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Dynamics of Non-Invasive Risk Factors of Sudden Cardiac Death after Myocardial Revascularization

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Abstract

Background*:* An attempt was made to study the effect of surgical myocardial revascularization on the processes of electrical myocardium instability underlying the occurrence of life-threatening ventricular arrhythmias, as well as the possibility of its non-invasive assessment by studying heart rate variability (HRV) and heart rate turbulence (HRT), as well as the duration and dispersion of the QT interval. Based only on the presence of viable myocardium, it is often impossible to predict the positive impact of revascularization on a patient's prognosis, especially with reduced myocardial contractility. Moreover, given the well-studied relationship between myocardial remodeling and neurohormonal activation, non-invasive methods for assessing the autonomic regulation of cardiac activity can provide additional diagnostic information. Along with this, changes in these indicators and their prognostic role in patients with coronary artery disease after revascularization are subjects of discussion.

Methods and Results: All patients underwent a comprehensive clinical and biochemical blood test, transthoracic echocardiography, tissue Doppler echocardiography, ultrasound examination of brachiocephalic arteries, selective coronary angio- and ventriculography, as well as Holter monitoring. Results show that a year after the coronary intervention, there was a significant positive trend in the frequency and structure of ventricular arrhythmias. HRV indicators generally did not show significant dynamics. Only an increase in the values of the standard deviation of 5-minute average NN intervals (SDANN) and low-frequency power (LFP) indices was noted, indicating a gradual increase in the activity of the sympathetic part of the autonomic nervous system. HRT indicators also did not show significant dynamics. A significant increase was found in the number of patients with no signs of impaired HRT. The average duration of the QT interval decreased significantly. There was also a tendency to shorten the corrected QT interval; however, it was insignificant. In terms of dispersion, both the QT interval and its corrected index, no significant dynamics were recorded in the general group of patients.

Conclusion: Our study found that in patients with prior myocardial infarction, after revascularization, significant positive dynamics were recorded in life-threatening ventricular arrhythmias, but were unreliable for the indicators of autonomic regulation of cardiac activity, such as HRV and HRT.(**International Journal of Biomedicine. 2023;13(3):59-65.**)

Keywords: heart rate variability • heart rate turbulence • myocardial infarction • electrical myocardium instability

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Abbreviations

CABG, coronary artery bypass graft; **CAD**, coronary artery disease; **CI**, circadian index; **EMI**, electrical myocardium instability; **EF**, ejection fraction; **HF**, heart failure; **HFP**, high-frequency power; **HRV**, heart rate variability; **HM**, Holter monitoring; **HRT**, heart rate turbulence; **LFP**, low-frequency power; **LVEF**, left ventricular ejection fraction; **LTVA**, life-threatening ventricular arrhythmias; **MI**, myocardial infarction; **PVC**, premature ventricular contractions; **PCI**, percutaneous intervention; **SCD**, sudden cardiac death; **SDANN**, standard deviation of 5-minute average NN intervals.

Introduction

Myocardial revascularization can significantly improve the long-term prognosis of patients with coronary artery disease (CAD). Currently, the indications for this intervention in the most severe patients are gradually expanding. Myocardial revascularization in patients with multivessel CAD significantly reduces the risk of death from fatal ventricular arrhythmias, progression of heart failure (HF), and acute myocardial infarction (MI).[1]

Even if there are indications for myocardial revascularization, it is necessary to choose the optimal method for its implementation: percutaneous intervention (PCI) or coronary artery bypass graft (CABG). It is important to consider that the best results to date have been obtained with auto-arterial bypass or angioplasty with implantation of drug-eluting stents; however, CABG can more often provide more complete myocardial revascularization than PCI.[2]

In recent years, there has been a peculiar evolution of endovascular interventions, largely due to the broader introduction into practice of the latest generation of drug-eluting stents, which led to a significant improvement in the results of PCI and made the level of PCI recommendations equal to CABG in patients with single-vessel disease (IA). In addition, PCI significantly improved its position in patients with two- and three-vessel lesions and SYNTAX scores less than 22. However, in patients with moderate and severe three-vessel disease (scores 23-32 or more), CABG remains the key method of revascularization.

