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Left ventricular global function index as a predictor of adverse cardiovascular events in patients with acute coronary syndrome

Aim	To evaluate the prognostic significance of the left ventricular global function index (LV GFI) in patients with acute coronary syndrome (ACS) using echocardiography (EchoCG).
Material and methods	The LV GFI is an index that integrates LV cavity volumes, stroke volume, and myocardial volume. This study included 2169 patients with ACS (1340 (61.8%) men) aged 64.1±12.6 years from two observational multicenter studies, ORACLE I and ORACLE II. 1800 (83%) cases were associated with increased concentrations of myocardial injury markers, including 826 (38.1%) cases of ST segment elevation myocardial infarction (MI). The observation was started on the 10th day of clinical condition stabilization and lasted for one year. EchoCG was performed with evaluation of LV GFI, which was calculated as a ratio of LV stroke volume to LV global volume. The LV global volume was calculated as a sum of mean LV cavity volume (LV end-diastolic volume + LV end-systolic volume/2) and LV myocardial volume.
Results	The main outcome of the study was all-cause death (n=193); recurrent coronary complications (n=253) were analyzed separately. The only EchoCG parameter indicating an adverse outcome during the one-year follow-up was a LV GFI decrease to below 22.6% with a sensitivity of 72% and a specificity of 60% (area under the curve, AUC=0.63). A LV GFI <22.6% was an independent predictor of all-cause death (p=0.019) along with age (p=0.0001), history of MI (p=0.034), and presence of heart failure (HF) (p=0.044), diabetes mellitus (p=0.012), and peripheral atherosclerosis (p=0.001). The LV GFI <22.6%, (p=0.044), heart rate upon discharge from the hospital (p=0.050), history of MI (p=0.006), presence of HF (p=0.014), and peripheral atherosclerosis (p=0.001) were also independent predictors for recurrent coronary complications. Decreased LV GFI was associated with the risk of fatal outcomes independent of the LV ejection fraction at baseline.
Conclusion	In patients with ACS, the left ventricular global function index is an independent predictor for all-cause death and recurrent coronary complications and may be used for risk stratification.

Keywords	Systolic function; left ventricle; global function index; ejection fraction; left ventricular remodeling; heart failure; myocardial infarction
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Introduction

Left ventricular ejection fraction (LVEF) is an important prognostic factor for patients suffering from acute coronary syndrome (ACS) [1]. However, due to the success of interventional cardiology, LVEF is preserved in most ACS patients. This stimulates the search for indicators for identifying patients requiring the most proactive prevention of possible cardiovascular events [1].

The left ventricular global function index (LVGFI) proposed in 2013 is determined by magnetic resonance imaging (MRI) of the heart [2]. The assessment of LV volumes and parameters of pathological myocardial remodeling included in this index may provide additional predictive value compared to LVEF. Initial research has shown that LVGFI can serve as an independent marker of various cardiovascular events in healthy individuals and in patients of certain groups, for example, those with a history of myocardial infarction (MI) [3, 4]. Moreover, the possibility of assessing LVGFI by echocardiography has also been demonstrated [5].

Aim

To assess the predictive value of LVGFI in patients with ACS using echocardiography.

Material and methods

Data of patients included in two Russian observational multicenter studies ORACLE (ObseRvation After Acute Coronary Syndrome for deveLopment of trEatment Options, NCT04068909) were analyzed. The first cohort of patients was included in 2004–2006; the second – in 2014–2016. The ORACLE I trial included patients with ACS on Day 10 after stabilization, while ORACLE II included patients with ACS with indications for revascularization [6, 7].

In total, the data of 2,169 patients were analyzed. At index hospitalization, 1,800 (83%) patients had elevated markers of myocardial damage, including 826 (38.1%) patients with ST-segment elevation myocardial infarction (STEMI).

At discharge, angiotensin-converting enzyme inhibitors or sartans were administered to 1,908 (88.0%) patients; beta-blockers – 1,911 (88.1%); calcium channel blockers – 431 (19.9%); thiazide diuretics – 733 (33.8%); antiplatelet drugs – 2017 (93.4%); statins 1722 (79.4%); oral glucose-lowering drugs – 201 (9.3%).

