the weeks after the collapse[3]. Dioxins slowly returned to normal background levels after three months[3]. The New York (NY) Department of Environmental Conservation (DEC) analyzed dust/ash samples collected close to the WTC site after September 11, 2001.

The purpose of this study was two-fold: 1. To characterize body burdens of polychlorinated biphenyls (PCBs), polychlorinated dibenzofurans (PCDFs), and polychlorinated dioxins (PCDDs) in rescue workers and citizens exposed the day of the WTC collapse and afterwards. 2. A pilot evaluation of a treatment method aimed at reducing toxic burden.

Methods and Materials:

Seven men who were present at the World Trade Center collapse and involved in the rescue and cleanup effort presented for treatment at Downtown Medical PC in April 2004 and agreed to participate in this study. Five were employed by the New York Fire Department (FDNY), one was a volunteer rescue worker and one worked nearby at the NY Stock Exchange. All were at the site the day of the collapse and for several weeks afterward when exposure would have been theoretically the highest. The rescue workers used little or no protective respiratory gear during the WTC cleanup and all of them currently live or work in New York. The average age was 44 (range is 37-53).

These individuals volunteered to have their blood drawn for purposes of measuring the levels of polychlorinated biphenyls (PCBs), polychlorinated dibenzofurans (PCDFs), and polychlorinated dioxins (PCDDs). Fifty milliliters of whole blood was drawn in chemically cleaned glass containers prepared by the analytic laboratory with anticoagulant with Teflon ® tops containing no paper products. Blood was frozen and sent frozen on dry ice to Germany for polychlorinated dioxin and furan analysis at ERGO Laboratory, a World Health Organization certified dioxin laboratory. Analysis was performed by gas chromatography/high-resolution mass spectrometry by methods previously described[4]. Measured levels have been converted to dioxin toxic equivalents (TEQ) using the 1998 WHO toxic equivalency factors (TEFs)[5].

These individuals also participated in a series of testing including thorough medical examination, completion of structured health and symptom questionnaires, and neurophysiologic testing.

Following examination and tests, the study subjects enrolled in the Hubbard method of detoxification, a treatment regimen including exercise, sauna bathing and vitamin and mineral supplements developed to address the adverse effects of chemical exposures[6]. On completion of treatment, all had blood drawn for post-treatment testing and complete follow-up examination as described above.

Findings:

The measured dioxin, dibenzofuran, and PCB congener levels and TEQ for each subject before and after detoxification is presented in Table 1 and represented by graph in Figure 1. Prior to detoxification treatment, Five rescue workers (HB50605, WB5005, WB8008, WB9009, WB13013) have elevations in 2,3,3',4,4'-PeCB (105), 2,3',4,4',5-PeCB (118) and/or 2,3,3',4,4',5-HxCB (156). Patient H 5-0605 was a firefighter who we initially tested in May 2003. Pre treatment total mono-ortho PCB blood levels ranged from 19 ppb to 416 ppb (WHO-TEQ 8.2-133.3) with a geometric mean of 41 ppb (WHO-TEQ 29.3).

Following detoxification, calculated WHO-TEQs for mono-ortho PCB blood levels averaged a 65%decrease. Measured levels ranged from 15 ppb to 302ppb (WHO-TEQ 3.6-67) with a geometric mean of 32 ppb (WHO-TEQ 8). Non-ortho WHO-TEQs averaged a 57% decrease.

Brominated dioxins, brominated dibenzofurans, and polybrominated diphenyl ether congeners were at low levels or below the limit of detection (data not shown).

These individuals presented with a similar pattern of health complaints and manifested symptoms including respiratory impairment, mental/emotional distress (two met PTSD criteria), decreased sensory systems, chronic muscle and joint pain, gastrointestinal disorders, and skin rashes. These symptoms completely resolved or were satisfactorily improved on completion of treatment. The neurophysiological test results also improved. (data not shown).

Discussion:

In view of the documented persistence of adverse health effects in individuals exposed during the attack and collapse of the World Trade Center, it is important to not just document symptoms and possible causes, it is essential to identify workable treatment modalities. The purpose of characterizing levels of these compounds was to determine whether compounds of this class could be detected in this population this long after exposure and, assuming detection, whether their levels could be reduced by detoxification treatment. It is useful to have a marker compound for use in future studies planned to evaluate the use of this treatment method for this exposure.

