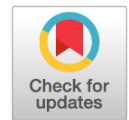# Factors of Cardiovascular Risk in Drivers of Locomotive Crews of Railway Transport with Ventricular Arrhythmias

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AIM: This study aimed to assess cardiovascular risk factors in drivers and assistant drivers of railway engine crews with ventricular rhythm disorders.

MATERIALS AND METHODS: The study included 120 patients aged 39 to 61 years (mean age M ± SD: 50.4 ± 4 years), who were distributed into two groups with and without ventricular rhythm disorders. All participants underwent 12-lead daily ECG monitoring with assessment of noninvasive markers of myocardial electrical instability (circadian profile, QT interval, late ventricular potentials, T-wave alternation, rhythm variability). Traditional factors of cardiovascular risk, the employment period in the profession, and the level of personal and situational anxiety on Spielberger's state-trait anxiety inventory (STAI) were evaluated.

RESULTS: In Group 1, in comparison with Group 2, significant differences were revealed in the duration of the PQ interval (during the day and at night) and the indicators of late ventricular potentials (RMS 40 and TotQRSF). When analyzing risk factors, elevated indices of total blood cholesterol were registered in both groups, and the risk on the SCORE scale was at a moderate level. In the group of workers with ventricular rhythm disorders, higher indicators of total blood cholesterol and the frequency of smoking and alcohol consumption were established. In individuals with ventricular rhythm disorders, a significant relationship was detected between the number of registered single monomorphic ventricular extrasystoles and the age of the employee ($r = -0.3$, $p < 0.05$), and blood pressure level ($r = 0.3$, $p < 0.05$), and the relationship between the level of anxiety and the registration of single supraventricular extrasystoles was established ($r = -0.3$, $p < 0.05$). In the Group 2, a significant correlation was revealed between the number of registered single supraventricular extrasystoles and age ($r = 0.2$, $p < 0.05$), the employment period in the profession of a driver ($r = 0.2$, $p < 0.05$), the blood pressure level ($r = 0.2$, $p < 0.05$), and the level of anxiety on the STAI ($r = 0.3$, $p < 0.05$).

CONCLUSIONS: Drivers of railway engine crews with ventricular rhythm disorders are characterized by a higher level of total blood cholesterol and a higher frequency of smoking and alcohol consumption. They have significant changes in the duration of the PQ interval (during the day and at night) and indicators of late ventricular potentials (RMS 40 and TotQRSF) according to Holter monitoring. The relationship of the number of ventricular rhythm disorders with age and the office values of systolic and diastolic blood pressure is noted in drivers of engine crews of railway transport.

Keywords: risk factors for cardiovascular disease; ventricular rhythm disorders; Holter monitoring; ventricular late potentials; workers of engine crews.

Факторы сердечно-сосудистого риска у работников локомотивных бригад железнодорожного транспорта с желудочковыми нарушениями ритма

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Цель исследования: оценить факторы сердечно-сосудистого риска у машинистов и помощников машинистов локомотивных бригад железнодорожного транспорта с желудочковыми нарушениями ритма.

Материалы и методы. В исследование включено 120 пациентов в возрасте от 39 до 61 года (средний возраст M ± SD: 50,4 ± 4 года), которые были разделены на две группы с желудочковыми нарушениями ритма и без желудочковых нарушений ритма. Всем исследуемым было выполнено 12-канальное суточное мониторирование ЭКГ с оценкой неинвазивных маркеров электрической нестабильности миокарда (циркадный профиль, интервал QT, поздние потенциалы желудочков, альтернация волны Т, вариабельность ритма). Оценивались традиционные факторы сердечно-сосудистого риска, а также стаж работы в профессии и уровень личностной и ситуационной тревожности по шкале Спилберга-Ханина.

Результаты. В первой группе, по сравнению со второй, выявлены значимые различия по длительности интервала PQ (в дневное и ночное время) и по показателям поздних потенциалов желудочков (RMS 40 и TotQRSF) . При анализе факторов риска в двух группах встречались повышенные значения уровня общего холестерина крови, риск по шкале SCORE находился на уровне умеренного. В группе работников с желудочковыми нарушениями ритма установлены более высокие показатели общего холестерина крови, частоты курения и употребления алкоголя. У лиц с желудочковыми нарушениями ритма выявлена значимая связь между количеством зарегистрированных одиночных мономорфных желудочковых экстрсистол с возрастом работника ($r = -0,3$, $p < 0,05$), и уровнем артериального давления ($r = 0,3$, $p < 0,05$), установлена связь уровня тревоги и регистрации одиночных суправентрикулярных экстрасистол ($r = -0,3$, $p < 0,05$). Во второй группе выявлена значимая корреляционная связь между количеством зарегистрированных одиночных суправентрикулярных экстрасистол с возрастом ($r = 0,2$, $p < 0,05$), и стажем труда в профессии машиниста ($r = 0,2$, $p < 0,05$), уровнем АД ($r = 0,2$, $p < 0,05$), и уровнем тревоги по шкале Спилберга-Ханина ($r = 0,3$, $p < 0,05$).