The follow-up period started on Day 10 following stabilization of the clinical condition and continued for one year. The follow-up data were recorded during repeated visits of patients to the hospital or via telephone consultations on Days 25, 90, 180, and 360 following inclusion.

The primary endpoint was all-cause death. Recurrent (fatal and non-fatal) coronary events were also analyzed separately.

The analysis includes patients who underwent transthoracic echocardiography using Logiq P6 ultrasound scanners with multi-frequency (1.5–5 MHz) sector probes 3SP and ACUSON-128XP and multi-frequency (2.5–4 MHz) sector probes V4c with the possibility of calculating LVGFI. Echocardiography was performed during the hospital stay for the index event on days 7–10 from the moment of ACS destabilization. Patients with suboptimal echocardiographic findings were not included in this analysis. The dimensions and volumes of the heart chambers were measured in accordance with the guidelines [8]. LVEF was calculated using the Simpson method in the 4-chamber apical view. Left ventricular mass (LVM) was calculated using the Devereux and Alonso formula (1986):

$$LVM = 0.8 \times \{1.04 \times [(LVEDD+IVS+LVPW)^3 - LVEDD^3]\} + 0,6,$$

where LVEDD – left ventricular end-diastolic dimension; IVS – interventricular septum; LVPW –left ventricular posterior wall.

The LVM index (LVMI) was calculated as the ratio of LVM to body surface area. LV myocardial hypertrophy was defined as LVMI > 95 g/m 2 for female patients and LVMI > 115 g/m 2 for male patients.

LVGFI was calculated by the formula:

$$LVGFI = \frac{SV}{\left(\frac{LVEDV+LVESV}{2}\right) + \text{LV myocardium volume}} \times 100\%,$$

where SV – stroke volume; LVEDV – left ventricular end-diastolic volume; LVESV – left ventricular end-systolic volume.

LV volume was calculated as LVM/LV density, where LV density was 1.05 g/mL.

Statistical processing was performed using SPSS Statistics version 23.0 and MedCalc version 18.3. The distribution and its normality were analyzed for continuous variables using the Kolmogorov-Smirnov test. Normally distributed variables were expressed using the mean and standard deviation (M±SD). Discrete variables were calculated as percentages, while the significance of differences was compared using

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Pearson's chi-square test. Quantitative variables with normal distribution were compared using Student's t-test. Survival analysis and assessment of the influence of clinical factors on the risk of adverse outcomes were performed using the log-rank Kaplan–Meier method and Cox regression. When the factors were included in multivariate analysis, multicollinearity was assessed and variance inflation factor (VIF) calculated. If VIF was less than 5, multicollinearity was rejected. The Cox univariate regression analysis included parameters that differed between groups of patients with favorable and unfavorable outcomes in the comparative analysis. The prognostic function was developed using multivariate logistic regression. The values were considered significant at $p<0.05$ in all types of analyses.

Results

During the follow-up period, 193 (8.9%) all-cause deaths and 122 (5.6%) coronary deaths were registered. Recurrent coronary events were reported in a total of 253 (11.7%) patients.

Clinical and laboratory characteristics of patients and comparison of the deceased patients and the survivors are presented in Table 1.

Table 1. Clinical characteristics of the deceased and survivors according to one-year follow-up results

