Kuzminykh N. A., Shcherbakova L. V.,
Gafarov V. V., Shramko V. S., Denisova D. V., Ragino Yu. I.
Research Institute of Therapy and Preventive Medicine, Branch of the Federal
Research Center of the Institute of Cytology and Genetics, Novosibirsk, Russia

Associations of ECG Signs of Ischemic and Non-Specific Signs of Metabolic Changes in the Myocardium With Unfavorable Cardiovascular Prognosis in a 7-Year Prospective Follow-Up of Young People Under 45 Years

Aim	To study ischemic and/or nonspecific ECG signs of metabolic changes in the myocardium and to determine their relationship with unfavorable cardiovascular prognosis in a 7-year prospective observation of young people under 45 years of age.
Material and methods	A cross-sectional population survey of a random sample aged 25–44 years (n=1363) was conducted in Novosibirsk. The survey program used the standardized epidemiological Rose questionnaire. Biochemical tests were used to measure blood concentrations of total cholesterol (C), triglycerides (TG), low- and high-density lipoprotein cholesterol (LDL–C, HDL–C), and fasting blood plasma glucose. Systolic and diastolic BP (SBP, DBP), the presence of arterial hypertension (AH), body mass index (BMI), waist circumference (WC), and smoking status were assessed. ECG was recorded at rest in 12 standard leads followed by interpretation according to the Minnesota Code. The presence of ischemic and/or nonspecific ECG signs of metabolic changes in the myocardium was determined. Subjects with ECG signs of ischemic changes in the myocardium were selected for long-term follow-up and additional examination by cardiologists. Then the whole cohort was monitored for 7 years, and cardiovascular events were recorded, including using data from the WHO Myocardial Infarction Registry in Novosibirsk. For statistical analysis of the results, cardiovascular events were combined into a composite endpoint.
Results	During 7 years, 40 people (27 men and 13 women) had an unfavorable cardiovascular prognosis. Multivariate regression analysis showed that a 7-year unfavorable cardiovascular prognosis in people younger than 45 years was associated with signs of ischemic myocardial alterations identified on the background ECG (OR 5.319, 95% CI: 1.543–18.342, p=0.008) and nonspecific ECG signs of metabolic changes in the myocardium (OR 2.978, 95% CI: 1.216–7.216, p=0.017) regardless of age, gender, the presence of arterial hypertension (AH) and type 2 diabetes mellitus (DM2).
Conclusion	In young people under 45 years of age, not only ECG signs of ischemic changes in the myocardium, but also nonspecific ECG signs of metabolic changes in the myocardium are associated with an unfavorable cardiovascular prognosis, directly and independently on age and gender, in a long-term, 7-year period.

Keywords	ECG; myocardial ischemic changes; myocardial metabolic changes; epidemiological study; population; lipid and nonlipid risk factors; long-term follow-up period; composite endpoint of cardiovascular events
For citations	Kuzminykh N.A., Shcherbakova L.V., Gafarov V.V., Shramko V.S., Denisova D.V., Ragino Yu.I. Associations of ECG Signs of Ischemic and Non-Specific Signs of Metabolic Changes in the Myocardium With Unfavorable Cardiovascular Prognosis in a 7-Year Prospective Follow-Up of Young People Under 45 Years. Kardiologiia. 2024;64(3):18–24. [Russian: Кузьминых Н.А., Щербакова Л.В., Гафаров В.В., Денисова Д.В., Шрамко В.С., Рагино Ю.И. Ассоциации ЭКГ признаков ишемических и неспецифических признаков метаболических изменений миокарда с неблагоприятным сердечно-сосудистым прогнозом в 7-летнем проспективном наблюдении молодых людей до 45 лет. Кардиология. 2024;64(3):18–24].

Corresponding author Ragino Yu. I. E-mail: ragino@mail.ru

Introduction

Cardiovascular diseases (CVD) remain the leading cause of mortality and disability in the working age population worldwide and in Russia. There is a known trend of increasing prevalence of CVD and its risk factors in the young population [1–5].

In epidemiologic studies, coronary artery disease (CAD) is traditionally defined by the presence of electrocardiographic (ECG) abnormalities, angina pectoris according to the Rose questionnaire, and a history of myocardial infarction. In this case, the analysis of the ECG pattern plays a key role [6, 7].

