Airway Hyperresponsiveness and Distal Airway Narrowing in 9/11 Rescue Workers Seventeen Years after The World Trade Center (WTC) Disaster

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ABSTRACT

Background: After the WTC disaster, many of the rescue workers were exposed to airborne ash and dust for days to months, predisposing them to lung injury. We sought to investigate the following in a cohort of 9/11 rescue workers exposed to the disaster 17 years post-fallout: 1) spirometric lung function; 2) impulse oscillometry (IOS) values with respect to airway hyperresponsiveness and distal airway narrowing; and 3) reversibility of these findings pre- and post-bronchodilator.

Methods: A retrospective chart review was performed at a single community-based outpatient allergy and asthma clinic. Inclusion criteria for this study were 1) positive exposure to the WTC fallout via rescue and cleanup operations and 2) IOS lung function testing. These subjects (n=18) were referred from the World Trade Center Health Program for management of allergy-immunology services and whose allergic hypersensitivity had been appropriately managed with biological modifiers, immunotherapy, and asthma controllers/relievers. Both impulse oscillometry and spirometry were analyzed in this cohort to determine the long-term impact of exposure to WTC fallout.

Results: Rescue workers who developed new-onset respiratory symptoms post-fallout still had severe, persistent symptoms with evidence of permanent small airway dysfunction (FEF25-75; n=12), distal airway narrowing (R5-R20, n=10) and airway hyperresponsiveness (X5, n=18), with partial reversibility. These findings were present despite management including steroid controllers/relievers, biological modifiers (anti-IgE, dupilumab), and allergy immunotherapy.

Conclusion: Seventeen years after exposure to the WTC disaster, exposed patients experience small airway dysfunction characterized by increased distal airway resistance and reactance not explained by obesity, smoking history, or allergic disease.

Keyword(s): Environmental occupational disorders other than asthma (laboratory animals, agricultural dusts, textiles)

Conflict of Interest Disclosure Statement: The authors attest that they have no conflicts of interest to disclose.

Ethical Conduct of Research Statement: The authors state they have followed the principles outlined in the amended Declaration of Helsinki in order to conduct a minimal-risk, retrospective investigation of human subjects from whom written informed consent was obtained for all testing discussed herein and for inclusion of their medical data in this study.

METHODS

A retrospective chart review was performed at a single, community, outpatient allergy and asthma clinic. Inclusion criteria:

1) Positive exposure to the WTC fallout via rescue and cleanup operations
2) Spirometry and IOS pulmonary function testing.

Comorbidities were selected based on prior studies on the WTC population: history of hypertension, former smoker, current smoker, current vaper, asthma, chronic obstructive pulmonary disease, sleep apnea, bronchiectasis, gastroesophageal reflux disease, history of environmental allergies, allergic rhinitis/post-nasal drip, chronic sinusitis, conjunctivitis, eczema, and idiopathic urticaria.

CareFusion MasterScreen IOS was used to conduct impulse oscillometry and spirometry. Both impulse oscillometry and spirometry were analyzed in this cohort to determine the long-term impact of exposure to WTC fallout. The Standard US Extrapolated module was used for predicted values.

RESULTS

	N	Value	SD	Range
Time since 9/11 (years)	18	15.9	± 1.2	(13-17)
Male	15	83.30%		
Age (years)	18	52.2	± 7.8	(42-74)
BMI	18	32.1	± 7.3	(19-47)
Former smoker (quit >1 yr ago)	6	33.30%		
Current smoker	0	0%		
Pack-year history	4	16.9	± 15.7	(5-40)
History of allergic rhinitis/post-nasal drip	17	94.40%		
History of asthma	16	88.90%		
History of hypertension	8	44.40%		
History of environmental allergies	13	72.20%		
History of sleep apnea	11	61.10%		
History of chronic sinusitis	9	50.00%		
History of gastroesophageal reflux disease	9	50.00%		
History of allergic conjunctivitis	6	33.30%		
History of chronic obstructive pulmonary disease	3	16.70%		
History of bronchiectasis	2	11.10%		
Eczema	1	5.60%		
Idiopathic urticaria	1	5.60%		
Allergies	18	100%		
– Dust mite	10	83.30%		
Tree	12	66.70%		
Grass	11	61.10%		
– Weed	11	55.60%		
– Cat	10	55.60%		
– Mold	10	55.60%		
Dog	9	50%		
– Food	7	38.90%		
Peak flow (L/min)	17	495.3	± 80.6	(350-650)
Serum IgE (IU/mL)	6	227.7	± 233.7	(5-562)
Abnormal exhaled nitric oxide	0	0%		
History of allergy immunotherapy	2	11.10%		
Current allergy immunotherapy	16	88.90%		
Xolair (anti-IgE)	3	16.70%		
Dupixent	1	5.56%		
Occupation				
– Police	15	83.33%		
– Security	2	11.12%		
Cleanup	1	5.56%		
Duration of exposure (months)	8	7.16	± 7.50	(0.25-24)
Presenting symptoms				
Cough	3	16.7%		
– Rhinitis	10	55.6%		
– Sinusitis	5	27.8%		
Bronchitis	3	16.7%		
– Asthma	9	50.0%		
– Dyspnea	2	11.1%		

