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Speckle tracking stress echocardiography on treadmill in assessment of the functional significance of the degree of coronary artery disease

Aim To determine diagnostic capabilities of left ventricular (LV) global longitudinal systolic strain (GLSS) in stress echocardiography (stress-EchoCG) with a treadmill test for diagnosing the functional significance of the degree of coronary stenosis.

Material and methods The study included 121 patients (73 men aged 68.3±7.7 years) with suspected or previously diagnosed ischemic heart disease (IHD). Speckle-tracking stress-EchCG (method of tracking speckles on two-dimensional gray-scale ultrasonic images) with a treadmill test and coronarography was performed for all patients. The patients were divided into 3 groups based on the severity of coronary artery (CA) stenosis according to the Gensini scale.

Results LV GLSS at rest did not significantly differ between the study groups. After the exercise, LV GLSS was significantly lower in patients with pronounced CA stenosis than in patients without or with moderate CA stenosis (15.9±4.6% vs. 20.6±3.7% (p<0.001) and 19.6±3.0% (p=0.003), respectively). Postexercise LV GLSS <16.9% suggested a pronounced CA stenosis with a sensitivity of 80% and a specificity of 70% (area under the curve, AUC, 0.76±0.06 at 95% confidence interval, CI, 0.63–0.89; p<0.001). In the patient group without CA stenosis, LV GLSS showed a significant increase after completion of the exercise (from 19.1±3.1 to 20.6±3.7; p=0.04).

Conclusion Evaluation of LV GLSS and its dynamics in stress-EchoCG with a treadmill test may be promising in patients with IHD, since in most patients with pronounced CA stenosis, LV GLSS is reduced at baseline and further reduces in response to exercise. In patients without CA stenosis, LV GLSS increases after completing the exercise.

Keywords Ischemic heart disease; speckle-tracking; stress-echocardiography; treadmill test; global longitudinal systolic strain

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Since coronary artery disease (CAD) is the leading cause of death worldwide [1], early diagnosis of CAD is one of the most urgent tasks facing modern cardiology. In this connection, stress echocardiography can be used to perform a non-invasive evaluation of the left ventricular (LV) systolic function [2]. However, since the subjective visual assessment of left ventricular wall motion abnormalities (WMAs) depends on the physician's experience, it is preferable to quantify the LV wall motion during stress echocardiography.

Speckle tracking (spot tracking in two-dimensional, gray-scale ultrasound imaging) is one of the most promising technologies for quantifying LV wall motion. The analysis of spot motion in a two-dimensional, gray-scale ultrasound image allows changes in the length of a myocardial segment (strain) during the cardiac cycle to be estimated [3]. Speckle tracking can also be used to quantify global and regional strains in longitudinal, circular, and radial directions [4], on a combination of which strains myocardial function is dependent. Nevertheless, longitudinal LV myocardial strain is particularly useful for indicating early signs of CAD due to its longitudinal arrangement of subendocardial fibers having increased sensitivity to ischemic changes [3].

The LV global longitudinal strain (GLS) has a diagnostic and prognostic value for patients with CAD [5–7]. Moreover, several trials showed LV GLS could be used to assess the functional significance of coronary stenosis in speckle tracking stress echocardiography [8-12]. In these trials, although the dobutamine stress test was mainly used, some studies used ergometry [8-12]. Since treadmill exercise is more physiological, it is relevant to study the possibilities of speckle tracking stress echocardiography using a treadmill stress test.

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Objective

Determine the possibilities of LV GLS in stress echocardiography using the treadmill stress test to estimate the functional significance of the degree of coronary stenosis.

Material and methods

The observational, comparative, single-center study comprised 138 patients hospitalized with suspected or known CAD. Exclusion criteria consisted of suboptimal cardiac imaging and the inability to calculate LV GLS following termination of a treadmill stress test during stress echocardiography. As a result, 17 patients were excluded from the study: 10 patients due to suboptimal imaging and 7 due to heart rate (HR) limitation.

Thus, data of 121 patients from 50 to 84 years old (mean age 68.3±7.7 years; 48 (39.7%) females and 73 (60.3%) males) were analyzed. Beta-blockers were discontinued 48 hours prior to commencing speckle tracking stress echocardiography. Antianginal drugs were discontinued on the day of stress echocardiography. Pre-test probability of CAD was assessed in all patients following the European guidelines of 2019 [13].