Выводы. Машинисты локомотивных бригад железнодорожного транспорта с желудочковыми нарушениями ритма характеризуются более высоким уровнем общего холестерина крови и более высокой частотой курения и употребления алкоголя. У них отмечаются значимые изменения длительности интервала PQ (в дневное и ночное время) и показателей поздних потенциалов желудочков (RMS 40 и TotQRSF) по данным Холтеровского мониторирования. У машинистов локомотивных бригад железнодорожного транспорта имеется связь количества желудочковых нарушений ритма с возрастом и офисными значениями систолического и диастолического АД.

Ключевые слова: факторы сердечно-сосудистого риска; желудочковые нарушения ритма; Холтеровское мониторирование; поздние потенциалы желудочков; работники локомотивных бригад.

One of the most urgent problems of modern medicine is the high mortality rate due to cardiovascular diseases (CVD). Due to their high prevalence, mortality from the pathology, and early disability, the medical and social significance of these diseases is very high. The mortality rate due to this CVD reaches 1462 cases per 100,000 population [1]. In most cases, the mechanisms underlying the development of sudden cardiac death (SCD) are ventricular tachycardia (VT) and ventricular fibrillation (VF) [1, 2].

Being an engine crew (EC) driver of railway transport (RT) is one of the professions of high social importance [3]. Issues related to train traffic safety are among the top priorities in RT [4]. However, all design, organizational, regime, and operational measures cannot ensure complete traffic safety, since among other things, it depends on the "reliability" of the human link in the control system [5]. The results of the analysis of the causes of sudden death among drivers and assistant drivers of the EC revealed that death was due to CVD in 80.6% of cases [6]. Due to a combination of negative stress factors, the dietary pattern and physical activity are disturbed, which increases the risk of the circulatory system diseases (CSD) [7, 8]. It is known that out of the total number of deaths that occurred in relation to traffic safety, the proportion of sudden arrhythmias was 2.1%. In addition, according to the literature, ventricular rhythm disorders were recorded in half of the drivers aged 40–49 years [6]. The above data indicate the expediency of investigating cardiovascular risk factors in RT workers, the prevalence and nature of recorded rhythm disorders, as well as noninvasive markers of myocardial electrical instability, as precursors of adverse, including fatal, outcomes.

Aim: The study aimed to evaluate cardiovascular risk factors in RT EC drivers and assistant drivers with ventricular rhythm disorder (VRD).

MATERIALS AND METHODS

The study included 120 male patients aged 39–61 years (mean age M ± SD: 50.4 ± 4 years). The average age of patients was 50 ± 4.2 years in Group 1 and 50.4 ± 3.8 years in Group 2. The patients were distributed into two groups according to the effect of heart rhythm disturbances (HRD) on life prognosis and labor prognosis. Group 1 consisted of patients with all types of HRD, including VRD (single and paired, polymorphic and monomorphic, runs of unstable VT), while Group 2 consisted of EC workers without VRD.

Group 1 consisted of 43 engine drivers and their assistants, which accounted for 36% of the total study population, while Group 2 consisted of 77 EC workers, which accounted for 64% of the study participants.

All employees were examined with regard to the annual commission to determine occupational aptitude. According to the medical documentation, 18 (41%) EC workers with a previously established diagnosis of arterial hypertension (AH) were identified in Group 1, and 45 (58%) patients with

AH were identified in Group 2. According to the survey, the participants did not constantly take antihypertensive drugs. ACE inhibitors and beta-blockers were taken symptomatically before the pre-trip medical check-up.

The inclusion criteria for the study were men over 18 years old, RT EC employees (drivers and assistant drivers), and signed an informed consent to participate in the study.

Exclusion criteria were refusal to participate in the study, ischemic heart disease, chronic heart failure, congenital and acquired heart defects, decompensated diabetes mellitus, active inflammatory diseases, mental illness, and oncological diseases.

The study was approved by the local ethics committee.