This was a complex exposure to many different compounds and under many different circumstances. Various reports suggest that PCBs, PCDDs, PCDFs and brominated flame retardants were not above background in the dust at the WTC site but that the large volume of material could lead to significant ambient exposure.[8] These compounds have long half-lives[9]. It is unclear why PCBs but not PCDDs, PCDFs or brominated flame retardants were elevated, despite previous positive findings decades after exposure in chemical workers[10]. We only can measure elevated levels in the human body if the total uptake adds significantly to the body burden. For comparison: The intake via food ranges between 50 and 100 pg TEQ/day. A typical air concentration may be at 0.05 pg TEQ/m^3. Even at a 1000 times elevated air concentration, 24 h inhalation (20 m^3) adds “only” 1000 pg to the body burden (equivalent to about 10 days additional uptake from food).

The elevated concentrations of the PCB congeners found in some rescue workers appear to be consistent with the several dozen firefighters tested by FDNY and were noted to have elevated PCB levels above 12 PPB utilizing the Webb and McCall technique[7] (general population average by this technique = 6ppb as reported by lab). These levels are considerably higher than what would be expected in the general population, and consistent with levels seen in occupational exposure to PCBs.[11] A particular firefighter (Patient HB50605) provided us with results of two prior PCB tests (based on Arochlor 1260, Webb and McCall technique[7]). Test results were 32ppb on January 9th, 2002 and 13ppb on September 9th, 2002. He had his blood drawn and analyzed for dioxin, furan and PCB at ERGO laboratory in May 2003 (Table 2). Using a more reliable and sensitive technique his levels measured 416ppb (WHO-TEQ 133.3). This firefighter (Patient H 5-0605) had also worked on the day of the collapse and several subsequent days later.

A study by Edelman et al, reported an unanticipated increase in heptachlorodibenzodioxin and heptachlorodibenzofuran, which was associated with exposure to WTC[12]. However, the authors do not presume the exposure to be WTC specific.

The symptoms presented by the seven men in this group matched the pattern seen in studies of WTC-exposed populations. A 2003 Mt. Sinai/NIOSH/CDC analysis of 250 WTC screening program participants documents that approximately half the sample had persistent WTC-related pulmonary, ENT and/or mental health symptoms that persisted a year following the exposures.[13] The observed persistent symptomatology and its improvements with detoxification is consistent with medical records from an additional 286 WTC-exposed men and women who have completed detoxification treatment to date.

This pilot is limited by its small sample size. No relationships can be inferred between the PCB contamination found and the observed symptoms, or between reduction in these levels and the improvements noted following treatment. However, it is interesting that studies evaluating the adverse effects of high levels of PCB exposure commonly list neurobehavioral,[14] rashes and acne, nausea and other gastrointestinal problems.[15] Studies in workers suggest that exposure to PCBs may also cause irritation of the nose and lungs, changes in the blood and liver, and depression and fatigue.[16] Further, previous studies of PCB-exposed firefighters have demonstrated neurologic symptom improvement on completion of this treatment.[17] As well, prior studies using this method of detoxification showed reduced body burden of PCBs, PBBs and chlorinated pesticides.[18] The data presented here will be used to inform a larger study where correlations may be further tested. Even three years after the WTC attacks, thousands of exposure victims continue to have persistent illness. New approaches to this public health crisis are urgently needed.

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Figure 1.

