CHRONIC EFFECT OF FIRE FIGHTING ON PULMONARY FUNCTION

JOHN M. PETERS, M.D., GILLES P. THERIAULT, M.D., LAWRENCE J. FINE, M.D., AND DAVID H. WEGMAN, M.D.

Abstract Pulmonary function was studied in 1430 Boston fire fighters during the period 1970 to 1972. Questionnaire information on exposures, current respiratory symptoms and smoking habits was also collected. Forced vital capacity and forced expiratory volume in one second were measured on two occasions. The rate of loss in pulmonary function observed for the entire population was more than twice the expected rate (77 vs. 30 ml for forced vital capacity). These changes were significantly related to frequency of fire exposure ($p < 0.01$) and could not be explained by differences in age, smoking habits or ethnic background. This study strongly suggests that occupational exposures are contributing to chronic impairment of pulmonary function in fire fighters. (N Engl J Med 291:1320-1322, 1974)

FIRE fighting is unquestionably a very hazardous occupation. Despite the many chemical and physical stresses of fire fighting, very little scientific inquiry has been directed to this large occupational group estimated at 200,000 full time plus 800,000 volunteers in the United States.

Although the medical literature contains several publications on the acute effects of smoke inhalation, information is lacking on the possible chronic pulmonary effects. Our first attempt to examine this question was a cross-sectional study of the entire Boston Fire Department. The results of this study revealed associations between occupational exposures and pulmonary disease.[1-3]

Because fire fighting requires certain physical capability, the person in whom shortness of breath develops frequently finds other employment. Thus, study of active fire fighters might allow underestimation of the true prevalence of disease. To obviate this problem, follow-up studies are necessary.

This report describes the results of the first year of a prospective study of Boston fire fighters to determine whether decrement in pulmonary function was excessive and if so whether occupational exposures could account for this excess.

METHODS

Repeat questionnaire and pulmonary-function data were collected on 1430 Boston fire fighters. This figure represented 81 per cent of the 1768 seen in 1970-71. Retirement, sickness, refusal and non-contact accounted for the failure to re-examine 19 per cent.

Questionnaire

Background information on rank, marital status, ethnic extraction, age, years with the Boston Fire Department and assignment within it was collected. Other pertinent occupational history was recorded. An interim medical history was taken. Exposures during the previous year were assessed by means of questions on frequency of runs and frequency and severity of smoke inhalation (if hospitalized, length of hospitalization, and days off duty). Each fire fighter was asked about the number of pastings and shellackings (fire fighter's terms for nonspecific malaise after a fire), and the amount of black sputum produced after fires. Frequency of use of oxygen at fires was ascertained.

From the Kresge Center for Environmental Health, Harvard School of Public Health (address reprint requests to Dr. Peters at the Department of Physiology, Harvard School of Public Health, 665 Huntington Ave., Boston, MA 02115).

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Current respiratory symptoms and smoking habits were collected with a standardized questionnaire by trained interviewers.[2]

Pulmonary Function

Forced vital capacity (FVC) and one-second forced expiratory volume ($FEV_{1.0}$) for each man were measured on a Stead—Wells spirometer using 32 mm per second paper speed. The $FEV_{1.0}$ was measured after extrapolation of the steepest part of the curve to the base line and use of this point as time zero.

The subjects were asked to perform five forced expiratory maneuvers standing, without nose clips. Any trial judged to be unsatisfactory because of poor co-ordination, decreased performance, or poor co-operation was rejected at the time of the test. The average of the three best trials was taken as the "true" value. All results were corrected to body temperature pressure saturated.

Height was not remeasured; estimated weights were obtained by inquiry.

Analysis

The data were processed on the Harvard-MIT computer (IBM 360/165). Most of the statistical procedures are outlined in *The Data-Text Primer* [4] and *SPSS: Statistical package for the social sciences.*[5] Multiple regression analysis[6] was the statistical test applied to study the effect of inter-related factors such as age, height, smoking history, duration of employment, exposure and ventilatory function. The variable of principal interest was the difference between the 1970-71 survey and the 1971-72 survey. Thus, a paired difference in pulmonary function for each fire fighter was obtained. We then attempted to see the exposure effect on that change.

RESULTS AND DISCUSSION

Table 1 presents the basic data on 1430 fire fighters. The variables of interest are FVC, $FEV_{1.0}$ and the $FEV_{1.0}$/FVC ratio. Decrements were recorded for all three of these variables. The decrements for both FVC and $FEV_{1.0}$ are greater than expected. Several cross-sectional and prospective studies[7-12] have revealed that the expect-

Table 1. Cohort of 1430 Fire Fighters Studied in 1970-71 and 1971-72.