ISSN 0022-9040. Kardiologiia. 2024;64(3). DOI: 10.18087/cardio.2024.3.n2571

Central illustration. Association of ECG signs of myocardial ischemic changes and nonspecific signs of myocardial metabolic changes with adverse cardiovascular prognosis in the 7-year prospective follow-up of young adults under 45 years of age

Cross-sectional study of a random sample of the population aged 25–44 in Novosibirsk (n = 1563, 47 % males, 53 % females). Cardiovascular risk factors (hyperlipidemia, hypertension, obesity, abdominal obesity, type 2 DM, smoking) and ECG signs of myocardial ischemic and metabolic changes were evaluated.

7-year follow-up of a cohort with a record of cardiovascular events or diseases (composite endpoint including cardiovascular death, CAD, myocardial infarction, CHF, stroke, and hypertensive heart disease)

Unfavorable cardiovascular prognosis in 40 individuals (27 males and 13 females).

Adverse cardiovascular prognosis was directly associated with ECG signs of myocardial ischemic changes (OR 5.319, 95 % CI: 1.543–18.342, p = 0.008) and metabolic changes (OR 2.978, 95 % CI: 1.216–7.216, p=0.017) at baseline, independent of age, sex, and presence of hypertension and type 2 DM.

ECG, electrocardiography; CVD, cardiovascular disease; DM, diabetes mellitus; CAD, coronary artery disease; CHF, chronic heart failure; OR, odds ratio; CI, confidence interval.

Cardiovascular risk factors can cause, among other things, the development of myocardial metabolic disorders and cardiomyopathies, the symptoms of which are not significant in the clinical picture of the disease. Disturbances in neuroendocrine effects and the development of myocardial energy and electrolyte deficiency and tissue hypoxia underlie this pathology [8–11]. ECG is also one of the best studied and most widely used diagnostic tools to detect conduction abnormalities, indirect signs of cardiac hypertrophy, and other nonspecific electrophysiological signs of myocardial metabolic disorders [12, 13].

The important prognostic role of electrocardiographic abnormalities in the development of cardiovascular events (cardiovascular death, fatal and non-fatal myocardial infarction, unstable angina, myocardial revascularization, and others) in isolation or in combination with traditional cardiovascular risk factors has been demonstrated in numerous prospective clinical and cohort studies. However, all results were obtained from observations in patients/populations older than 45 years [14–17]. Therefore, the objective of this study was to evaluate the prognostic value of ECG signs of ischemic changes or nonspecific ECG signs of myocardial metabolic abnormalities in relation to adverse cardiovascular prognosis in a 7 year prospective observational study of adults younger than 45 years (25–44 years old).

Material and methods

A cross-sectional population study of a random sample of Novosibirsk residents aged 25–44 years was conducted in the Research Institute of Internal and Preventive Medicine (Branch of the Institute of Cytology and Genetics, Siberian Branch of Russian Academy of Sciences) in 2013–2017. The study was approved by the local ethics committee (Minutes #6/2013 of 25/06/2013). All subjects signed an informed consent for the examination and processing of personal data.

This study included 1363 individuals who were examined at the Screening Center of the Research Institute of Internal and Preventive Medicine. A single blood sample was taken from the ulnar vein in the morning on an empty stomach, 12 hours after a meal. Lipid profile (total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL–C), and high-density lipoprotein cholesterol (HDL–C)) and glucose were measured by enzymatic methods using standard reagents (TermoFisher, Finland) on a KoneLab 30i automated biochemical analyzer (TermoFisher, Finland).

The screening program included a smoking questionnaire, anthropometry, and triple blood pressure (BP) measurements. The presence of diabetes mellitus was determined according to epidemiologic criteria (fasting plasma glucose (FPG) ≥7 mmol/L). The following CAD risk factors were assessed: smoking, elevated body mass index (BMI) >25 kg/m^2, waist circumference (WC) ≥94

cm in male patients, ≥80 cm in female patients, presence of hypertension≥140/≥90 mm Hg, elevated LDL–C ≥116 mg/dL or≥3 mmol/L, elevated TG ≥150 mg/dL or ≥1.7 mmol/L, elevated non-high-density lipoprotein cholesterol (non-HDL–C) ≥130 mg/dL or ≥3.4 mmol/L [18].