Due to the great urgency of the problem of choosing the optimal method of revascularization in patients with CAD, attempts to compare the results of PCI and CABG continue. Based on the results of multicenter studies conducted in recent years, devoted to the study of this issue, 3 main conclusions can be drawn: (1) After CABG, there are excellent results in patient survival, especially with long-term follow-up;[3] (2) CABG leads to a decrease in the incidence of cardiovascular and cerebrovascular complications;[4-6] (3) There is a higher rate of repeat revascularization after PCI.

However, despite successful myocardial revascularization, a number of patients develop life-threatening ventricular arrhythmias already in the first year, and the symptoms of heart failure (HF) do not decrease or progress. This is due to the fact that in the pathogenesis of the development of life-threatening ventricular arrhythmias, myocardial ischemia is only one of the factors,[7] and thus, myocardial revascularization, reducing the effect of ischemia on the development of arrhythmia, has a limited effect on the substrate of ventricular arrhythmias in the form of cicatricial myocardial damage. In addition, the ongoing progress of the atherosclerotic process in the coronary arteries and the development of shunt or stent obstruction also affect the results of revascularization.[8]

One of the important tasks is the earliest detection of patients at high risk of developing various adverse events, primarily life-threatening ventricular arrhythmias. To date, non-invasive indicators have been proposed that are determined using Holter monitoring, particularly heart rate variability (HRV) and heart rate turbulence (HRT).[9] Based on numerous data, their effectiveness in assessing the risk of cardiovascular mortality and sudden cardiac death (SCD) in patients with CAD and HF has been demonstrated.

The currently existing models of stratifying patients by sudden-death risk groups usually provide for assessing changes in the systolic function of the left ventricle, and to a lesser extent, indicators characterizing the electrical instability of the myocardium. At the same time, the study of HRV, HRT, and QT interval dispersion to clarify the specific mechanisms of development and progression of life-threatening ventricular arrhythmias, especially in patients with acute MI, seems to be a promising direction.[10] Even more interesting is the study of the effect of myocardial revascularization on the dynamics of non-invasive indicators of myocardial electrical instability.

The aim of this study was to evaluate non-invasive risk factors for SCD in post-MI patients with preserved LVEF, as well as their correction after various methods of myocardial revascularization.

Materials and Methods

To study the possibilities of non-invasive assessment of electrical myocardium instability (EMI), we examined 239 patients aged 35 to 84 years (median age - 61 [55; 66] years) with a history of acute MI of various localization and with different natures of the lesion of the coronary bed, established based on the results of diagnostic selective coronary angiography.

Exclusion criteria were patients with impaired sinoauricular or atrioventricular conduction, or with no history of MI, hyperthermia, or the presence of diseases that significantly alter HRV (diabetes mellitus, hypo- or hyperthyroidism, extensive alcohol consumption, severe respiratory, renal, or hepatic insufficiency, cancer, etc.).

Upon admission to the hospital, all patients underwent a comprehensive clinical and biochemical blood test, transthoracic echocardiography, tissue Doppler echocardiography, ultrasound examination of brachiocephalic arteries, selective coronary angio- and ventriculography, as well as Holter monitoring using the CardioSens+ system (XAI-MEDICA, Ukraine). Monitoring was carried out in conditions of free movement of patients on standard therapy, which included antiplatelets, β-blockers, ACE inhibitors or ARBs, statins, nitrates (if necessary), and amiodarone (if necessary, in patients with potentially dangerous ventricular arrhythmias). Premature ventricular contractions (PVC) of III-V grades (Lown grading system)[11] and ≥10 PVC/hour were regarded as potentially dangerous ventricular arrhythmias.

The analysis of the obtained data included time and frequency domain methods of HRV, To, and Ts of HRT, as well as QT interval duration and dispersion.

Statistical analysis was performed using the statistical software «Statistica» (v13.0, StatSoft, USA). Baseline characteristics were summarized as frequencies and percentages for categorical variables. Continuous variables with normal distribution were presented as mean (standard deviation [SD]); non-normal variables were reported as median (Me) (interquartile range [IQR]). A probability value of $P<0.05$ was considered statistically significant.

The study protocol was reviewed and approved by the Ethics Committee of the Republican Specialized Scientific and Practical Medical Center of Cardiology. All participants provided written informed consent.

Results

The clinical characteristics of the patients were compiled according to the results of the initial examination. The main group of patients consisted of men (82.8%) of ≥55 years (mean age 60.1±8.1 years), mostly with a history of anterior MI (57.7%) (Table 1). The presence of post-infarction aneurysm of the left ventricle was noted in 10.5% of cases. Also, it should be noted that 46.0% of patients were overweight and 40.1% were obese, with varying degrees of severity; thus, only 13.8% had normal body weight.