Parameter	All patients (n = 2169)	Survivors (n = 1976)	Deceased (n = 193)	p
Clinical characteristics				
Age, years	64.1±12.6	63.1±12.5	72.9±10.9	0.0130
Male, n (%)	1340 (61.8)	1226 (62.0)	114 (59.0)	0.0810
Smoking, n (%)	544 (25.1)	500 (25.3)	44 (22.8)	0.1440
History of CAD, n (%)	1483 (68.4)	1319 (66.8)	164 (84.9)	0.0010
History of MI, n (%)	629 (28.9)	537 (27.2)	92 (47.6)	0.0001
History of stroke, n (%)	216 (10.0)	190 (9.6)	26 (13.5)	0.1230
Max SBP, mm Hg	191.43±28.093	190.3±27.9	196.3±25.3	0.0560
Max DBP, mm Hg	105.44±23.211	104.2±14.4	111.3±71.1	0.0010
Hypertension, n (%)	1807 (88.3)	1633 (82.6)	174 (90.1)	0.0700
HF, n (%)	1043 (48.1)	904 (45.7)	139 (72.0)	0.0001
DM, n (%)	416 (19.2)	354 (17.9)	62 (32.1)	0.0001
Peripheral atherosclerosis, n (%)	913 (42.1)	811 (41.0)	102 (52.8)	0.0001
HR at discharge, bpm	69.4±11.11	68.8±10.8	72.6±16.8	0.0010
SBP at discharge, mm Hg	124.5±13.15	124.2±12.62	122.2±16.9	0.0100
DBP at discharge, mm Hg	77.7±19.63	77.97±22.5	75.9±9.3	0.6240
Biochemistry				
Total cholesterol, mmol/L	5.21±1.463	5.3±1.4	5.0±1.8	0.0620
LDL-C, mmol/L	2.92± 1.346	2.93±1.5	2.85±1.4	0.6130
HDL-C, mmol/L	1.10±0.440	1.1±0.5	1.0±0.3	0.0090
Creatinine, μmol/L	101.63±35.36	99.3±30.3	110.8±54.1	0.0010
Uric acid, μmol/L	370.06±205.03	369.4±230.286	421.4±196.3	0.0820
Glucose, mmol/L	7.15±3.643	7.2±3.4	8.1±3.9	0.0010
Echocardiographic parameters				
SV, mL	65.17±17.539	66.9±18.6	63.8±26.9	0.9640
LVEDD, cm	5.02±11.721	5.0±1.3	5.09±0.9	0.1400
LVPW, cm	11.96±4.908	11.91±0.5	12.87±0.2	0.7550
IVST, cm	11.08±4.854	10.9±0.5	11.29±0.7	0.2640
LVMI, g/m^2	109.8±32.98	106.9±32.8	128.7±34.1	0.0340
LVEDV, mL	106.63±43.453	105.8±42.1	120.9±54.6	0.0050
LVESV, mL	50.96±30.039	49.1±29.4	57.7±35.4	0.0100
LVEF, %	53.60±13.071	54.0±12.6	48.7±13.2	0.4650
LVGFI, %	22.52±9.070	23.0±8.3	19.7±6.7	0.0001

The data are expressed as the mean and standard deviation (M ± SD), if not otherwise specified. CAD, coronary artery disease; MI, myocardial infarction; SBP, systolic blood pressure; DBP, diastolic blood pressure; AH, arterial hypertension; HF, heart failure; DM, diabetes mellitus; HR, heart rate; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; SV, stroke volume; LVESD, left ventricular end-diastolic dimension; LVPW, left ventricular posterior wall thickness; IVST, interventricular septal thickness; LVMI, left ventricular mass index; LVEDV, left ventricular end-diastolic volume; LVESV, left ventricular end-systolic volume; LVEF, left ventricular ejection fraction; LVGFI, left ventricular global function index.

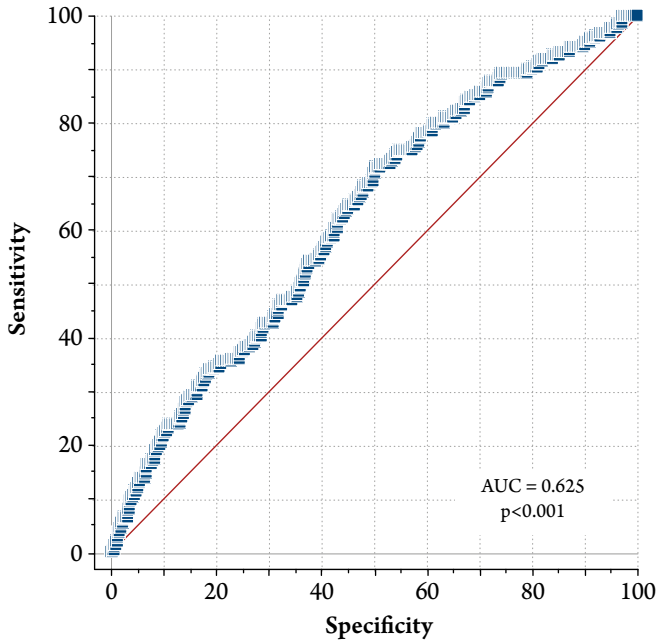
As shown in Table 1, deceased patients were older and had a generally more unfavorable range of risk factors: they were more likely to have comorbidity diseases (heart failure (HF), diabetes mellitus (DM), peripheral atherosclerosis) and a history of coronary artery disease (CAD) and MI. Moreover, the deceased had higher blood levels of creatinine and glucose. Applicable therapies did not differ significantly between deceased and survivors at the time of discharge.