All patients underwent clinical investigations: electrocardiogram, transthoracic echocardiography, treadmill stress echocardiography. The coronary bed was assessed using coronary angiography (CAG), while the severity of coronary stenosis was estimated by the Gensini score.

On completion of CAG, all patients were divided into three groups: Group 1 included 44 patients without coronary stenosis recorded in the CAG reports (Gensini score: 0). Group 2 included 57 patients with moderate coronary stenosis (Gensini score: <34). Group 3 comprised 20 patients with severe coronary stenosis (Gensini score:≥35). Clinical characteristics of patients are presented in Table 1.

There were more male patients in the groups with moderate and severe coronary stenosis. Patients with severe coronary stenosis were relatively older. The groups were generally matched by body mass index, frequency of suspected or known CAD, history of exertional angina functional class I-II, documented hypertensive heart disease, history of heart rhythm disorders, history of atrial fibrillation, bronchial asthma and chronic obstructive pulmonary disease. The pre-test statistical probability of CAD significantly higher in the severe coronary stenosis group than in the group of patients without coronary disease (p=0.02).

Standard stress echocardiography was performed using a Vivid E95 ultrasound system [14]. The treadmill stress test was performed in a Series 2100 GE Healthcare device according to the Bruce protocol with ECG and HR registered at rest and with exercise; blood pressure (BP) was measured using a manual tonometer at each step of the exercise.

During stress echocardiography, measurements were carried out at baseline and immediately after the treadmill test. The highest quality records were selected from continuous recording of the digital echocardiographic data carried out following the termination of exercise. Five views were registered simultaneously: the apex view of the LV long axis, four- and two-chamber views, as well as the parasternal view of the LV long axis and short axis at the papillary muscle level. The duration of all required records was not more than 1.5 minutes following termination of the treadmill stress test (0.51±0.39 minutes).

The WMA index was calculated during the visual evaluation of WMAs at rest and after the termination of the exercise [14]. The LV ejection force was calculated at rest and after exercise as a ratio of systolic BP to end-systolic LV volume [15]. The LV contractile reserve was calculated as a ratio of the LV ejection

Table 1. Clinical characteristic of the patient groups

Parameter	Group 1 (n=44)	Group 2 (n=57)	Group 3 (n=20)	p
Female	26 (59)	18 (32)	4 (20)	p_{1-2}=0.02 p_{1-3}=0.01 p_{2-3}=0.39
Age, years (M±SD)	63.0±8.2	64.6±10.0	69.1±9.1	p_{1-2}=0.22 p_{1-3}=0.01 p_{2-3}=0.24
Body mass index, kg/m2, M ± SD	28.7±4.7	29.0±4.6	26.7±3.9	p_{1-2}=0.66 p_{1-3}=0.30 p_{2-3}=0.15
Pre-test probability of CAD (%), Me [Q1; Q3]	16.0 [6.0; 27.0]	22.0 [11.0; 27.0]	24.0 [22.0; 44.0]	p_{1-2}=0.12 p_{1-3}=0.02 p_{2-3}=0.18
CAD (suspected or documented)	37 (88.1)	43 (76.8)	18 (90.0)	p_{1-2}=0.19 p_{1-3}=0.65 p_{2-3}=0.30
Hypertensive heart disease	31 (70.5)	48 (84.2)	16 (80.0)	p_{1-2}=0.14 p_{1-3}=0.35 p_{2-3}=0.99
History of exertional angina FC I–II	19 (45.2)	21 (37.5)	8 (40.0)	p_{1-2}=0.53 p_{1-3}=0.99 p_{2-3}=0.78
History of arrhythmia	12 (28.6)	13 (23.2)	4 (20.0)	p_{1-2}=0.64 p_{1-3}=0.75 p_{2-3}=0.99
History of AF	7 (16.7)	12 (21.1)	4 (20.0)	p_{1-2}=0.61 p_{1-3}=0.72 p_{2-3}=0.99
Bronchial asthma	1 (2.4)	3 (5.4)	1 (5.0)	p_{1-2}=0.63 p_{1-3}=0.53 p_{2-3}=0.99
COPD	3 (7.1)	7 (12.5)	1 (5.0)	p_{1-2}=0.50 p_{1-3}=0.99 p_{2-3}=0.67

The data are expressed as the absolute number of patients (%), unless otherwise is specified. CAD, coronary artery disease; FC, functional class; AF, atrial fibrillation; COPD, chronic obstructive pulmonary disease.

force after the termination of exercise to the LV ejection force before exercise [15].