Table 1.

Clinical characteristics of the general group of patients (n=239).

Age, years		60.1±8.1	61 [55; 66]
Sex	Men Women	198 (82.8%) 41 (17.2%)	
BMI, kg/m ^{2}		29.1±4.6	29 [25.8; 31.6]
Normal body weight, n (%)		33 (13.8%)	
Overweight, n (%)		110 (46.0%)	
Obesity	Class I Class II Class III	82 (34.3%) 8 (3.3%) 6 (2.5%)	
MI localization	Anterior Posterior	138 (57.7%) 101 (42.3%)	
Left ventricular aneurysm		25 (10.5%)	

Table 2.

Dynamics of heart rate according to Holter monitoring data in the general group of patients (n=239) after 1 year of follow-up.

Parameter	Initial value		One year after of revascularization		*P*-value
	M±SD	Me[Q1;Q3]	M±SD	Me[Q1;Q3]	
Average HR, bpm	68.6±8.9	68.5[62;75]	72.7±9.3	71[67;77]	0.010
Maximum HR, bpm	101.1±14.7	100[90.5;112]	110.8±19.1	109[99;119]	0.008
Minimum HR, bpm	54.2±7.8	54[49;59.5]	55.1±9	53[49;60]	0.409
Daytime average HR, bpm	71.2±10.5	71[64.5;78.5]	76.5±10.1	74[69;82]	0.019
Nighttime average HR, bpm	69.2±57.4	65[59;71]	66.5±8.8	65[61;71]	0.229
CI	1.1±0.06	1.1[1.06;1.13]	1.15±0.08	1.15[1.1;1.2]	0.000

When assessing heart rate (Table 2), attention is drawn to the frequency, density, and categories of PVCs using Holter monitoring (Table 3), as well as to the relative rigidity of the baseline sinus rhythm, which is expressed in an insignificant difference between the average values of daytime and nighttime heart rate and, accordingly, in a decrease in the circadian index (CI).

PVCs noted in all subjects, as a whole, had a relatively unfavorable character (Table 3). Potentially dangerous ventricular arrhythmias were observed in almost 60% of the examined patients. When analyzing the structure of potentially dangerous ventricular arrhythmias, taking as a basis the maximum class of PVC registered in the patient, classes II and V of PVC were not observed in any of the examined patients, class III was detected in 19.9%, IVA in 26.9%, and IVB in 12.3%. When assessing the frequency of PVCs, frequent extrasystoles >10 PVCs/hour were detected in 48.5% of cases.

Table 3.

Dynamics of the frequency and structure of ventricular ectopic activity according to Holter monitoring data in the general group of patients (n=239).

Parameter		Initial value	One year after REV	Friedman ANOVA χ^2	*P*-value
PVC density, %		1.09±3.86	0.41±0.88	0.07	0.789
PDVA, n (%)		141(58.9%)	110 (46.0%)	31.0	0.000
Frequent (>10/hour) PVC, %		110(46.0%)	79 (33.1%)	31.0	0.000
PVC class (Lown), registered in a patient, n (%)	I II III IV A IV B	239(100%) 82(34.5%) 136(56.7 %) 91(38.0 %) 29(12.3 %)	197 (82.4%) 34 (14.2%) 107 (44.8%) 70 (29.3%) 14 (5.9%)	42.0 48.0 29.0 21.0 15.0	0.000 0.000 0.000 0.000 0.000
Highest registered PVC class (Lown), n (%)	0 I III IV A IV B	0(0%) 98(40.9%) 48(19.9%) 64(26.9%) 29(12.3%)	42 (17.6 %) 87 (36.4%) 34 (14.2%) 62 (25.9%) 14 (5.9%)	42.0 11.0 14.0 2.0 15.0	0,000 0,001 0,000 0,157 0,000

REV -revascularization; PDVA -Potentially dangerous ventricular arrhythmias

HRV, assessed per day by both time and frequency methods, was characterized by a significant decrease in the values of indicators of both the total HRV and its components, as well as the predominance of the low-frequency component of HRV with an increase in the LFP/HFP ratio to 3.5, which indicates predominant sympathetic activity (Table 4).