All patients enrolled in the study underwent a 12-lead resting ECG with the interpretation using the Minnesota Code (MC) criteria. ECG signs of myocardial ischemic changes and the presence of CAD (according to the Definite CAD epidemiological criteria) were analyzed: exertional angina pectoris (positively completed WHO questionnaire (J. Rose questionnaire); resting ECG abnormalities – Q-QS waves – MC (121–127), ischemic myocardial changes MC (4–1, 4–2 and/or 5–1, 5–2) without 3–1, 3–3; a history of myocardial infarction (survey) [7]. ECG signs of myocardial ischemic changes and the presence of CAD (according to epidemiologic criteria) were detected in 46 of 1363 patients examined. All 46 patients were under continuous long-term follow-up by cardiologists in the diagnostic department of the Clinic of the Research Institute of Internal and Preventive Medicine. Patients underwent additional examinations; existing cardiovascular risk factors were corrected, and medical therapy was prescribed as indicated.

The presence of non-specific ECG signs of myocardial metabolic changes was also analyzed: S-T segment elevation above the baseline >0.5 mm with downward convexity MC (9-7-1, 9-7-2), S-T segment depression below the baseline >0.5 mm of non-ischemic type (fast oblique S-T segment with a decrease of less than 0.15 mV (1. 5 mm) from J point) MC (4–3, 4–4), abnormal T wave (flattening, smoothing and decrease in amplitude of T wave in leads where R wave is leading; biphasic in leads II, V3 – V6; double-humped in leads V2 – V6; negative in leads I, II, AVF, V3 – V6) MC (5–3, 5–4), TV1 >TV6 syndrome (T amplitude in V1 exceeds T amplitude in V6 – as a sign of left ventricular myocardial load and early qualitative electrocardiographic sign of left ventricular hypertrophy (LVH)), ECG signs of LVH (Sokolow-Lyon criteria (S V1 + R V5 (V6)) ≥35 mm, Gubner-Ungerleider criteria (RI + SIII) >25 mm, R aVL>11 mm, R V5 (V6) ≥27 mm, Cornell voltage criteria (R aVL + S v3) >28 mm) – no specific code, but includes MC (3–1, 3–3) [7].

During the 7 year long-term follow-up of all patients examined (n=1363), new-onset cardiovascular events were registered in 40 patients (27 males and 13 females) with the use, among others, of the World Health Organization's Acute Myocardial Infarction Registry program (WHO, Copenhagen, 1976; started on 01/01/1977), which is implemented in the Research Institute of Internal and Preventive Medicine (Table 1).

Table 1. Cardiovascular events (composite endpoint) in a 7-year, prospective, observational study of young adults aged<45 years

Cardiovascular event (documented)	Number of patients	Male/female
Cardiovascular death	7	6/1
CAD (stable/unstable exertional angina pectoris)	5	4/1
Myocardial infarction	4	3/1
Chronic heart failure	5	4/1
Ischemic stroke	3	2/1
Cerebrovascular disease	2	1/1
Hypertensive heart disease (hospitalized)	14	7/7
Total	40	27/13

All events were combined into a composite cardiovascular endpoint for statistical analysis.

SPSS (IBM, USA) for Windows 17.0 was used for statistical processing of the results. The odds ratios (OR) and 95% confidence intervals (CI) in the multivariate logistic regression model and the χ test were calculated. A 95% level of statistical significance was used.

Results

Based on the 7 year long-term follow-up data of the young cohort, we divided all subjects into subgroups with a favorable cardiovascular prognosis and an unfavorable prognosis (presence of the composite cardiovascular endpoint). According to the data in Table 2, patients with an unfavorable cardiovascular prognosis at baseline were 6.1 times more likely to have ECG signs of myocardial ischemic changes (15.2%) compared with patients with a favorable cardiovascular prognosis (2.5%). Patients with an unfavorable cardiovascular prognosis at baseline were also 4.1 times more likely to have nonspecific ECG signs of metabolic myocardial changes (7.0%) compared with patients with a favorable cardiovascular prognosis (1.7%). In addition to ECG abnormalities, patients with an unfavorable cardiovascular prognosis at baseline were more likely to have elevated blood TG and TC (2.3-fold), LDL–C and non-HDL–C (2-fold), fasting plasma glucose (4.8-fold), abdominal obesity (2.4-fold), and hypertension (4.8-fold) compared with those with a favorable cardiovascular prognosis (Table 2).