Table 1: Patient demographics

Seventeen years after September 11, 2001, we identified 18 patients who were part of the World Trade Center Monitoring program and referred to our clinic for management of upper and lower respiratory tract allergy symptoms. The majority of our cohort were male (n=15, 83.30%). At time of their most recent lung function testing, our cohort had an average age of 52.5 years, average body mass index (BMI) of 32.1, and were exposed to the World Trade Center disaster on average 15.9 years ago. Only 8 patients had reported their duration of exposure, averaging 7.16 months. Fifteen patients (83.3%) were part of the police force, two (11.12%) worked security, and one (5.56%) conducted cleanup. Six patients were former smokers (33.33%), none were current smokers. Presenting symptoms were rhinitis (n=10, 55.6%), asthma (n=9, 50%), sinusitis (n=5, 27.8%), cough (n=3, 16.7%), bronchitis (n=3, 16.7%), and dyspnea (n=2, 11.1%).

RESULTS

The most common prior medical conditions were allergic rhinitis/post-nasal drip (n=17, 94.4%), asthma (n=16, 88.9%), environmental allergies (n=13, 72.2%), sleep apnea (n=11, 61.1%), and chronic sinusitis (n=9, 50%). All patients were positive to at least one antigen on percutaneous skin prick testing. We did not detect an elevated exhaled nitric oxide from any patients. Sixteen patients (88.9%) were receiving allergen immunotherapy at time of their most recent pulmonary testing and only 2 patients (11.1%) had received allergen immunotherapy prior to presentation. Four patients were receiving biologic immunotherapy: three were receiving omalizumab, and one was receiving dupilumab.

	Total Baseline	SD	Pre-BD	SD	Post-BD	SD	BD Response (% predicted)	SD
IOS	N=18		N=14		N=14		N=14	
R5, % predicted	132.67	±44.4	135.25	±45.78	111.02	±56.83	31.93	±26.11
R20, % predicted	117.7	±35.71	115.26	±34.31	93.48	±44.21	28.1	±29.38
R5-20%R5	32.25	±20.53	37.14	±20.11	31.05	±21.14	18.80	±15.02
X5	-1.58	±1.02	-1.67	±1.13	-1.32	±0.76	12.98	±27.01
Fres	16.72	±4.18	17.45	±4.32	15.65	±3.56	8.68	±16.60
AX, %predicted	130.1	±131.6	134.4	±135.6	84.8	±81.26	16.35	±44.07
Spirometry								
FEV1, % predicted	86.33	±20.67	92.8	±9.96	89.19	±20.43	5.55	±12.34
FVC, % predicted	89.28	±20.82	94.6	±13.76	93.38	±20.75	5.52	±18.35
FEV1/FVC, % predicted	96.28	±8.19	98.4	±6.88	95.63	±11	0.77	±8.12
FEF25-75%, % predicted	59.89	±22.91	64.6	±19.83	63.19	±21.22	17.90	±18.61

Table 2: Cohort pulmonary function testing

	Improvement from Normal			Improvement from Abnormal			Fold
	N	Baseline	SD	N	Baseline	SD	Difference
IOS							
R5, % predicted	9	-19.62	31.48	5	-17.31	22.33	0.88
R20, % predicted	12	-20.67	31.63	2	-0.7	1.19	0.03
D5-20, % predicted	4	-10.81	38.90	9	-8.21	13.87	0.76
X5	0			14	0.58	0.55	
Fres	0			14	3.55	3.09	
AX, % predicted	11	-9.69	46.64	3	-40.79	24.66	4.21
Spirometry							
FEV1, % predicted	10	2.53	3.48	6	10.6	19.65	4.19
FVC, % predicted	10	0.89	4.19	6	13.24	29.4	14.88
FEV1/FVC, % predicted	16	4.48	2.44	0			
FEF25-75%, % predicted	4	21.72	12.42	12	16.63	20.57	0.77

Table 3: Responses to bronchodilator

CONCLUSIONS

Seventeen years after exposure to the WTC disaster, exposed patients experience small airways dysfunction characterized by increased distal airways resistance and reactance not explained by obesity, smoking history, or allergic disease. Patients with baseline abnormal resistance values on IOS have less benefit from bronchodilator than those with normal baseline values suggesting a degree of non-inflammatory lung injury. Although airway hyperresponsiveness improved more in those with an abnormal baseline, the highly abnormal X5 and Fres suggest this improvement is occurring within the large airways.

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Please see presenting author for list of referenced literature.