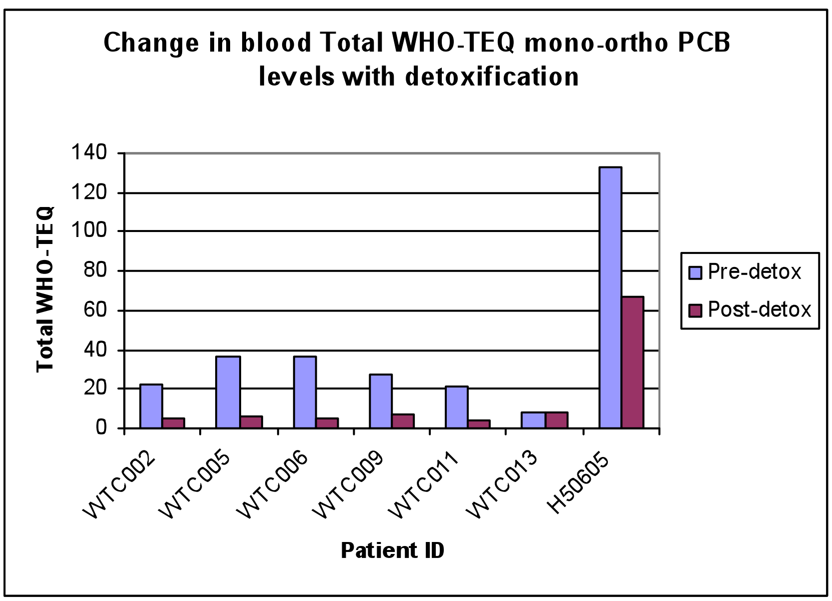

Table 1. Measured dioxin, dibenzofuran, and polychlorinated biphenyl levels[*] before and after treatment of WTC-exposed individuals, NY 2004.