Subsequent multivariate regression analysis showed that 7 year unfavorable cardiovascular prognosis in young people<45 years of age was associated with ECG signs of myocardial ischemic changes (detected at baseline) independent of age and sex, body mass index, waist

ISSN 0022-9040. Kardiologiia. 2024;64(3). DOI: 10.18087/cardio.2024.3.n2571

Table 2. Prevalence of cardiovascular events (composite endpoint) in subgroups with risk factors at baseline, n (%)

Factor at baseline examination of the cohort, number of subjects assessed for the presence of the factor		Without composite cardiovascular endpoint, n=1323	With composite cardiovascular endpoint, n=40	p
Sex, n=1363	Male, n=654	627 (95.9)	27 (4.1)	0.012
	Female, n=709	697 (98.3)	13 (1.7)	
Ischemic changes on ECG, n=1363	No, n=1317	1284 (97.5)	33 (2.5)	0.0001
	Yes, n=46	39 (84.8)	7 (15.2)	
Nonspecific metabolic changes on ECG, n=1003*	No, n=817	803 (98.3)	14 (1.7)	0.0001
	Yes, n=186	173 (93.0)	13 (7.0)	
Smoking, n=1363	No, n=895	871 (97.3)	24 (2.7)	0.594
	Yes, n=468	453 (96.8)	16 (3.2)	
Elevated TG (≥ 1.7 mmol/L), n=1356**	No, n=1126	1100 (97.7)	26 (2.3)	0.015
	Yes, n=230	218 (94.8)	12 (5.2)	
Elevated TC (≥ 5.0 mmol/L), n=1356**	No, n=693	681 (98.3)	12 (1.7)	0.015
	Yes, n=663	637 (96.1)	26 (3.9)	
Elevated LDL-C (≥ 3.0 mmol/L), n=1356**	No, n=604	593 (98.2)	11 (1.8)	0.049
	Yes, n=752	724 (96.4)	27 (3.6)	
Elevated non-HDL-C (≥ 3.4 mmol/L), n=1356**	No, n=531	522 (98.3)	9 (1.7)	0.047
	Yes, n=825	796 (96.5)	29 (3.5)	
Diabetes mellitus (FPG≥7 mmol/L), n=1356**	No, n=1324	1290 (97.4)	34 (2.6)	0.001
	Yes, n=32	28 (87.5)	4 (12.5)	
Overweight, n=1363	No, n=670	655 (97.8)	15 (2.2)	0.136
	Yes, n=693	668 (96.4)	25 (3.6)	
Abdominal obesity, n=1363	No, n=757	743 (98.2)	14 (1.8)	0.008
	Yes, n=606	580 (95.7)	26 (4.3)	
Hypertension, n=1363	No, n=1106	1087 (98.3)	19 (1.7)	0.0001
	Yes, n=257	236 (91.8)	21 (8.2)	

ECG, electrocardiography; FPG, fasting plasma glucose; TG, triglycerides; TC, total cholesterol;
LDL-C, low-density lipoprotein cholesterol; non-HDL-C, non-high-density lipoprotein cholesterol;
* Only subjects with 2 or more ECG signs of myocardial metabolic changes are included in the group;
** Only subjects who had blood drawn for biochemical studies are included in the group.

circumference, SBP, DBP, TC, TG, and blood creatinine (Table 3).

In addition, multivariate regression analysis showed that 7 year unfavorable cardiovascular prognosis in young people<45 years of age was associated with nonspecific ECG signs of myocardial metabolic changes (detected at baseline), independent of age, sex, body mass index, waist circumference, presence of hypertension, diabetes mellitus (according to epidemiologic criteria), non-HDL–C, TG, and blood creatinine (Table 4).