Mean LVGFI was 22.64 ± 8.12% (median 22.63% [25th percentile 17.52%; 75th percentile 27.17%]). Figure 1 shows the predictive value of LVGFI determined by the ROC analysis (Figure 1).

According to the ROC analysis, the area under the curve (AUC) was 0.63, while the threshold value of LVGFI for predicting the risk of death was 22.6% with a sensitivity of 72% and a specificity of 60% (1st quartile sensitivity – 36.13%, specificity – 76.23%; 2nd quartile sensitivity – 67.54%, specificity – 52.35%; 3rd quartile sensitivity – 88.48%, specificity – 26.89%; 4th quartile sensitivity – 98.1%, specificity – 0.2%).

The absence of statistically significant differences in LVEF and presence of statistically significant differences in LVGFI were of interest. Multivariate analysis showed that, along with age, a history of MI, HF, DM and peripheral atherosclerosis, LVGFI was the only echocardiographic indicator independently associated with the risk of all-cause death. Table 2 presents the results of the univariate and multivariate regression analyses of parameters associated with the risk of death.

Figure 1. ROC analysis of the predictive value of LVGFI in assessing the risk of all-cause death



LVGFI – left ventricular global function index.

The contribution of various factors included in the resulting prediction model of all-cause death is presented in Table 3.

In addition, factors associated with the risk of recurrent coronary events were analyzed. Clinical, biochemical and echocardiographic parameters are presented in Table 4 by groups of patients depending on the adverse coronary outcomes. This type of analysis did

Table 2. Univariate and multivariate regression analyses of parameters associated with the risk of death

Parameter	Univariate analysis OR (95% CI)	p	Multivariate analysis OR (95% CI)	p
A 10-year increase in age	1.917 (1.670–2.180)	0.0001	1.850 (1.520–2.260)	0.0001
History of CAD	2.620 (1.720–3.990)	0.0010	1.007 (0.530–1.890)	0.9860
History of MI	2.340 (1.730–3.16)	0.0010	1.620 (1.030–2.550)	0.0340
Max DBP	1.010 (0.990–1.010)	0.1150	–	–
HF	2.950 (2.120–4.120)	0.0010	1.680 (1.020–2.770)	0.0440
DM	2.070 (1.500–2.870)	0.0010	1.670 (1.120–2.510)	0.0120
Peripheral atherosclerosis	1.750 (1.370–2.250)	0.0010	2.420 (1.620–3.610)	0.0010
HR at discharge	1.024 (1.012–1.037)	0.0010	1.010 (0.990–1.030)	0.1400
SBP at discharge	0.980 (0.970–1.020)	0.0960	–	–
LDL-C	0.520 (0.314–0.861)	0.0110	0.610 (0.320–1.190)	0.1480
Creatinine	1.007 (1.003–1.011)	0.0010	1.003 (0.997–1.008)	0.3310
Glucose	1.065 (1.026–1.105)	0.0010	0.990 (0.930–1.070)	0.8760
LVMI	1.000 (0.997–1.003)	0.7600	–	–
LVGFI	0.938 (0.910–0.930)	0.0001	0.960 (0.930–0.990)	0.0190

OR, odds ratio; CI, confidence interval; CAD, coronary artery disease; MI, myocardial infarction; DBP, diastolic blood pressure; HF, heart failure; DM, diabetes mellitus; HR, heart rate; SBP, systolic blood pressure; HDL-C, high-density lipoprotein cholesterol; LVMI, left ventricular mass index; LVGFI, left ventricular global function index.