PERIOD	AGE	HEIGHT	FVC	$FEV_{1.0}$	$FEV_{1.0}$/FVC	YR WITH FIRE DEPARTMENT
	yr	*cm*	*liters*		%	
1970-71	43.13	173.7	4.461	3.578	80.2	16.8
1971-72	44.13	—	4.383	3.509	80.1	17.8
Difference	1.0	—	−0.077	−0.068	− 0.1	1.0

Table 2. Mean Decrement in Ventilatory Capacity According to Age Group of 1430 Fire Fighters.

Age (Yr)	Mean $FEV_{1.0}$ (Ml)	Mean FVC (Ml)	No. of Men
<25	− 17.9	+ 20.2	74
25-34	− 53.0	+ 6.2	294
35-44	− 57.8	− 67.3	282
45-54	− 62.9	− 93.8	613
55+	−154.2	−219.1	167
Means for all men	− 68.2	− 76.7	1430

ed annual loss for $FEV_{1.0}$ and FVC is about 25 to 30 ml per year. The rate observed in fire fighters over one year doubled that expectation. The rate seen in fire fighters more nearly resembles that rate of 80 ml per year seen in patients with chronic obstructive lung disease.[13-15]

Our data are shown according to age groups in Table 2. The most striking finding is the significantly greater rate of decrement in fire fighters over the age of 55 years.

The rate of decrement was analyzed by a breakdown of exposure variables. The most striking findings were with the number of fires fought. Men who fought no fires (78) were excluded from this analysis because poor health often results in non-fire-duty assignments.

Table 3 therefore includes the 1352 active fire fighters broken into three exposure categories based on the number of fires fought. A frequency distribution revealed a bimodal shape to the number of fires, with the dividing point being at about 40 fires per year. To get a third category, those who fought more than 40 fires were arbitrarily divided in two groups (41 to 99 and 100 and over). The loss of pulmonary function correlates with frequency of exposure, the heavily exposed losing more than double that of the lightly exposed fire fighters ($p < 0.01$ for FVC and < 0.02 for $FEV_{1.0}$).

Effect of Age

Since age had an effect on the rate of decrement, the results could possibly be related to difference in age in the exposure categories. We therefore calculated an expected decrement based on the age of each exposure category. Age does not explain the decrement related to exposure. The maximum difference attributable to age is 8.7 ml for FVC and 4.6 ml for $FEV_{1.0}$. The group of fire fighters who attended less than 40 fires represents a better estimate of the expected decrement than the total population.

Smoking Effect

Smoking habits could have accounted for the observed differences; however, there were no significant differences in the three exposure groups according to current smoking habits, years smoked or lifetime packages.

Table 3. Decrement in Ventilatory Capacity over One Year According to Number of Fires Fought.

No. of Fires	FVC (Ml)	$FEV_{1.0}$ (Ml)	No. of Men
1-40	− 51	− 49	861
41-99	− 78 (p<0.01)	− 71 (p<0.02)	216
100+	−135	−109	275

Ethnic Group

The rate of decrement for Irish fire fighters was slightly less than for the rest of the fire fighters (68.2 vs. 79.7 ml per year for $FEV_{1.0}$). It was therefore necessary to ascertain that ethnic distribution could not account for the observed relation with exposure. Those who fought less than 40 fires were 62.8 per cent Irish, those who fought 41 to 99 were 70.8 per cent Irish, and those fighting over 100 were 68.4 per cent. Thus, it is not possible to account for the observed decrement by ethnic differences. If anything, the Irish were under-represented in the lowest exposure group.

The possibility that other confounding variables could explain our results seems small because of the similarity of the three groups. Ages and heights are almost identical and smoking habits are essentially the same. The initial mean values for FVC and $FEV_{1.0}$ are also very close (Table 4).

Table 4. Summary of Possible Confounding Variables According to Number of Fires Fought (1971).

No. of Fires	Age	Height	FVC	$FEV_{1.0}$	Yr with Fire Department	LTP*	CPD†
	yr	*cm*	*liters*				
1-40	43.5	173.7	4.449	3.576	15.0	8523	17.2
41-99	43.2	174.0	4.545	3.646	15.5	8726	17.4
100+	43.7	173.6	4.541	3.652	16.6	8397	17.6

*Lifetime packages of cigarettes. †Cigarettes/day.

Other Exposure Variables

The number of "shellackings," number of times overcome at a fire, frequency of black sputum and oxygen use were not significantly associated with the rate of decrement in FVC or $FEV_{1.0}$. For the 64 fire fighters who were hospitalized for smoke inhalation, the annual decrement was somewhat greater than the average of men not hospitalized (90.3 ml per year for FVC and 98.1 ml per year for $FEV_{1.0}$). It appears that severe overexposures can also accelerate loss of pulmonary function.

