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Depression and heart rate variability in firefighters

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Abstract

Introduction: Depression has been found to increase the risk of mortality in patients with coronary artery disease through a mechanism of changing cardiac autonomic tone which is reflected by alteration of heart rate variability indices. This study investigated whether such mechanism existed in firefighters who were at high risk of depression and sudden cardiac death.
Methods and results: In total, 107 firefighters were recruited. All completed Beck Depression Inventory and underwent 24-h ambulatory electrocardiographic monitoring. The root-mean-square of successive differences, standard deviation of all normal-to-normal intervals index, and the percentage of differences between adjacent normal-to-normal intervals >50 ms were significantly lower in depressed than in non-depressed firefighters after controlling for hypertension, age, and body mass index (40.1 ± 18.8 vs 62.5 ± 77.4, $p < 0.01$; 63.0 ± 19.2 vs 72.1 ± 34.8, $p < 0.01$; 8.4 ± 7.2 vs 12.7 ± 10.9, $p < 0.01$, respectively).
Conclusion: Decreased vagal tone is a possible mechanism linking depression and sudden cardiac death in firefighters.

Keywords

Depression, heart rate variability, firefighters

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Introduction

Depression has been found to be the most common mental disorder in men and it affects 4% men.[1] In patients after acute myocardial infarction, the prevalence of depression is even higher.[2] Depression is associated with low productivity, expensive healthcare cost, and increased cardiac mortality.[3] Penninx et al.[4] reported that depression increased the risk of cardiac mortality by 1.6 to 3.0 times in cardiac patients and 1.5 to 3.9 times in community residents without apparent cardiac disease.

Some mechanisms linking depression to cardiac mortality have been proposed.[5] Among them, altered autonomic nervous system activity is a plausible one.[6–8] Altered cardiac autonomic tone can cause the instability of cardiac electricity conduction, thus predisposing individuals to ventricular tachycardia, ventricular fibrillation, and sudden cardiac death (SCD).[9,10] Heart rate variability (HRV) which is acquired with electrocardiographic recordings and analyzed by a special computer program is a sensitive marker of cardiac parasympathetic tone.[11]

Although the altered HRV probably links depression to cardiac events, the mechanism has only been investigated in patients with coronary artery disease. This study focused on firefighters who are a special subpopulation at increased risk of depression and SCD. The prevalence of depression in rescue workers such as firefighters is as high as 10%.After exposed to a disaster, the prevalence increases to 22%.[12,13] Surprisingly, the first reason for on-duty death in firefighters is SCD but not asphyxiation or trauma. From 1995 to 2004, 440 firefighters nationwide died suddenly due to cardiovascular causes and that constitutes 44% of deaths in firefighters.[14] Even though there are high prevalences of depression and SCD in firefighters, no study has explored the possible mechanism linking depression to SCD in this subpopulation. This study aimed to examine whether depression was

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associated with cardiac autonomic tone reflected by HRV in firefighters.

Methods

This is secondary-data analysis using the data from the Surveying and Assessing Firefighters Fitness & Electrocardiogram (SAFFE) study (NIH 1R21NR011077-01). Methods of data collection were previously described in detail.[15,16] Briefly, professional firefighters completed 24-h ambulatory 12-lead electrocardiogram (ECG) using H12+ Holter recorders (Mortara Instrument, Milwaukee, WI, USA). Recordings were obtained at high resolution (1000 samples/s) with frequency bandwidth 0.05–60 Hz. All recordings were automatically analyzed using H-scribe software (Mortara Instrument). Additionally, firefighters completed baseline paper-and-pencil surveys regarding sleep patterns, depression, and substance use. Ethical approval for this study was obtained from the Institutional Review Board of the State University of New York at Buffalo and each firefighter signed the informed consent.

Depression measurement

The previously validated Beck Depression Inventory-II (BDI-II) was used to measure depressive symptoms.[17] BDI-II is composed of 21 multiple-choice questions (scores range between 0 and 63) and takes approximately 5 min to complete. A cutoff score of $\geqslant$10 was considered a marker of depression.[18]

HRV analysis

The H-Scribe software (Mortara Instrument) automatically yielded time-domain HRV indices. The standard deviation of all normal-to-normal (NN) intervals (SDNN) is the most widely used HRV index and was selected as a major outcome for this study. SDNN reflects all the variations in heart beats over a 24-h period. Other indices of this study are the root-mean-square of successive differences (rMSSD) and the mean of SDNN in all 5-min segments (SDNN index). The rMSSD represents short-term heart rate variation due to respiration and quantifies vagal tone, and the SDNN index reflects intermediate-term variation due to cycles shorter than 5 min.[11,19] They were included for exploratory analysis.

Data analysis

The distribution of most time-domain HRV indices is right-skewed. In this analysis, all the time-domain HRV indices, including SDNN, SDNN Index, rMSSD, and the percentage of differences between adjacent NN intervals >50 ms (pNN50), were natural log transformed to meet the normal distribution assumption behind the analysis of covariance (ANCOVA) and reported both with original values and log transformed values.

Demographic and medical features of firefighters were described with mean values ± SD for continuous variables and percentage (%) for categorical variables. In order to determine whether depression was associated with HRV after controlling for confounders such as age, body mass index (BMI), smoking status, hypertension, history of coronary disease and sleep apnea, univariate analyses and ANCOVAs were used.[20–23] First, Chi-square tests (Fisher's exact tests if expected frequency in a cell is less than 5) and two-tailed *t*-tests were conducted to determine whether there was difference in demographic and clinical conditions between the depressed and non-depressed groups. Then, potential covariates were defined as *p* value was less than 0.2 and were retained for the following ANCOVA. The significant level of alpha was set at 0.05 for the ANCOVA.