Thus, not only ECG signs of myocardial ischemic changes, but also nonspecific ECG signs of myocardial metabolic changes detected at baseline in young subjects <45 years of age, independent of sex, age, and some risk factors, are directly associated with an unfavorable cardiovascular prognosis in the long-term 7 year period.

Discussion

Numerous studies have been devoted to investigating the relationship between ECG abnormalities and adverse long-term cardiovascular prognosis, including those aimed at contrasting and comparing the effects of ECG abnormalities and conventional cardiovascular risk factors on the development of future adverse cardiovascular events in people over the age of 45. For example, Auer et al. concluded that the prediction of CAD using conventional cardiovascular risk factors is less accurate in a population of elderly people over 70 years of age than in middle-aged adults, and that on the contrary, ECG abnormalities are important for the prediction of CAD (acute myocardial infarction, death from CAD, hospitalization for unstable angina, or myocardial revascularization) [19]. Niu et al. investigated whether ECG abnormalities could be an additional factor in addition to the conventional

cardiovascular risk factors in the long-term follow-up period. The authors concluded that the detection of ECG abnormalities at screening, in addition to conventional risk factors, may provide some improvement in the prediction of cardiovascular risk in high-risk individuals over 40 years of age [16]. Novo et al. concluded from their study that the combination of the EuroSCORE with ECG assessment may be a useful tool to prevent the risk of cardiovascular events in people without CVD over the age of 50 years [20].

Our findings suggest a significant role of not only myocardial ischemic changes but also nonspecific myocardial metabolic ECG abnormalities in the development of cardiovascular events in young adults under 45 years of age over a 7 year period. Our findings are consistent with previous similar prospective studies at the population level and studies conducted in selected clinical groups of CVD patients over 45 years of age. Krittayaphong et al. showed that in patients with CAD or cardiovascular risk factors older than 45 years, independent predictors

Table 3. Results of multivariate logistic regression analysis of associations of ECG signs of myocardial ischemic changes with the odds of having an unfavorable cardiovascular prognosis in the 7-year prospective follow-up of young people under 45 years of age

Parameters	B (regression coefficient)	OR	95 % CI	p
Ischemic changes on ECG	1.671	5.319	1.543–18.342	0.008
Age	0.131	1.140	1.037–1.252	0.007
Sex (male)	1.098	2.998	1.020–8.812	0.046
BMI	0.029	1.030	0.948–1.119	0.490
WC	0.030	1.031	0.999–1.063	0.056
SBP	0.021	1.021	0.999–1.044	0.061
DBP	0.048	1.049	1.011–1.089	0.011
TC	0.402	1.494	0.540–4.130	0.439
TG	0.630	1.877	0.567–6.211	0.302
Creatinine	0.036	1.036	1.000–1.073	0.047

OR, odds ratio; CI, confidence interval; ECG, electrocardiography; BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglycerides.

Table 4. Results of multivariate logistic regression analysis of associations of nonspecific ECG signs of myocardial metabolic changes with the odds of having an unfavorable cardiovascular prognosis in the 7-year prospective follow-up of young people under 45 years of age

Parameters	B (regression coefficient)	OR	95 % CI	p
Nonspecific metabolic changes on ECG	1.091	2.978	1.216–7.216	0.017
Age	0.078	1.081	1.006–1.160	0.033
Sex (male)	-0.562	0.570	0.216 -1.503	0.256
BMI	0.018	1.018	0.944–1.098	0.641
WC	0.011	1.011	0.980–1.043	0.501
AH	1.370	3.934	1.627–9.512	0.002
Diabetes mellitus (epidemiologic criteria)	1.496	4.463	1.247–15.977	0.021
Non-HDL-C	0.009	1.009	1.001–1.017	0.032
TG	0.061	1.063	0.751–1.505	0.730
Creatinine	0.022	1.022	0.984–1.063	0.259

OR, odds ratio; CI, confidence interval; ECG, electrocardiography; BMI, body mass index; WC, waist circumference; non-HDL-C, non-high-density lipoprotein cholesterol; TG, triglycerides.