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Table 3. Regression coefficients of the prediction model for the risk of all-cause death

Model	Non-standardized regression coefficient		Standardized regression coefficient	t	p
	B	SE	Beta		
Constant	–0.170	0.041	–	–4.142	0.000
History of MI	0.041	0.014	0.066	2.973	0.003
HF	0.026	0.014	0.046	1.957	0.049
Diabetes mellitus	0.042	0.016	0.058	2.700	0.007
Peripheral atherosclerosis	0.045	0.011	0.088	4.087	0.000
A 10-year increase in age	0.038	0.005	0.107	4.457	0.000
LVGFI	–0.003	0.001	–0.075	–3.462	0.001

MI, myocardial infarction; HF, heart failure; LVGFI, left ventricular global function index.

Table 4. Clinical characteristics of patients depending on the development of recurrent coronary events

Parameter	Patients without coronary events (n = 1,845)	Patients without recurrent coronary events (n = 253)	p
Clinical characteristics			
Age, years	63,4±12,5	68,4±12,4	0,1130
Male, n (%)	1138 (61,7)	144 (56,9)	0,0870
Smoking, n (%)	478 (25,9)	65 (25,7)	0,0010
History of CAD, n (%)	1277 (69,2)	209 (82,6)	0,0001
History of MI, n (%)	516 (27,9)	113 (44,7)	0,0001
History of stroke, n (%)	191 (10,4)	26 (10,3)	0,9550
Max SBP, mm Hg	190,5±27,9	193,7±26,1	0,3140
Max DBP, mm Hg	104,1±14,1	110,5±62,7	0,1340
Hypertension, n (%)	1577 (85,5)	227 (89,7)	0,1500
HF, n (%)	871 (47,2)	174 (68,8)	0,0040
DM, n (%)	350 (18,9)	68 (15,0)	0,0050
Peripheral atherosclerosis, n (%)	755 (40,9)	158 (62,5)	0,0010
Statins, n (%)	1504 (81,5)	158 (62,5)	0,0010
HR at discharge, bpm	68,7±11,1	72,2±14,2	0,0010
SBP at discharge, mm Hg	124,0±12,6	124,0±15,6	0,9960
DBP at discharge, mm Hg	77,5±23,1	76,2±9,5	0,3430
Biochemistry			
Total cholesterol, mmol/L	5,3±1,4	5,1±1,8	0,1240
LDL-C, mmol/L	3,0±1,5	3,0±1,3	0,7520
HDL-C, mmol/L	1,1±0,5	1,0±0,3	0,0040
Creatinine, μmol/L	99,3±30,6	107,8±49,1	0,0010
Uric acid, μmol/L	372,4±236,1	388,1±167,1	0,7340
Glucose, mmol/L	7,2±3,4	7,4±3,9	0,0010
Echocardiographic parameters			
SV, mL	66,4±18,7	67,5±26,4	0,9850
LVEDD, cm	5,0±1,3	5,2±0,8	0,4990
LVPW, cm	1,1±0,6	1,1±0,2	0,6820
IVST, cm	1,2±0,6	1,2±0,2	0,2750
LVMI, g/m2	106,9±33,7	123,3±33,7	0,2110
LVGFI, %	22,9±8,4	19,4±6,6	0,0040

The data are expressed as the mean and standard deviation (M ± SD), if not otherwise specified. CAD – coronary artery disease; MI – myocardial infarction; SBP – systolic blood pressure; DBP – diastolic blood pressure; AH – arterial hypertension; HF – heart failure; DM – diabetes mellitus; HR – heart rate; LDL-C – low-density lipoprotein cholesterol; HDL-C – high-density lipoprotein cholesterol; SV – stroke volume; LVESD – left ventricular end-diastolic dimension; LVPW – left ventricular posterior wall thickness; IVST – interventricular septal thickness; LVMI – left ventricular mass index; LVGFI – left ventricular global function index.

not include patients who died of non-coronary causes (stroke, HF, cancer, pneumonia, etc.).