Results

All 107 firefighters were male. The age span was 21–58 years. Most of them were middle-aged (43.7 ± 7.7 years), and on average, they had served as firefighters for 15.7 years. The prevalence of smoking, sleep apnea, coronary heart disease, hypertension, and hyperlipidemia in this population was low but their average BMI (29.2 kg/m^2) was in the range of overweight. Demographic and clinical comparisons of depressed and non-depressed firefighters are presented in Table 1. The groups differed in hypertension ($p = 0.13$). There were no other significant demographic or clinical differences between the groups. Hypertension was retained in the following ANCOVAs as a covariate for each HRV index. With consideration of the wide age span and considerable variance in BMI in the firefighters, age and BMI were added as additional covariates in the analysis. After adjustment for hypertension, age, and BMI, depression was significantly associated with rMSSD, SDNN index, and pNN50 but not with SDNN, mean of heart rates (HR), or mean of heart periods (HP) (Table 2).

Discussion

During 24 h of Holter monitoring, the depressed firefighters had significantly lower rMSSD, SDNN index, and pNN50 which reflect short-term and intermediate-term variations of heart rate, respectively. The reduction in these indices, especially in rMSSD, may help to explain the increased risk of SCD in firefighters. The rMSSD predominantly reflects vagal tone. Decrease in vagal tone predisposes vulnerable animals and humans who have history of myocardial ischemia or infarction to ventricular fibrillation.[24,25] Although firefighters seem to be free of cardiac disease, investigation after firefighters' sudden deaths revealed that most of victims died of unrecognized cardiac ischemic disease.[14] This

Table 1. Comparisons of demographic and medical characteristics between the depressed and non-depressed groups ($n = 107$).

Demographic and clinical characteristics	Depressed group ($n = 22$)	Non-depressed group ($n = 85$)	p value
Age (year)	43.1 ± 6.4	44.1 ± 8	0.59
Men	22 (100%)	85 (100%)	1
Race			
White	18 (81.8%)	68 (80%)	
Black	4 (18.2%)	11 (12.9%)	
Others	0 (0%)	6 (7.1%)	0.39
Years as a firefighter (year)	15.4 ± 6.3	15.8 ± 7.3	0.59
Body mass index (kg/m^2)	29 ± 3.5	30 ± 4.2	0.35
Current smoker	2 (9.1%)	10 (11.8%)	1
Sleep apnea	2 (9.1%)	3 (3.5%)	0.27
Coronary heart disease	0 (0%)	3 (3.5%)	0.5
Hypertension (>140/90 mm Hg)	5 (22.7%)	34 (40%)	0.13
Hyperlipidemia	2 (9.1%)	3 (3.5%)	0.27

SD: standard deviation.
Values are expressed as mean ± SD.

Table 2. Adjusted HRV indices in firefighters with and without depression[a] ($n = 107$).

	Depressed group ($n = 22$)	Non-depressed group ($n = 85$)	p value
SDNN (ms)	157.9 ± 41.9	169.1 ± 89.3	
Ln (SDNN)	5.03 ± 0.285	5.038 ± 0.453	0.14
SDNN index (ms)	63.0 ± 19.2	72.1 ± 34.8	
Ln (SDNN index)	4.12 ± 0.301	4.20 ± 0.442	<0.01
rMSSD (ms)	40.1 ± 18.8	62.5 ± 77.4	
Ln (rMSSD)	3.53 ± 0.312	4.02 ± 0.224	<0.01
pNN50 (%)	8.47 ± 7.21	12.7 ± 10.9	
Ln (pNN50)	1.78 ± 1.17	2.17 ± 1.03	<0.01
Mean HR	76.6 ± 9.52	75.7 ± 9.57	0.44
Mean HP	0.804 ± 0.104	0.807 ± 0.123	0.34

HRV: heart rate variability; SDNN: the standard deviation of all normal-to-normal intervals in millisecond; SDNN index: the mean of standard deviations of all normal-to-normal intervals in all 5-min segments in millisecond; rMSSD: the square root of the mean of the sum of the squares of differences between adjacent normal-to-normal intervals in milliseconds; pNN50: the percentage of differences between adjacent normal-to-normal intervals >50 ms; mean HR: the mean of heart rates; mean HP: the mean of heart periods.
Values are expressed as mean ± SD.
[a]Adjusted for hypertension, age, and body mass index.

may support that decreased vagal tone is a possible mechanism for SCD in depressed firefighters as well.

There is no significant association between depression and SDNN in this study. This result is not consistent with a previous study in which depressed patients with coronary artery disease had decreased SDNN compared to non-depressed controls.[7] This difference may be due to different activity levels of subjects in Carney et al.'s study and in this study. Data in this study were collected on firefighters' on-duty days. They were very active of taking exercise and responding to medical and fire calls. Carney et al.'s study monitored hospital patients whose physical activity was minimal. SDNN includes all variations during 24 h and may be influenced by physical activity. Further investigation is deserved to clarify the effect of physical activity on HRV. In this study, mean HR and mean HP are not significantly different between groups. This result may be attributable to the insensitivity of the two variables to change in cardiac autonomic tone.

A limitation of this study is its cross-sectional design. Depression and HRV were measured at one time, therefore the evidence of a temporal relationship between depression and HRV cannot be provided. Depression and reduced HRV may be an outcome of a third party, such as a gene. In order to confirm the cause-and-effect relationship between depression and reduced HRV, a prospective study is needed.

Conclusion

The results of the study support that depression is associated with reduced cardiac vagal tone in firefighters. Whether such a change in vagal activity actually explains SCD in firefighters remains to be determined by prospective studies.

In addition, studies excluding the effect of other possible mechanisms on SCD such as health-related behaviors are needed as well.

Declaration of conflicting interests

No conflict of interest has been declared by the authors.

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