We conclude that frequent exposure to combustion products as measured by the frequency of fires fought is associated with an accelerated loss of pulmonary function; the more frequent the exposure, the greater the loss. Acute smoke inhalation necessitating hospitalization also produces accelerated loss of pulmonary function.

This group is still under study to determine more precisely which exposures are the most hazardous. Extensive air sampling is under way to identify the combustion products. It seems proper to suggest the more frequent use of respiratory protective equipment. However, equipment available to the fire fighters is far from ideal. Much more work needs to go into development of better equipment for respiratory protection.

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RELATION OF CORNEAL ARCUS TO CARDIOVASCULAR RISK FACTORS AND THE INCIDENCE OF CORONARY DISEASE

RAY H. ROSENMAN, M.D., RICHARD J. BRAND, PH.D., ROBERT I. SHOLTZ, M.S. AND C. DAVID JENKINS, PH.D.

Abstract The relation of corneal arcus to the incidence of clinical coronary heart disease was prospectively studied in 3152 men, 39-59 years old at intake. During a mean 8 ½-year follow-up period, coronary disease developed in 255 initially well men. At entry into the study, arcus prevalence was found to be significantly related to age, serum cholesterol and smoking habits, but was not related to hematocrit, blood pressure, weight or obesity, habitual physical activity or diet, parental history of coronary heart disease, serum triglycerides or lipoproteins or to alcohol use. Subjects under 50 years of age with corneal arcus had a significantly higher incidence of coronary heart disease even after adjustment for age, serum cholesterol and smoking habits. Corneal arcus at younger ages is an independent risk factor for coronary heart disease. (N Engl J Med 291:1322-1324, 1974)

CORNEAL arcus has long intrigued clinicians. Although occurring at almost all ages, the term arcus senilis indicates its common association with aging.[1] It initially appears as a translucent segment in the lower and upper peripheral cornea and progresses until the segments fuse circumferentially to become a semitranslucent annulus and finally may become an opaque, grayish or yellow-white ring, usually separated from the limbus by a clear zone. Histochemically, it consists of cholesterol, triglycerides and phospholipids, thus suggesting a derivation from circulating blood by infiltration at the limbus from scleral vessels.[1,2] It is almost universally observed in higher prevalence in males,[1,3,4] but noteworthy differences in racial, color and geographic prevalence[5] led to the hypothesis of a genetic basis, supported by reported similar development in twins and a pattern of dominant inheritance.[5]

Prevalence of arcus was not found to be related to diabetes,[6] vitamin deficiencies,[5] obesity,[6] hypertension[4,6] or exercise.[6] A reported association with alcohol intake[6] was not confirmed.[7] Its correlation with xanthomatosis appears established,[3,5] but an association with serum lipids remains disputed.[1,3,4,6]

The old belief that arcus is correlated with coronary disease[1,3] is not universally accepted.[4,6] It is not correlated with generalized arteriosclerosis studied at autopsy.[8] The present studies were designed to clarify the clinical meaning of corneal arcus.

From the Harold Brunn Institute, Mount Zion Hospital and Medical Center, San Francisco, the School of Public Health, University of California, Berkeley, and the Department of Behavioral Epidemiology, Boston University School of Medicine (address reprint requests to Dr. Rosenman at the Harold Brunn Institute, Mount Zion Hospital and Medical Center, P.O. Box 7921, San Francisco, CA 94120).

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Material and Methods

The Western Collaborative Group Study was initiated in 1960[9] as a prospective study of the incidence of clinical coronary heart disease in men 39 to 59 years old employed in 10 companies. Comprehensive data were obtained at entry into the study and annually during a mean 8 ½-year follow-up period. A population of 3152 healthy subjects remained at risk for coronary heart disease, of whom 2248 were 39 to 49 and 904 were 50 to 59 years of age at entry into the study. Initial data included clinical, biochemical, dietary and behavioral variables whose detailed methodology has already been reported.[9] Corneal arcus was determined by meticulous gross inspection with flashlight illumination. A small, faint, translucent segment was not considered an arcus for the present purposes. The diet and alcohol intakes were obtained by a seven day diary[10] that was analyzed in detail for all nutrient components in a representative sample of 908 subjects. Diabetes was determined only by history.

Various follow-up data from the Western Collaborative Group Study have been presented.[11] Reported findings are based upon data collected at entry into the study. Statistical significance was analyzed by the chi-square test and by Student's t-test. Assessment of an association between arcus and coronary disease, with