Polysomnographic Diagnoses Among Former World Trade Center Rescue Workers and Volunteers

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Brief Communication

Polysomnographic Diagnoses Among Former World Trade Center Rescue Workers and Volunteers

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ABSTRACT. An increased risk for obstructive sleep apnea (OSA) has been suggested for World Trade Center (WTC)-exposed workers. The authors reviewed the results from nocturnal polysomnograms (PSGs), to investigate diagnostic differences between WTC-exposed and -unexposed subjects. Six hundred fifty-six nocturnal PSGs performed at our sleep center were reviewed, 272 of them in former WTC workers. Seven diagnostic categories were compared between the 2 groups by bivariate and logistic regression analyses. The WTC group had a significantly higher predominance of the male gender, but slightly lower body mass index (BMI). There was no significant difference in the distribution of PSG diagnoses between the 2 groups in unadjusted ($p = .56$) or adjusted ($p = .49$) analyses. The authors did not identify a significant difference in PSG diagnoses between the WTC-exposed and -unexposed subjects. OSA was significantly associated with age, BMI, and gender in this patient population.

KEYWORDS: occupational medicine, respiratory diseases, sleep apnea, World Trade Center

A variety of adverse health effects have been reported among former rescue and recovery workers and volunteers at the World Trade Center (WTC) disaster site.[1] Snoring and sleep disorders are common among those workers, and the risk of obstructive sleep apnea (OSA; as assessed by a screening questionnaire) seemed correlated with heavier occupational exposures among firefighters deployed at the WTC disaster site.[2] Rhinitis and gastroesophageal reflux disease (GERD) are highly prevalent in this patient population,[1] in good measure temporally related to the occupational exposures. Rhinitis has been associated with snoring[3] and, in some studies, with OSA,[4] and a similar association has also been proposed for GERD.[5] Other observations (and our preliminary ones) suggested that perhaps some milder forms of OSA may be more frequently diagnosed in former WTC workers,[6] with the speculation that WTC-related rhinitis and GERD are on the causal pathway from the exposures to the development of OSAS. On the other hand, a study using diagnostic nocturnal polysomnograms (PSGs) among 100 former WTC workers and volunteers failed to identify an association between OSA and the intensity of WTC occupational exposure indicators, or with WTC-related rhinitis and reflux disorders.[7] We reviewed the results from PSG at our Sleep Center, to investigate whether rapid eye movement (REM)-related OSA and upper airway resistance syndrome (UARS) were more frequently diagnosed among occupationally WTC-exposed subjects compared with WTC-unexposed subjects.

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METHODS

Study population

We reviewed 656 consecutive nocturnal PSGs performed at the Mount Sinai Sleep Center between 2002 and 2006, 272 of them in former WTC rescue and recovery workers and volunteers. Age, height, weight, and WTC worker/volunteer status were determined before, or on the date of the PSG. The latter group was required to have met eligibility criteria to receive medical services at the WTC Health Effects Treatment Program (WTC HETP) at Mount Sinai Medical Center. The exposure duration criterion consisted of a minimum of 24 hours of rescue, recovery, and service restoration work (or volunteering) during the period from September 11 to September 30, 2001, or of 80 hours from September 11 to November 30, 2001. The worksite location criterion included sites south of Canal Street in Manhattan, the Staten Island landfill, the barge loading piers, and the Office of the Chief Medical Examiner. Virtually every occupational group present during the rescue and recovery of the WTC site is represented in the WTC HETP population.

Nocturnal PSGs were conducted using Embla recording systems (Embla, Broomfield, CO), consisting of nocturnal recordings of the following physiologic channels: O1–A2, O2–A1, C3–A2, and C4–A1 electroencephalograms (sampled at 256 Hz), right and left electrooculograms, a single bipolar electrocardiogram, chin electromyogram, oxyhemoglobin saturation by pulse oximetry, chest and abdominal excursion by inductance plethysmography, airflow by nasal cannula, and body position by a mercury gauge. If the PSG was performed with a split-night protocol (ie, continuous positive airway pressure (CPAP) was applied and titrated for the second half of the study), only the data from the diagnostic part of the test were reviewed. Forty-seven PSGs were excluded because their protocol and montage differ from what was described above, or the original data were unavailable for this review.

Polysomnographic diagnoses were categorized as: no sleep disordered breathing (SDB), simple snoring, REM-related obstructive sleep apnea (OSA), upper airway resistance syndrome (UARS), and mild, moderate, and severe OSA. These categories were mutually exclusive, and hierarchically assigned when coexistent. The apnea-hypopnea index (AHI) served to define and categorize the severity of OSA. AHI ranges of 5 to 14.9, 15 to 29.9, and at least 30 events/hour defined the mild, moderate, and severe OSA categories, respectively.[8] Simple snoring, UARS, and REM-related OSA all required a normal overall AHI (fewer than 5 events/hour), but the latter required a REM AHI at least twice the non-REM AHI, with at least 30 minutes of REM sleep present during the recording. UARS was diagnosed indirectly by the presence of flattened inspiratory nasal cannula pressure tracing in association with an arousal—a respiratory effort–related arousal (RERA). A subset of subjects without any PSG diagnosis of SDB as described above were diagnosed with simple snoring if snoring was evident during the study.