Analysis of the HRT indicators did not reveal a decrease in the values of the To and Ts indicators, on average, for the group examined (Table 5). However, with an appropriate division of the patients, a quarter of them had HRT disorders, which allowed them to be classified either in category 1(19.0%) or category 2(5.9%) (Table 6).

The daily duration of both the QT interval and its corrected QTc index, calculated according to the Bazett formula, as a whole had normal values (Table 7).

Table 4.

Dynamics of HRV according to Holter monitoring data in the general group of patients (n=239).

Parameter	Initial value		One year after revascularization		*P*-value
	M±SD	Me [Q1; Q3]	M±SD	Me [Q1; Q3]	
SDNN, ms	41.4±14.8	39.3 [31.6; 47.8]	41.8±14.9	39.7 [32.5; 49.4]	0.237
SDANN, ms	80.6±25.8	79.7 [64.2; 96.7]	99.4±32.1	96.2 [78.6; 114.1]	0.013
rMSSD, ms	23.3±16.7	18.7 [14.3; 27.7]	20.9±9.6	18.2 [15.1; 26.1]	0.694
pNN50, %	5.1±8.1	1.8 [0.5; 6.1]	3.6±4.3	1.5 [0.7; 4.9]	0.694
HRV TI	9.1±2.8	9 [7.3; 10.7]	8.9±2.5	8.7 [7.3; 10.3]	0.694
TP, ms^2	2240.4±1624.4	1806.2 [1174.2; 2624.8]	2516.9±2058.6	1934.2 [1340; 3139.9]	0.435
ULF, ms^2	93.8±245	25.9 [11.5; 68.1]	102.2±176.4	45.7 [22.2; 80.2]	0.149
VLF, ms^2	1452.8±1058.8	1150.8 [786.5; 1826.9]	1593.3±1307.2	1288.1 [813.2; 2048.3]	0.435
LF, ms^2	445.8±366.8	333.7 [197.1; 566.9]	580.2±542	456.8 [253.3; 715.1]	0.006
LFnorm, %	67.3±12.9	70.4 [59.3; 76.4]	70.3±10	71.9 [63.7; 78.1]	0.237
HF, ms^2	247.5±335.9	137.7 [71.1; 309.3]	241.3±215.4	178.8 [90.8; 338.8]	0.088
HFnorm, %	32.3±12.7	29.5 [23.5; 40.2]	29.7±10	28.1 [21.9; 36.3]	0.237
LF/HF	3.5±2	3.1 [2.1; 4.5]	3.8±2.4	3.3 [2.4; 4.7]	0.358

Table 5.

Dynamics of HRT according to Holter monitoring data in the general group of patients (n=239).

Parameter	Initial value		One year after revascularization		*P*-value
	M±SD	Me [Q1; Q3]	M±SD	Me [Q1; Q3]	
To, %	-0.93±1.91	-0.81 [-2.2; 0.15]	-1.03±3.1	-0.99 [-1.72; -0.3]	0.689
Ts, ms/RRi	4.92±4.18	4.07 [1.59; 6.93]	6.97±8.91	4.95 [2.55; 8.2]	0.230

Table 6.

Dynamics of the category of decrease in HRT according to Holter monitoring data in the general group of patients (n=239).

		Initial value	After 1 year of observation	ANOVA χ^2	*P*-value
HRT category of decrease, n (%)	0	180 (75.1%)	213 (89.1%)	33.0	0.000
	1	45 (19.0%)	21 (8.8%)	24.0	0.000
	2	14 (5.9%)	5 (2.1%)	9.0	0.003

Table 7.

Dynamics of QT interval duration and dispersion according to Holter monitoring data in the general group of patients (n=239)

Parameter	Initial value		After 1 year of observation		*P*-value
	M±SD	Me[Q1;Q3]	M±SD	Me[Q1;Q3]	
QT, ms	396.4±39.5	396[368;424]	380.7±29.2	380[360;400]	0.011
QTc, ms	417.3±42.3	421[394;440]	413.8±25	411[394;433]	0.896
dQT, ms	91.7±44.9	84[64;108]	93.9±39.2	84[64; 16]	0.894
dQTc, ms	70±39.2	60[43;85]	74.7±38	61[45;96]	0.683

The QT interval dispersion (dQT) of the corrected QTc interval (dQTc), measured as the difference between the maximum and minimum values of the QT interval and QTc obtained from the analysis of the daily ECG recording, also did not show a significant increase (Table 7).