Table 5 contains data of the univariate and multivariate regression analyses of parameters related to the risk of coronary events in ACS patients. Independent variables associated with the risk of recurrent coronary events included history of MI, current HF, peripheral atherosclerosis and HR achieved by the time of discharge, as well as a decrease in LVGFI.

The contribution of various factors included in the resulting prediction model of adverse coronary events is presented in Table 6.

Figure 2 shows the results of the analysis of survival and risk of coronary events in ACS patients in groups with different LVGFI quartiles.

Survival analysis in groups having different LVGFI values divided by quartiles revealed a significant deterioration in survival in the two lower quartiles. Adverse coronary events were more common in the two lower quartiles of LVGFI (see Figure 2). Thus, a LVGFI less than the median of 22.6% can be considered a risk factor for unfavorable outcomes and recurrent coronary events (Figure 1, Figure 2).

Discussion

Age, history of MI, HF, DM, peripheral atherosclerosis, and HR achieved upon discharge were associated with the risk of all-cause death and/or recurrent coronary events in ACS patients in this prospective cohort study. As well as the listed clinical and anamnestic factors, LVGFI was studied by echocardiography. LVGFI <22.6% was associated with both the risk of all-cause death and recurrent coronary events. It should be emphasized that, out of all the analyzed echocardiographic parameters, only LVGFI had a predictive value for all-cause death and the risk of recurrent coronary events. Other indicators, including LVEF, had no predictive value either for all-cause death or for recurrent coronary events.

Our findings on the predictive value of LVGFI are consistent with the previous trials, in which MRI was used in slightly smaller groups of MI patients [3, 4]. Moreover, according to a multicenter randomized clinical trial, which included CAD patients subjected to reperfusion in STEMI, LVGFI had additional value compared to LVEF in predicting all-cause death [3]. However, in our study, unlike in these trials, LVEF

Table 5. Univariate and multivariate regression analyses of the risk of coronary events

Parameter	Univariate analysis OR (95% CI)	p	Multivariate analysis OR (95% CI)	p
Smoking	1.260 (1.090–1.450)	0.001	1.033 (0.835–1.278)	0.776
History of CAD	2.040 (1.450–2.850)	0.001	0.979 (0.599–1.600)	0.931
History of MI	2.050 (1.560–2.670)	0.001	1.758 (1.175–2.632)	0.006
HF	2.420 (1.830–3.220)	0.001	1.677 (1.111–2.533)	0.014
DM	1.540 (1.140–2.080)	0.005	1.131 (0.744–1.720)	0.545
Peripheral atherosclerosis	2.680 (2.130–3.360)	0.001	2.756 (1.918–3.960)	0.001
HR at discharge	1.023 (1.011–1.034)	0.001	1.015 (1.000–1.029)	0.050
Administration of statins at discharge	0.410 (0.300–0.560)	0.001	0.872 (0.573–1.329)	0.525
LDL-C	0.540 (0.350–0.820)	0.005	0.738 (0.447–1.221)	0.237
Creatinine	1.006 (1.002–1.009)	0.001	1.003 (0.998–1.008)	0.214
Glucose	1.018 (0.979–1.057)	0.374	–	–
LVGFI	0.972 (0.954–0.990)	0.003	0.961 (0.926–0.996)	0.044

OR, odds ratio; CI, confidence interval; CAD, coronary artery disease; MI, myocardial infarction; HF, heart failure; DM, diabetes mellitus; HR, heart rate; HDL-C, high-density lipoprotein cholesterol; LVGFI, left ventricular global function index.