of the development of the composite cardiovascular endpoint (cardiovascular death, nonfatal myocardial infarction, hospitalization for unstable angina, or heart failure) in the long-term period included baseline ECG abnormalities such as atrial fibrillation, LVH, abnormal Q wave, and intraventricular conduction delay [17]. Zhang et al. demonstrated the significance of Q/ST-T changes on ECG in individuals over 45 years of age as predictors of future fatal cardiac events and all-cause mortality [14]. Ricardo Pires et al. showed that detection of ECG signs of LVH in hypertensive individuals over 50 years of age is an independent predictor of cardiovascular events [15]. Shin et al. showed that the presence of ST segment, T wave, or PQ interval abnormalities on ECG was associated with worse cardiovascular outcomes (MACE, a composite endpoint including cardiovascular death, myocardial infarction, coronary artery disease, and stroke) over a 12 year follow-up period in a population aged 40–69 years (n=8444) [21].

Conclusion

Thus, it can be concluded that the detection of ECG signs of not only myocardial ischemic changes but also non-specific signs of myocardial metabolic changes in young people under 45 years of age is very important for

ISSN 0022-9040. Kardiologiia. 2024;64(3). DOI: 10.18087/cardio.2024.3.n2571

assessing the risk of unfavorable long-term cardiovascular prognosis.

We showed that ECG signs of myocardial ischemic changes and nonspecific ECG signs of myocardial metabolic changes detected at baseline in young subjects <45 years of age, independent of sex, age, and some risk factors, are directly associated with an unfavorable cardiovascular prognosis in the long-term 7 year period.

Limitations

The population studied and followed for 7 years is young. Therefore, the number of cardiovascular disease/event endpoints was low. Therefore, all cardiovascular disease/event endpoints were combined into the composite endpoint to achieve statistical significance.

Funding

The study was a part of the budget topic under the State Assignment # FWNR-2024–0004 and supported by the Russian Science Foundation grant # 21-15-00022.

No conflict of interest is reported.