As well as the visual assessment of LV wall motion, the longitudinal LV strain was calculated during stress echocardiography. Apex view records having a frame rate of at least 50 frames per second were used. The longitudinal systolic strain was evaluated using a Vivid E95 device and Automated Functional Imaging (AFI) algorithm. LV GLS and regional longitudinal strain (RLS) were assessed [4]. LV GLS delta was calculated as the difference between LV GLS at rest and following the termination of exercise.

CAG was performed according to the Judkins technique by an independent interventional surgeon within 3 months before or after stress echocardiography. The severity of coronary stenosis was evaluated by the Gensini score: no coronary stenosis – 0; moderate coronary stenosis – 1–34; severe coronary stenosis – ≥35 [16].

All subjects signed an informed consent form prior to inclusion in the study. The study protocol was approved by the ethics committee of the Central State Medical Academy.

The statistical processing was performed using the SPSS v23.0 software suite. The normality of distribution was tested using the Kolmogorov-Smirnov test with Lilliefors correction. In a normal distribution, the quantitative data were expressed as the mean±standard deviation (M±SD) and estimated using the Student's t-test. The non-normally distributed quantitative indicators were described using the median (Me) and the lower and upper quartiles [Q1; Q3] and estimated using the Mann–Whitney U-test. The Bonferroni correction was used to nullify the effect of multiple comparisons. The categorical indicators were expressed as a percentage. Pearson's chi-squared test was used to assess the statistical significance of the differences between percentages. After performing ROC analysis, the ROC curves were constructed for LV GLS at rest and following termination of exercise, LV WMA index at rest and following termination of exercise, as well as for LV GLS delta. The differences were statistically significant at p<0.05.

Results

A total of 4,114 segments were analyzed during speckle tracking stress echocardiography. Quantitative LV RLS could not be obtained for 15 segments at rest and 40 segments following termination of exercise.

The stress echocardiography parameters are provided in Table 2.

During stress echocardiography, the number of patients who achieved the sub-maximum heart rate, or who complained of heart pain and/or dyspnea during the exercise did not differ statistically significantly between groups. Typical angina pectoris was recorded in only two patients with severe coronary stenosis. The durations of exercise, mean exercise load, BP at rest and after exercise, as well as heart rate at rest, were similar in all patient groups. The achieved HR at the maximum load was statistically significantly lower in the group of severe coronary stenosis as compared to the group of patients without coronary disease (p=0.03). Statistically significantly more patients with severe coronary stenosis had positive stress echocardiography results than those patients in the group without coronary disease (p=0.04).

Treadmill stress echocardiography and CAG showed that the provisional diagnosis of CAD should be reviewed in 88.6% of patients in Group 1. CAD with normal coronary arteries could be suspected in 11.4% of patients with positive stress echocardiography without coronary disease. Interestingly, there was a relatively small number of patients with angina pain despite a history of exertional angina having been established in 37.5 to 45.2% of cases.

There were no statistically significant differences between patients in terms of contractile reserve.

In the severe coronary stenosis group, LV WMA indices following termination of exercise were statistically significantly higher compared to the groups without coronary stenosis and having moderate coronary stenosis – 1.14±0.20 compared to 1.00±0.03 (p<0.001) and 1.01±0.04 (p<0.001), respectively. The ROC analysis was performed to assess the diagnostic value of the LV WMA index after exercise for the detection of coronary stenosis. Here, model quality was poor; the area under the curve (AUC) was 0.59±0.05. The analysis of the diagnostic value of LV WMA index in detecting severe coronary stenosis showed good model quality (AUC=0.78±0.07) with a sensitivity and specificity of 66 and 88%, respectively, for the index of 1.02.

The evaluation of changes in LV WMA index in the groups of patients without coronary disease and with moderate coronary stenosis showed no statistically significant increase in the values. The increase in LV WMA index was statistically significant in patients with severe coronary stenosis (1.03±0.09 versus 1.14±0.20; p=0.03).