Table 6. Regression coefficients of the prediction model of the risk of unfavorable coronary outcomes

Model	Non-standardized regression coefficient		Standardized regression coefficient	t	p
	B	SE	Beta		
Constant	–0,116	0,055	–	–2,119	0,034
History of MI	0,066	0,018	0,091	3,647	0,000
HF	0,048	0,017	0,071	2,823	0,005
Peripheral atherosclerosis	0,118	0,014	0,102	4,432	0,000
LVGFI	–0,002	0,001	–0,051	–2,132	0,033
HR at discharge	0,003	0,001	0,091	3,795	0,000

MI, myocardial infarction; HF, heart failure; LVGFI, left ventricular global function index; HR, heart rate.

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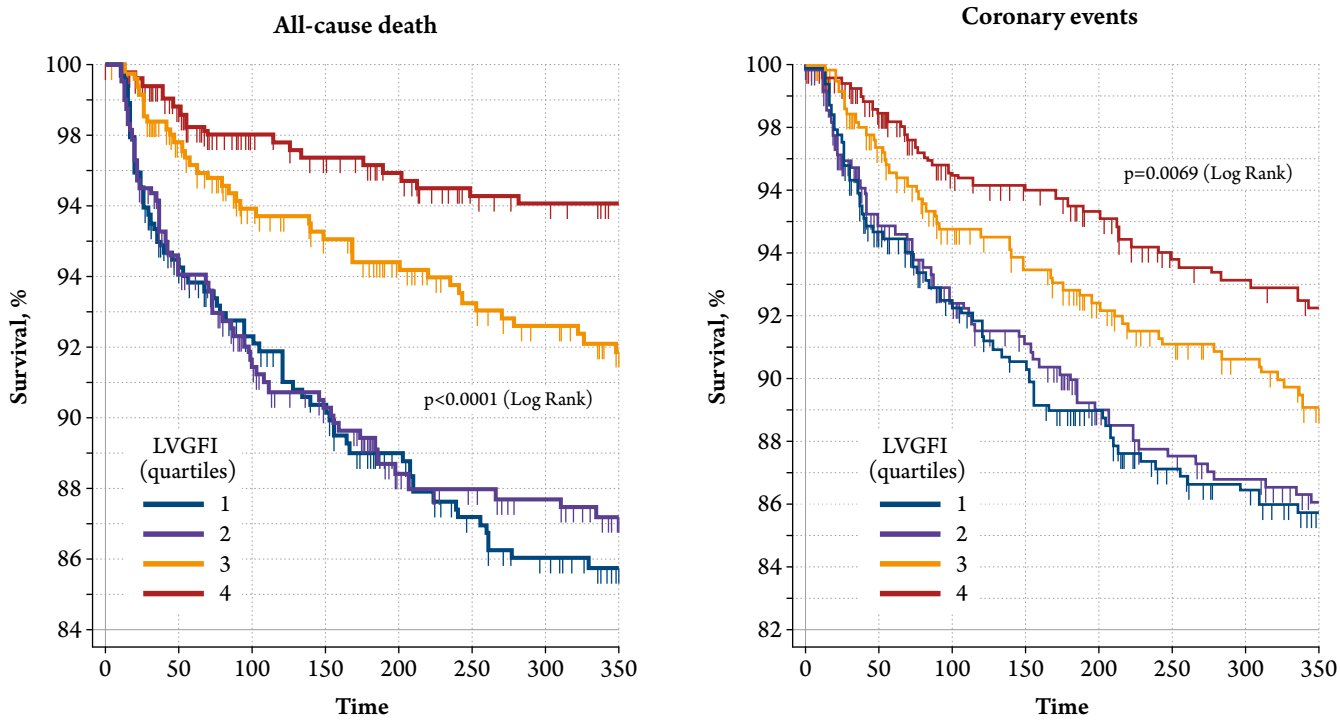
Figure 2. Analysis of survival and risk of coronary events in patients with different values of left ventricular global function index



did not show a predictive value for all-cause death. In some literatures sources, LVEF was only shown to have a predictive value for all-cause death in univariate analyses [3, 4].

Although Reinstadler et al. [4] revealed the absence of a higher predictive value of LVGFI compared to LVEF immediately following MI, they emphasize that LVGFI is a powerful predictor of cardiovascular events for MI patients in the long-term follow-up period [4].