One year after the coronary intervention, the patients underwent HM again. The results showed that the heart rate, on average, increased somewhat (Table 2), so both the average and maximum heart rate, as well as the average daily heart rate, significantly increased. At the same time, both the minimum heart rate and the average nighttime heart rate slightly decreased, which, despite the absence of significant dynamics from these indicators, led to a significant increase in the CI.

When analyzing ventricular arrhythmias according to dynamic HM in the general group of patients, we found a significant positive trend in both the frequency and structure of PVC (Table 3). In particular, in 17.6% of patients, there were no signs of ventricular ectopic activity, and all previously diagnosed PVC classes, according to the Lown grading system, registered significant positive dynamics.

The majority of the HRV indicators did not show significant dynamics (Table 4) in the general group of patients. Only an increase in the values of the SDANN and LFP indicators was noted, indicating a further increase in the activity of the sympathetic division of the autonomic nervous system.

HRT indicators also did not show significant dynamics, remaining within normal physiological values, on average (Table 5). However, with the appropriate division into groups, according to the category of HRS reduction (Table 6), the number of patients with no signs of HRS disorders and who were included in category 0 increased significantly from 75.1% to 89.1%, with a corresponding significant reduction in the number patients in categories 1 and 2.

The duration of the QT interval, according to HM in the general group of patients, significantly decreased (Table 7). There was also a tendency to shorten the corrected QT interval; however, it was not significant. In terms of dispersion, for both the QT interval and its corrected index, no significant dynamics were recorded in the general group of patients.

Discussion

The most common cause of SCD in patients with a history of life-threatening ventricular arrhythmias is monomorphic ventricular tachycardia with the transition to ventricular fibrillation, polymorphic ventricular tachycardia of the "torsades de pointed," and primary ventricular fibrillation.[12] It is now well known that myocardial ischemia is one of the important triggers of ventricular arrhythmias and, therefore, myocardial revascularization, eliminating the cause of ischemia and reducing the risk of complete occlusion of the coronary artery, can reduce the risk of developing life-threatening ventricular arrhythmias and improve prognosis.[2] In particular, myocardial revascularization significantly reduces the risk of developing life-threatening ventricular arrhythmias in the presence of damage to the trunk and proximal anterior descending artery and, in this case, is a necessary intervention.[13]

The main factors that most often provoke the development of life-threatening ventricular arrhythmias in CAD are myocardial ischemia, which acts as an arrhythmia trigger, and the presence of myocardial cicatricial changes after a past acute MI, acting as a substrate. Several studies[14,15] showed that this combination of trigger and substrate most often leads to the development of fatal ventricular arrhythmias. Acute ischemia caused even by complete occlusion of the coronary artery is much less likely to cause fatal ventricular arrhythmias in the absence of arrhythmia substrate in the form of myocardial cicatricial changes. On the contrary, in the presence of cicatricial changes in the myocardium, even a partial narrowing of the arterial lumen can already lead to ventricular tachycardia induction in most patients.[15]

With extensive areas of post-infarction myocardial damage affecting global LV systolic function, the amount of viable myocardium plays an important role in improving myocardial contractility after revascularization. Identifying a sufficient amount of viable myocardium [16] can often influence the decision on the possibility of revascularization, especially in patients with reduced LVEF.

Unfortunately, viable myocardial contractility after revascularization cannot be recovered in all cases. In 2004, Schinkel et al.[17] did not observe improvement in LV contractility after revascularization in about a third of patients with viable myocardium and, first of all, in patients with signs of severe post-infarction myocardial remodeling. In such a large study as STICH, the initial presence of a viable myocardium did not affect improvement in the survival of patients after surgical myocardial revascularization, compared with patients who received conservative therapy.[18] These results demonstrated that relying only on the presence of viable myocardium made it impossible to predict the positive effect of revascularization on the prognosis for patients, especially those with reduced myocardial contractility; and given the well-studied relationship between myocardial remodeling and the development of HF with neurohormonal activation, such non-invasive methods for assessing the autonomic regulation of cardiac activity using HM, such as HRV and HRT, can provide additional diagnostic information.