In accordance with the National Russian recommendations for the use of the 24-h ECG monitoring (24-h ECGM) technique in clinical practice [9], a 12-lead 24-h ECGM was performed using Incart devices in the Result-2 program, with an analysis of traditional indicators, including daytime and nighttime heart rate (HR), average HR per day, circadian index (CI, the ratio of average daytime to average nighttime HR), HRD (presence and number of supraventricular and ventricular extrasystoles and tachycardias), conduction (presence of atrioventricular and sino-atrial blocks), PQ intervals (interval duration during the day and at night), QT intervals (assessment of the value of the corrected QT interval and QT interval dispersion), and parameters of myocardial repolarization (assessment of ST-segment and T-wave displacement). In addition, indicators of heart rate variability were analyzed. Moreover, the presence of T-wave alternation and indicators of late ventricular potentials (LVP) were assessed (TotQRSF as the duration of the filtered QRS complex after averaging, RMS40 as the root mean square value of the tension in the last 40 ms of the QRS complex (RMS40), LAS40 as the low-amplitude signal duration, and below 40 μV).

Risk factors (RF) were studied, such as age, employment period in the EC driver profession, smoking and the degree of nicotine addiction according to the Fagerström test, the frequency and amount of alcohol consumed. The level of personal and situational anxiety on the Spielberger's state-trait anxiety inventory (STAI) was assessed, and the body mass index (BMI), impaired tolerance (IT) to carbohydrates, level of total blood cholesterol, degree of AH, risk on the SCORE scale, and results of bicycle ergometry (BEM) were evaluated.

Statistical analysis of the data was performed using the Statistica 10.0 program. The differences between the groups was assessed using the Mann–Whitney test, the significance level was considered as $p < 0.05$. Continuous variables were presented as mean and standard deviation, and qualitative variables were expressed as absolute number and percentage. The correlations between pairs of quantitative variables were assessed using the non-parametric Spearman coefficient, and the significance level was considered as $p < 0.05$.

RESULTS AND DISCUSSION

Rhythm disorders in the studied groups were presented as shown in Table 1.

There was no significant difference in the occurrence of supraventricular rhythm disorders between the groups. In both groups, single SVES were recorded in all subjects. In addition, in both groups, patients with paired and group SVES, as well as episodes of unstable SVT were identified. According to studies, supraventricular rhythm disorders in the population were recorded at a frequency of 20%–50%. The increase in the incidence of supraventricular extrasystole in RT EC workers is due to a shift work schedule and the frequent night shifts, which provokes an increase in sympathetic influences and a decrease in parasympathetic control over the heart rhythm. In patients with AH, an insufficient decrease in BP at night, associated with a specific work schedule, also induces supraventricular rhythm disorders [10].

In Group 1, compared with Group 2, significant differences were revealed in the duration of the PQ interval (during the day and at night) and in terms of LVP (RMS 40 and TotQRSF).

Table 2 presents the differences in the studied parameters according to the 24-h ECGM data between the two groups.

The RT EC workers in Group 1 had ventricular rhythm disorders of high grades according to the Rayn classification, which may indicate a myocardial restructuring and the appearance of an arrhythmogenic substrate. The short episodes of ventricular tachycardia in patients represent an unfavorable factor associated with a significant risk of SCD [11]. In addition, in Group 1, this also can be evidenced by changes in the LVP parameters,

Table 1. Rhythm disorders in RT EC workers.

Cardiac rhythm disorders	Group 1 (*n* = 43)	Group 2 (*n* = 77)
Single SVES, *n* (%)	43(100)	77(100)
Single SVES, *n* (%)	16(37)	28(36)
Group SVES, *n* (%)	11(25)	14(18)
SVT, *n* (%)	4(10)	5(6)
Single monomorphic VES, *n* (%)	15(34)	–
Single polymorphic VES, *n* (%)	26(60)	–
Paired monomorphic VES, *n* (%)	3(7)	–
Paired polymorphic VES, *n* (%)	4(8)	–
MVT, *n* (%)	2(3)	–

Note: SVES — single supraventricular extrasystoles, SVT — supraventricular tachycardia, VES — ventricular extrasystoles, MVT — monomorphic ventricular tachycardia.

Table 2. Indicators of 24-h ECGM among RT EC workers.

Indicator	Group 1 (*n* = 43)	Group 2 (*n* = 77)
HR during the day, beats/min	75 ± 8	75 ± 8
HR at night, beats/min	62 ± 7	61 ± 7
CI, c.u.	1.21 ± 0.1	1.2 ± 0.1
Corrected QT, ms	404.6 ± 13	406 ± 16
QT dispersion, ms	14 ± 8	14 ± 9
PQ day, ms	162.3 ± 26*	170 ± 24
PQ night, ms	173 ± 30*	180 ± 26
TotQRSFcp, ms	93.4 ± 11.8*	87 ± 5
RMS 40 max uV	55.9 ± 39*	115 ± 48
T-wave alternation, people (%)	32 (74)	55(71)

Note: *$p < 0.05$; HR — heart rate; CI — circadian index; TotQRSF, RMS 40 — indicators of the ventricular late potentials.