Due to sharply increasing the LV burden, MI induces its remodeling. Myocyte death triggers a cascade of intracellular biochemical reactions that modulate subsequent LV changes such as scar tissue formation, dilatation and hypertrophy [9–11]. Thus, the resulting LV dysfunction, which is traditionally assessed using LVEF, comprises a key prognostic factor. LVEF is used as a predictor to assess the possibility of early discharge (Second Primary Angioplasty in Myocardial Infarction (PAMI II) score) and long-term risk following MI [12, 13]. LVM and other LV structural parameters are noted to be significant predictors in MI [14]. However, unlike LVGFI, which includes the LV volumes, including SV, and the LV myocardial volume, LVEF excludes such structural components of heart remodeling as LV hypertrophy. Therefore, an important advantage of LVGFI is that it takes the process of LV remodeling into account.

The predictive value of LVGFI for all-cause death has been demonstrated not only in patients with ACS and MI, but also in a large multi-ethnic study of atherosclerosis in healthy individuals [2]. This indicator was assessed as a predictor of the risk of HF, severe cardiovascular events (MI, cardiac arrest, death of CAD, fatal and non-fatal stroke), as well as composite endpoint (all-cause death, angina pectoris and cases of percutaneous coronary intervention). In multivariate analysis, LVGFI demonstrated itself to be the most reliable significant predictor of risk in all three presented groups. While LVEF was also analyzed in this study, its levels were not statistically significant in assessing the risk in the group of patients having experienced severe cardiovascular events. The fact that LVMI was a statistically significant indicator in all three groups of patients, as well as LVGFI, underlines the important role played by the LV remodeling process.

Initially, it was proposed to evaluate LVGFI using MRI. However, echocardiography is the most widely used and available imaging technique in modern cardiological practice used to assess the function and anatomy of the heart. According to our findings, only Nwabuo et al. [5] have used echocardiography to assess LVGFI. In this large long-term study, LVGFI was evaluated in apparently healthy individuals as a predictor of HF and cardiovascular events, including severe cardiovascular events (fatal and non-fatal MI, stroke, and CAD) and cases of percutaneous coronary intervention and unstable angina. The authors' finding that LVGFI was a strong independent predictor

of HF and cardiovascular diseases in apparently healthy individuals provides additional predictive value compared to LVEF. In addition, LVGFI was associated with early risk factors for cardiovascular events, including male sex, Negroid race, increased BP, increased BMI and smoking.

Our study is the first to determine the relationship between LVGFI and the risk of all-cause death and recurrent coronary events in patients with ACS and frequent MI. The question naturally arises concerning the mechanism according to which LVGFI achieves its predictive value. This comes from the integral assessment of the unidirectional increase in three elements of LV remodeling due to repeated attacks of ischemia:
1. compensatory enlargement of the LV cavity (left ventricular end-diastolic volume (LVEDV));
2. compensatory increase in the LV myocardial volume;
3. LV systolic dysfunction (left ventricular end-systolic volume).

In sum, it can be stated that LVGFI comprises a promising indicator for assessing LV dysfunction, early detection of pathological remodeling and assessing the prognosis of cardiovascular events in various clinical patient groups and healthy individuals. This indicator, which can be calculated by MRI and echocardiography, significantly expands the possibilities for studying and using LVGFI. Our data on the predictive value of LVGFI for the risk of all-cause death and coronary events in patients with ACS and frequent MI generally correspond to the findings obtained using MRI [3, 4].

Limitations

Our study was limited by the impossibility of performing echocardiography in all patients due to the acoustic accessibility of their heart organs being suboptimal.

Conclusion

As shown by the one-year follow-up, the only echocardiographic parameter independently associated with unfavorable outcomes of acute coronary syndrome was a left ventricular global function index of less than 22.6%. However, age, a history of myocardial infarction, heart failure, diabetes mellitus and peripheral atherosclerosis, were also independently associated with the risk of all-cause death.

The risk of developing coronary events was associated with a history of myocardial infarction, the presence of heart failure, diabetes mellitus, and peripheral atherosclerosis, a decrease in the global left ventricular function index and the heart rate achieved during therapy by the time of discharge.

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