The article was received on 11/08/2023

REFERENCES

1. Vilkov V.G., Shalnova S.A. Thirty-year trends in the prevalence of cardiometabolic risk factors in the populations of the Russian Federation and the United States of America. Cardiovascular Therapy and Prevention. 2022;21(8):34–9. [Russian: Вилков В.Г., Шальнова С.А. Тридцатилетняя динамика распространенности кардиометаболических факторов риска в популяциях Российской Федерации и Соединенных Штатов Америки. Кардиоваскулярная терапия и профилактика. 2022;21(8):34-9]. DOI: 10.15829/1728-8800-2022-3304
2. Shukor MFA, Musthafa QA, Mohd Yusof YA, Wan Ngah WZ, Ismail NAS. Biomarkers for Premature Coronary Artery Disease (PCAD): A Case Control Study. Diagnostics. 2023;13(2):188. DOI: 10.3390/diagnostics13020188
3. Jahangiry L, Abbasalizad Farhangi M, Najafi M, Sarbakhsh P. Clusters of the Risk Markers and the Pattern of Premature Coronary Heart Disease: An Application of the Latent Class Analysis. Frontiers in Cardiovascular Medicine. 2021;8:707070. DOI: 10.3389/fcvm.2021.707070
4. Babahajiani M, Zarepur E, Khosravi A, Mohammadifard N, Noohi F, Alikhasi H et al. Ethnic differences in the lifestyle behaviors and premature coronary artery disease: a multi-center study. BMC Cardiovascular Disorders. 2023;23(1):170. DOI: 10.1186/s12872-023-03192-0
5. Andreenko E.Yu., Yavelov I.S., Loukianov M.M., Vernohaeva A.N., Drapkina O.M., Boytsov S.A. Ischemic Heart Disease in Subjects of Young Age: Current State of the Problem: Prevalence and Cardio-Vascular Risk Factors. Kardiologiia. 2018;58(10):53–8. [Russian: Андреенко Е.Ю., Явелов И.С., Лукьянов М.М., Вернохаева А.Н., Драпкина О.М., Бойцов С.А. Ишемическая болезнь сердца у лиц молодого возраста: распространенность и сердечно-сосудистые факторы риска. Кардиология. 2018;58(10):53-8]. DOI: 10.18087/cardio.2018.10.10184
6. Muromtseva G.A., Vilkov V.G., Konstantinov V.V., Deev A.D., Oshchepkova E.V., Rotar O.P. et al. The prevalence of electrocardiographic abnormalities in the Russian population in the early 21st century (the ESSE-RF study). Russian Journal of Cardiology. 2018;23(12):7–17. [Russian: Муромцева Г.А., Вилков В.Г., Константинов В.В., Деев А.Д., Ощепкова Е.В., Ротарь О.П. и др. Распространенность электрокардиографических нарушений в российской популяции в начале XXI века (по данным исследования ЭССЕ-РФ). Российский кардиологический журнал. 2018;23(12):7-17]. DOI: 10.15829/1560-4071-2018-12-7-17
7. Kalinina A.M., Shalnova S.A., Gambaryan M.G., Eganyan R.A., Muromtseva G.A., Bochkareva E.V. et al. Epidemiological methods for identifying the main chronic non-communicable diseases and risk factors during mass population surveys. Methodical guide. Edited by Prof. Boytsov S.A. - M.: GNICPM; 2015. - 96p. Av. at: https://gnicpm.ru/wp-content/uploads/2020/01/metodposobie_epid_metody_viyavleniya_hniz_pri_massovih_obsledovaniyah.pdf. [Russian: Калинина А.М., Шальнова С.А., Гамбарян М.Г., Еганян Р.А., Муромцева Г.А., Бочкарева Е.В. и др. Эпидемиологические методы выявления основных хронических неинфекционных заболеваний и факторов риска при массовых обследованиях населения. Методическое пособие. Под ред. проф. Бойцова С.А. - М.: ГНИЦПМ; 2015. - 96с. Доступно на: https://gnicpm.ru/wp-content/uploads/2020/01/metodposobie_epid_metody_viyavleniya_hniz_pri_massovih_obsledovaniyah.pdf]
8. Antropova O.N., Silkina S.B., Polyakova I.G., Perevozchikova T.V. Association of hemodynamic parameters and cardiovascular risk factors with cardiac remodeling in young patients with prehypertension and hypertension. Russian Journal of Cardiology. 2020;25(6):73–8. [Russian: Антропова О.Н., Силкина С.Б., Полякова И.Г., Перевозчикова Т.В. Ассоциация гемодинамических характеристик и факторов риска с ремоделированием сердца у молодых пациентов с предгипертонией и артериальной гипертонией. Российский кардиологический журнал. 2020;25(6):73-8]. DOI: 10.15829/1560-4071-2020-3797
9. Bogatyreva F.M., Kaplunova V.Yu., Kozhevnikova M.V., Shakaryants G.A., Privalova E.V., Belenkov Yu.N. Correlation between markers of fibrosis and myocardial remodeling in patients with various course of hypertrophic cardiomyopathy. Cardiovascular Therapy and Prevention. 2022;21(3):28–35. [Russian: Богатырева Ф.М., Каплунова В.Ю., Кожевникова М.В., Шакарьянц Г.А., Привалова Е.В., Беленков Ю.Н. Взаимосвязь маркеров фиброза и ремоделирования миокарда у пациентов с различными вариантами течения гипертрофической кардиомиопатии. Кардиоваскулярная терапия и профилактика. 2022;21(3):28-35]. DOI: 10.15829/1728-8800-2022-3140
10. Shishkova V.N., Martynov A.I. Insulin resistance: focus on the pathogenesis of cardiomyopathy. Consilium Medicum. 2020;22(10):52–4. [Russian: Шишкова В.Н., Мартынов А.И. Инсулинорезистентность: фокус на патогенез кардиомиопатии. Consilium Medicum. 2020;22(10):52–4]. DOI: 10.26442/20751753.2020.10.200341
11. Karavaev P.G., Veklich A.S., Koziolova N.A. Cardiovascular remodeling in patients with diabetic cardiomyopathy. Russian Journal of Cardiology. 2019;24(11):42–7. [Russian: Караваев П.Г., Веклич А.С., Козиолова Н.А. Диабетическая кардиомиопатия: особенности сердечно-сосудистого ремоделирования. Российский кардиологический журнал. 2019;24(11):42-7]. DOI: 10.15829/1560-4071-2019-11-42-47
12. Timoshenko N.A., Ragino Yu.I., Voevoda M.I. Metabolic cardiomyopathy. Current state of problem. Ateroscleroz. 2013;9(1):65–76. [Russian: Тимошенко Н.А., Рагино Ю.И., Воевода М.И. Метаболическая кардиомиопатия. Современное состояние проблемы. Атеросклероз. 2013;9(1):65-76]
13. Kuzminykh N.A., Shcherbakova L.V., Shramko V.S., Denisova D.V., Ragino Yu.I. Associations of cardiovascular disease risk factors with electrophysiological signs of myocardial metabolic disorders in young people 25—44 years old. Prevention Medicine. 2021;24(12):49–56. [Russian: Кузьминых Н.А., Щербакова Л.В., Шрамко В.С., Денисова Д.В., Рагино Ю.И. Ассоциации факторов риска сердечно-сосудистых заболеваний с электрофизиологическими признаками метаболических нарушений миокарда в