Table 3. Parameters of cardiovascular risk in RT EC workers.

Parameter	Group 1 (n = 43)	Group 2 (n = 77)
BP, n (%)	20(46)	42(54)
SCORE, %	2.6 ± 1.7	2.2 ± 1.1
Level of total cholesterol, mmol/l	5.4 ± 1*	5.1 ± 0.8
SBP, mmHg	125 ± 8	123 ± 8
DBP, mmHg	80 ± 5	78 ± 6
Employment period, years	26 ± 9	25 ± 9
Level of anxiety, points	11.6 ± 7	13 ± 6
Smoking, n (%)	30 (70)	35 (45)
Pack/years index, c.u.	15 ± 12*	9 ± 12
Level of nicotine addiction, points	2.4 ± 2.2*	1.5 ± 2
Alcohol consumption, n (%)	42 (97)	63 (81)
Level of alcohol consumption, points	3.9 ± 2*	2.8 ± 2
Glucose IT, n (%)	8 (19)	12 (16)
BMI, kg/m^2	28 ± 4*	27.3 ± 4
Age, years	20(46)	42(54)

Note: *p < 0.05; SBP — systolic blood pressure; DBP — diastolic blood pressure; IT — impaired tolerance; BMI — body mass index.

as a noninvasive criterion for possible arrhythmogenic processes and confirmation of a more heterogeneous process of ventricular myocardial repolarization [12]. The PQ interval in both groups was within the normal range; however, in the group of EC workers with VRD, the PQ interval revealed was significantly shorter than in the group of workers without VRD. This phenomenon is probably because the atrioventricular (AV) node receives innervation from the sympathetic and parasympathetic nervous systems and is sensitive to circulating catecholamines. Sympathetic stimulation, in turn, shortens AV conduction, while parasympathetic stimulation leads to the opposite effects [13].

All the patients examined had a negative BEM test. Rhythm disorders were not recorded during the exercise.

RT EC workers are characterized by the presence of traditional cardiovascular risk factors (Table 3). Analysis of RF in both groups was performed by reviewing the medical records (the presence of AH, calculation of the 10-year risk of death on the SCORE scale, total blood cholesterol, working BP level, employment period and age, anxiety level, presence of bad habits such as smoking and alcohol consumption, BMI, and presence of IT to glucose). The analysis of RF in both groups revealed elevated levels of total blood cholesterol, and the risk according to the SCORE scale was at the moderate level. In the group of EC workers with VDR, most of subjects surveyed smoked and drank alcohol. Significant differences between the two groups were revealed in terms of total blood cholesterol, the frequency of smoking as determined by the pack/year index and the Fagerström Test for Nicotine Dependence, and the degree of alcohol consumption calculated using the AUDIT scale. Significantly higher rates of total blood cholesterol, frequency of smoking and alcohol consumption, and degree of nicotine dependence were revealed in the group of railway workers with VRD. Identification of these RFs can exacerbate the course of VRD and accelerate the development of fatal complications [14].

A correlation analysis revealed a significant relationship between the number of registered single monomorphic VESs and the age of the EC workers in Group 1 ($r = -0.3$, $p < 0.05$), as well as SBP ($r = 0.3$, $p < 0.05$) and DBP ($r = 0.3$, $p < 0.05$). In addition, a relationship was revealed between the level of anxiety on the Spielberger's STAI and the occurrence of single SVES ($r = -0.3$; $p < 0.05$).

In Group 2, a significant correlation was revealed between the number of registered single SVES and age ($r = 0.2$; $p < 0.05$), employment period in the profession of an RT EC driver ($r = 0.2$; $p < 0.05$), BP level ($r = 0.2$; $p < 0.05$), and anxiety level according to the Spielberger's STAI ($r = 0.3$; $p < 0.05$).

The study revealed a high prevalence of rhythm disorders and CVD RF, mainly related to the lifestyle and working conditions of the profession of an EC driver. The data obtained may be of practical value in preventive interventions for EC workers.

CONCLUSIONS

1. Drivers of RT engine crews with ventricular rhythm disorders are characterized by a higher level of total blood cholesterol, and a higher frequency of smoking and alcohol consumption.

2. The number of ventricular rhythm disorders is associated with age and office values of systolic and diastolic BP among drivers of RT engine crews, while the number of supraventricular extrasystoles is associated not only with age and BP level, but also with employment period in the profession and the level of anxiety.

3. Drivers of railway engine crews with ventricular rhythm disorders have significant changes in the duration of the PQ interval (during the day and at night) and indicators of LVP (RMS 40 and TotQRSF) according to Holter monitoring, which may be significant when examining this cohort.

ADDITIONAL INFORMATION

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