In patients with HF events and risk of ventricular tachycardia, the interaction of multidirectional regulatory mechanisms is probably important, which can be indirectly assessed using HRV and HRT. In various studies, the analysis of the HM data of patients immediately before the onset of ventricular tachycardia revealed signs of worsening HRV.[19]

With the help of the main parameters used in the analysis of HRV, one can first of all single out a group with a significant decrease in HRV and with formation of the so-called «rigid» rhythm, which, in itself, unequivocally, can be called a prognostically unfavorable sign. That is because in large studies a poor prognosis was demonstrated in this category of patients who underwent acute MI and a pronounced decrease in HRV. Thus, the possibility of using the HRV assessment technique to determine the risk of adverse events, primarily general and cardiovascular mortality, was confirmed.[20]

Numerous studies[20-24] have shown the role of HRV indicators as a prognostic criterion for mortality. SDNN is considered the indicator of a temporary method that is most often mentioned in the results of clinical trials and effectively determines the prognosis of mortality after acute MI. As for the study of the effect of revascularization on HRV parameters, based on the literature data, it can be concluded that myocardial revascularization, and, in particular, CABG, is accompanied by a decrease in HRV in the immediate postoperative period, and over the next 2-3 months there is an increase in indicators for HRV to preoperative levels, even in patients with low LVEF. Also, there is evidence of an association between low HRV and higher mortality in patients 3 years after CABG.[24]

Both characteristics of HRT are significantly affected by the level of LVEF. HR parameters are significantly reduced in patients with HF events, as well as those with structural heart lesions, even with intact EF. The prognostic value of the method has been demonstrated in such studies as MPIP, EMIAT, ISAR-HRT, and FINGER as a predictor of cardiac death, including SCD, and as a risk factor for ventricular arrhythmias (CARISMA study). According to the data, patients with pathological HRT category 2 have the most unfavorable prognosis. In the case of pathological HRT category 1, the prognosis was more often determined by the change in the Ts index.

A change in HRT affects the prognosis in patients with reduced EF and, importantly, increases the positive predictive value of reduced EF.[25] It is important that HRT determines the prognosis of cardiovascular mortality and SCD not only in patients with reduced LVEF, but also in patients without severe systolic dysfunction.[26] In particular, in the ISAR-Risk study, the levels of SCD and cardiovascular mortality in patients with severe autonomic dysfunction and in patients with preserved LVEF were similar to that with a significant decrease in EF of <30%.

The impact of surgical revascularization on HRT scores on subsequent adverse events has been researched in only a few studies. One of them proved the influence of the preoperative Ts value on mortality during the first year after CABG; another study[27] demonstrated a deterioration in HRT after surgery, which may have been associated with a change in baroreflex function and autonomic regulation after the surgical intervention. Indeed, the results of many studies testify to the deterioration of various indicators of autonomic regulation after major surgery. However, it is necessary to consider that the rate of recovery of autonomic regulation of cardiac activity and the degree of its decrease in patients may be different, which may reflect a different functional state of the patient and affect outcomes after surgery in different ways. Therefore, there is a need to further study the HRT dynamics at different times after myocardial revascularization and the impact of these changes on further prognosis.

Thus, literature data indicate that myocardial revascularization is an effective treatment for patients with CAD. HF, ventricular arrhythmias, and relapses of angina pectoris and MI are the main problems that determine an unfavorable outcome in the postoperative period in a number of patients. There is important evidence that violations of the autonomic regulation of the heart's activity and the heterogeneity of repolarization processes in the myocardium are integral indicators of morphofunctional changes that occur during the progression of CAD. The role of HRV and HRT indicators as predictors of SCD, mainly due to fatal ventricular arrhythmias and cardiovascular mortality, has been demonstrated. Along with this, changes in the above indicators and the prognostic role in patients with CAD on the background of revascularization are subjects of discussion because there are practically no works devoted to studying the effect of various methods of revascularization on the parameters of myocardial electrical instability, as one of the most important factors in the development of life-threatening ventricular arrhythmias, which is a predictor of SCD, especially in patients who have previously had MI.

The number of studies on the effect of myocardial revascularization on the indicators of autonomic regulation of cardiac activity and the possibility of their use as prognostic criteria before and after surgery is also insufficient, which determines the relevance of further research in this direction.

In conclusion, our study found that in patients with prior MI, after revascularization, significant positive dynamics were recorded in life-threatening ventricular arrhythmias, but were unreliable for the indicators of autonomic regulation of cardiac activity, such as HRV and HRT.

Competing Interests

The authors declare that they have no competing interests.

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