молодой популяции 25-44 лет. Профилактическая медицина. 2021;24(12):49–56]. DOI: 10.17116/profmed20212412149
14. Zhang Z, Prineas RJ, Soliman EZ, Baggett C, Heiss G, (for the ARIC Research Group). Prognostic significance of serial Q/ST-T changes by the Minnesota Code and Novacode in the Atherosclerosis Risk in Communities (ARIC) study. European Journal of Preventive Cardiology. 2012;19(6):1430–6. DOI: 10.1177/1741826711426091
15. Ricardo Pires J, Teixeira M, Ferreira F, Viseu I, Afreixo V, Neves C. Electrocardiography in Hypertensive Patients without Cardiovascular Events: A Valuable Predictor Tool? International Journal of Hypertension. 2022;2022:7038894. DOI: 10.1155/2022/7038894
16. Niu J, Deng C, Zheng R, Xu M, Lu J, Wang T et al. The Association and Predictive Ability of ECG Abnormalities with Cardiovascular Diseases: A Prospective Analysis. Global Heart. 2020;15(1):59. DOI: 10.5334/gh.790
17. Krittayaphong R, Muenkaew M, Chiewvit P, Ratanasit N, Kaolawanich Y, Phrommintikul A et al. Electrocardiographic predictors of cardiovascular events in patients at high cardiovascular risk: a multicenter study. Journal of Geriatric Cardiology. 2019;16(8):630–8. DOI: 10.11909/j.issn.1671-5411.2019.08.004
18. Mach F, Baigent C, Catapano AL, Koskinas KC, Casula M, Badimon L et al. 2019 ESC/EAS guidelines for the management of dyslipidaemias: Lipid modification to reduce cardiovascular risk. Atherosclerosis. 2019;290(1):140–205. DOI: 10.1016/j.atherosclerosis.2019.08.014
19. Auer R, Bauer DC, Marques-Vidal P, Butler J, Min LJ, Cornuz J et al. Association of Major and Minor ECG Abnormalities With Coronary Heart Disease Events. JAMA. 2012;307(14):1497–505. DOI: 10.1001/jama.2012.434
20. Novo S, Diana D, Tomasino C, Zambelli G, Mignano A, Scalmato A et al. Electrocardiographic abnormalities, preclinical carotid atherosclerosis and cardiovascular risk in an apparently healthy real-world population. Data from the 'No Stroke, No Infarction' project of the Rotary International - district 2110 (Sicily and Malta). International Angiology. 2021;40(6):470–7. DOI: 10.23736/S0392-9590.21.04637-X
21. Shin J, Lee Y, Park J-K, Shin J-H, Lim Y-H, Ran H et al. Prognostic value of myocardial injury-related findings on resting electrocardiography for cardiovascular risk in the asymptomatic general population: the 12-year follow-up report from the Ansan-Ansung cohort. Annals of Medicine. 2020;52(5):215–24. DOI: 10.1080/07853890.2020.1755052

ISSN 0022-9040. Kardiologiia. 2024;64(3). DOI: 10.18087/cardio.2024.3.n2571