Statistical analyses

Univariate (*t* test and chi-square test), logistic regression, and nominal regression analyses (using age, gender, and body mass index [BMI] as predictors) were used as appropriate, to examine differences in predictor and outcome variables between the WTC and non-WTC groups. The first outcome variable examined was AHI. The second outcome variable was OSA, defined categorically by an AHI of 5 events/hour or more. A post hoc analysis defining OSA with an AHI of 15 or more was conducted as well. The third outcome variable was polysomnographic diagnosis, with the 7 categories defined above. The discrimination of the logistic regression model for OSA diagnosis was evaluated by means of the *c* statistic, and 95% confidence intervals were calculated for the estimates.

Two-tailed statistical significance required a *p* value of less than .05. Statistical analyses were conducted using the SPSS statistical package (version 17.0; SPSS, Chicago, IL) for all analyses, except for logistic regression models, for which the SAS statistical package (version 9.1; SAS Institute, Cary, NC) was used.

This study was approved by the Institutional Review Board at Mount Sinai School of Medicine.

RESULTS

Table 1 summarizes the characteristics of, and main findings in, the 2 groups. The WTC group had a significantly higher predominance of men (86.8% vs 56.3%; $p < .001$), but lower mean BMI (31.4 vs 33.2 kg/m^2; $p = .002$). The WTC group seemed slightly younger, but the difference did not reach statistical significance (49.8 vs 51.6 years; $p = .08$). Univariate analyses did not reveal a significant difference between the 2 groups in mean AHI ($p = .29$), OSA (diagnosed by AHI $\geq$ 5 events/hour; $p = .36$), or PSG diagnoses ($p = .56$).

Adjusting for potential confounders (age, gender, and BMI), there was no difference in OSA defined as AHI of 5 or more events/hour (see Table 2), and the secondary analysis defining OSA by an AHI of 15 or more events/hour yielded the same results (data not presented). The value of the *c* statistic for this model was .77.

When the 7 categories of polysomnographic diagnoses were examined (with no SDB as the reference), there was again no difference between the WTC and non-WTC occupationally exposed subjects ($p = .49$), after adjustment for age, gender, and BMI (see Table 2).

COMMENT

Snoring is a very commonly reported symptom by former WTC workers and volunteers, and a questionnaire-based study suggested a slightly increased risk for OSA in this

Table 1.—Characteristics of the Study Population and Univariate Analyses of the Outcomes

	WTC subjects	Non-WTC subjects	p value
Subjects, n	272	384	n.a.
Predictors			
Age, years			.08
Mean	49.8	51.6	
SD	9.2	16.3	
Male sex, %	86.8	56.3	.001
BMI, kg/m^2			.002
Mean	31.4	33.2	
SD	5.1	8.9	
Outcomes			
AHI, events/hour			.29
Mean	23	25.3	
SD	24.7	29.9	
OSA (AHI ≥ 5), n	215	291	.36
PSG diagnoses, n			.56
No SDB	16	32	
Snoring	11	21	
UARS	17	20	
REM-related OSA	17	22	
Mild OSA	80	119	
Moderate OSA	58	63	
Severe OSA	73	107	

Table 2.—Adjusted Logistic Regression Models for OSA and PSG Diagnoses

		Estimates	
	p value	Odds ratio	95% CI
OSA (AHI ≥ 5)			
WTC exposure	.45	0.85	0.55–1.31
Age	<.0001	1.05	1.03–1.07
Female sex	<.0001	0.19	0.12–0.30
BMI	<.0001	1.12	1.09–1.16
PSG diagnoses			
WTC exposure	.49		
Diagnosis			
No SDB		1.00 (ref)	
Snoring	.95	0.98	0.46–2.08
UARS	.47	1.40	0.57–3.46
REM-related OSA	.20	1.69	0.75–3.80
Mild OSA	.14	1.83	0.82–4.10
Moderate OSA	.92	1.02	0.64–1.63
Severe OSA	.19	1.40	0.84–2.35

population.[2] In our previous study, using PSG (the diagnostic gold standard for OSA), we did not identify WTC-related occupational exposure as a risk factor for that disease.[7] In the present study, we examined polysomnographic diagnoses to include OSA as well as other sleep disorders (simple snoring, UARS, and REM-related OSA), in a larger group of occupationally WTC-exposed subjects and compared them with WTC-unexposed subjects. We hypothesized that there could be a difference between the 2 groups in their diagnoses, particularly for what some regard as milder forms of OSA,[9] as was recently suggested by a much smaller study.[6] We did not identify a significant difference in SDB diagnoses between the exposed and unexposed groups.

The presence and severity of OSA in this patient population was significantly associated with age, BMI, and gender, all established and well-known predictors of that condition. With these 3 predictors, the logistic regression model performed remarkably similarly (as assessed by the c statistic) to previously published prediction equations for OSA.[10]

In a heavily "observed" population such as the former WTC workers, it is possible that a lower diagnostic threshold might have introduced a bias, by studying subjects with milder symptoms and lower risk for OSA, which would dilute any true effect of WTC exposures. The slightly younger age of the WTC subjects at the time of the study, and their lower BMI, could be interpreted as suggestive of that. On the other hand, this subpopulation was enriched for what seemed to be the strongest risk factor, the male gender. It is also possible, however, that such a bias could have also led to fewer

diagnoses of any SDB disorder, and that did not seem to be the case. Sleep-related breathing disorders include a variety of disease subtypes, and the findings in this study do not exclude a possible association between one of those subtypes and a risk factor or comorbidity related to occupational WTC exposures. It is possible that the slightly increased risk for OSA detected in a large questionnaire-based survey of WTC firefighters[2] relates to a number of cofactors such as those identified in this study, as well as a detection bias resulting from the high prevalence among the former WTC workers of chronic rhinitis, a well known risk factor for habitual snoring, but not for SDB.[3]

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