Identification	WTC002		WTC005		WTC006		WTC009		WTC011		WTC013		H50605		Comparison NHANES III	
Congener	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	L.O.D.	75th
2.3.7.8-Tetra-CDD	1.9	1.3	3.2	2.1	2.2	1.8	1.4	1.7	3.0	1.4	1.6	1.6	2.6	2.0	4.8 pg/g	n.d.
1.2.3.7.8-Penta-CDD	5.3	4.1	7.1	7.0	8.1	7.3	5.8	7.1	4.1	3.5	4.1	5.7	6.3	6.2	5.3	n.d.
1.2.3.4.7.8-Hexa-CDD	4.0	3.5	6.5	5.6	6.1	4.8	5.8	6.3	2.4	n.d.(2)	n.d.(4)	n.d.(4)	6.	9.6		
1.2.3.6.7.8-Hexa-CDD	31	29	38	35	49	44	33	40	20	14	15	16	41	36	7.5	36.1
1.2.3.7.8.9-Hexa-CDD	2.8	3.4	5.6	5.9	5.1	6.2	4.0	5.8	5.4	3.4	n.d.(3)	n.d.(3)	5.6	6.3	7.6	n.d.
1.2.3.4.6.7.8-Hepta-CDD	26	27	56	54	48	42	51	63	21	26	24	25	47	55	24.7	61.9
OCDD	94	95	272	250	437	426	195	242	66	79	134	114	186	251	145	445
2.3.7.8-Tetra-CDF	n.d.(1)	n.d.(1)	1.2	1.2	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	1.3	1.4	1.3	1.4	4.6	n.d.
1.2.3.7.8-Penta-CDF	n.d.(1)	n.d.(1)	1.3	1.3	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	1.1	1.1	1.9	1.9	5	n.d.
2.3.4.7.8-Penta-CDF	3.4	4.0	10.3	9.8	7.7	7.9	4.7	6.0	3.5	2.9	6.6	6.3	9.1	10	4.8	n.d.
1.2.3.4.7.8-Hexa-CDF	4.3	4.7	9.2	8.8	8.2	6.8	7.3	7.3	3.8	4.2	6.0	6.6	10.4	13	4.7	n.d.
1.2.3.6.7.8-Hexa-CDF	3.2	3.4	7.0	7.1	7.5	6.6	3.9	6.1	2.3	3.3	4.8	5.6	7.2	10	4.8	n.d.
1.2.3.7.8.9-Hexa-CDF	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(1)	n.d.(2)	n.d.(1)	n.d.(2)	n.d.(2)	n.d.(2)	n.d.(3)	n.d.(3)	n.d.(5)	n.d.(5)	4.6	n.d.
2.3.4.6.7.8-Hexa-CDF	1.4	n.d.(2)	3.5	2.7	2.3	1.5	2.5	2.1	1.6	n.d.(1)	5.4	5.4	2.1	6.0	4.8	n.d.
1.2.3.4.6.7.8-Hepta-CDF	3.1	2.7	4.8	5.5	5.7	6.5	5.9	8.3	3.6	5.0	5.7	4.4	6.1	6.8	5.2	n.d.
1.2.3.4.7.8.9-Hepta-CDF	n.d.(2)	n.d.(1)	n.d.(1)	n.d.(2)	n.d.(1)	n.d.(3)	n.d.(1)	n.d.(2)	n.d.(2)	n.d.(3)	n.d.(5)	n.d.(5)	n.d.	n.d.(8)		
OCDF	n.d.(4)	n.d.(3)	n.d.(3)	n.d.(5)	n.d.(3)	n.d.(10)	n.d.(4)	n.d.(5)	n.d.(6)	n.d.(11)	n.d.(22)	n.d.(24)	n.d.	n.d.(33)	12.6	n.d.
3,3',4,4'-TCB (77)	n.d.(14)	n.d.(24)	n.d.(13)	n.d.(17)	n.d.(12)	n.d.(22)	n.d.(18)	n.d.(27)	n.d.(17)	n.d.(23)	n.d.(26)	n.d.(28)	68.	n.d.(31)		
3,4,4',5-TCB (81)	n.d.(2)	2.6	2.5	3.8	n.d.(2)	2.4	2.4	4.6	n.d.(3)	3.3	5.2	9.0	12.0	9	25.8	n.d.
3,3',4,4',5-PeCB (126)	23	28	44	41	64	65	41	44	20	14	36	39	197	163	9	n.d.
3,3',4,4',5,5'-HxCB (169)	21	28	23	23	48	49	26	43	23	16	31	28	51	56	9.9	n.d.
2,3,3',4,4'-PeCB (105)	1203	1006	7908	5222	537	443	4050	3626	1881	1184	1782	1886	41765	31469	6400	n.d.
2,3,4,4',5-PeCB (114)	675	581	1906	1380	1253	1000	980	887	771	500	1236	1289	17746	13986	6400	n.d.
2,3',4,4',5-PeCB (118)	6153	4955	31225	22656	4665	3266	20163	16772	9408	5355	10062	9705	207921	152910	6400	14700
2',3,4,4',5-PeCB (123)	232	234	492	556	283	227	245	421	149	174	310	373	1900	2853		
2,3,3',4,4',5-HxCB (156)	8045	6807	6987	4598	9759	7214	6478	6403	7501	4290	9977	9371	95751	66304	6400	n.d.
2,3,3',4,4',5'-HxCB (157)	1596	1548	1396	1086	2042	1606	1480	1523	1550	1003	2485	2293	18706	16126	6400	n.d.
2,3',4,4',5,5'-HxCB (167)	756	798	2029	1601	1096	911	1683	1802	1047	2123	1918	1867	18881	16344	6400	n.d.
2,3,3',4,4',5,5'-HpCB (189)	531	629	475	430	952	955	594	790	523	413	846	738	2324	2336		
Total PCDDs/PCDFs	180	177	424	396	587	562	320	395	136	142	210	193	333	416.1		
Total non-ortho-PCBs	44	58	70	68	112	116	70	91	43	33	72	76	328	229		
Total mono-ortho-PCBs	19191	16558	52417	37530	20587	15623	35673	32223	22832	15042	28616	27521	404994	302328		
Total WHO-TEQ PCDDs/PCDFs	13.9	12	23.1	21	22.4	21	15.8	19	12.7	9.1	13	14	21	22		
Total WHO-TEQ non-ortho-PCBs	8.4	3.1	13.8	4.3	14.0	7.0	11.3	4.8	8.4	1.6	3.9	4.2	111.9	17		
Total WHO-TEQ mono-ortho-PCBs	22.3	5.2	37	6.4	36.5	5.4	27.1	6.6	21	3.6	8.2	7.8	133.3	67		

Values in pg/g (ppt), lipid based; Samples from Human Blood

+ Patient H 5-0605 blood tested in 5/2003 [firefighter sent us his PCB value of 32ppb (Webb and McCall) on 1/9/02]

NHANES III data from Second National Report on Human Exposure to Environmental Chemicals. US Dept of Health and Human Services NCEH Pub. No. 02-0716 March 2003