LV GLS values were not statistically different between the groups. After termination of exercise, LV GLS was statistically significantly lower in patients with severe coronary stenosis than in those without coronary stenosis and with moderate coronary stenosis – 15.9±4.6% versus 20.6±3.7% (p<0.001) and 19.6±3.0% (p=0.003), respectively.

In assessing changes in LV GLS in the group of patients without coronary stenosis, a statistically significant increase in LV GLS after the termination of exercise was observed (from 19.1±3.1 to 20.6±3.7%; p=0.04). In the group of moderate coronary stenosis, there was also an increase in LV GLS after exercise, but it was less pronounced and statistically insignificant compared to the baseline values (from 19.0±2.7 to 19.6±3.0%; p=0.25). Although, in contrast to the two other groups, LV GLS decreased in the group with severe

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Table 2. Stress echocardiography findings

Parameter	Group 1 (n=44)	Group 2 (n=57)	Group 3 (n=20)	p
SBP at rest, mm Hg (M±SD)	127.2± 12.9	128.7± 14.6	127.2± 11.7	$p_{1-2}=0.49$ $p_{1-3}=0.82$ $p_{2-3}=0.62$
SBP after exercise, mm Hg (M±SD)	180.0± 24.3	179.7± 27.6	172.5± 17.2	$p_{1-2}=0.69$ $p_{1-3}=0.20$ $p_{2-3}=0.39$
DBP at rest, mm Hg (M±SD)	77.6± 8.4	77.3± 9.8	76.0± 7.7	$p_{1-2}=0.77$ $p_{1-3}=0.46$ $p_{2-3}=0.65$
DBP after exercise, mm Hg (M±SD)	83.2± 11.7	82.3± 11.8	81.7± 10.0	$p_{1-2}=0.83$ $p_{1-3}=0.92$ $p_{2-3}=0.96$
HR at rest, bpm (Me, Q1–Q3)	67.0 [62.0; 75.5]	68.0 [63.0; 74.0]	65.0 [58.5; 71.5]	$p_{1-2}=0.45$ $p_{1-3}=0.55$ $p_{2-3}=0.23$
HR after exercise, bpm (Me, Q1–Q3)	133.0 [126.5; 139.5]	133.0 [122.0; 141.0]	121.0 [107.0; 133.0]	$p_{1-2}=0.73$ $p_{1-3}=0.03$ $p_{2-3}=0.06$
Chest pain	3 (6.8)	6 (10.5)	3 (15.0)	$p_{1-2}=0.72$ $p_{1-3}=0.36$ $p_{2-3}=0.68$
Angina pectoris treated with nitrates	–	–	2 (10)	–
New-onset arrhythmia	31 (70.5	38 (66.7)	12 (60.0)	$p_{1-2}=0.83$ $p_{1-3}=0.56$ $p_{2-3}=0.59$
including:				
• Isolated/pair of supraventricular and ventricular extrasystoles	31 (100)	37 (97.4)	12 (100)	$p_{1-2}=0.67$ $p_{1-3}=0.56$ $p_{2-3}=0.79$
• VT runs	–	1 (2.6)	–	–
Dyspnea	19 (44.2)	21 (36.8)	12 (60.0)	$p_{1-2}=0.53$ $p_{1-3}=0.28$ $p_{2-3}=0.33$
Sub-maximum HR achieved	35 (79.5)	41 (71.9)	11 (55.0)	$p_{1-2}=0.48$ $p_{1-3}=0.21$ $p_{2-3}=0.51$
Mean load, METS (Me, Q1–Q3)	7.0 [4.6; 7.0]	7.0 [4.6; 7.0]	4.6 [4.6; 7.0]	$p_{1-2}=0.71$ $p_{1-3}=0.18$ $p_{2-3}=0.18$
Load time, min (Me [Q1–Q3])	5.4 [4.3; 6.4]	5.4 [4.4; 7.1]	4.4 [3.2; 6.2]	$p_{1-2}=0.50$ $p_{1-3}=0.17$ $p_{2-3}=0.11$
Positive treadmill test	5 (11.4)	15 (26.3)	7 (35)	$p_{1-2}=0.77$ $p_{1-3}=0.11$ $p_{2-3}=0.15$
Positive stress echocardiography	5 (11.4)	8 (14.0)	8 (40.0)	$p_{1-2}=0.23$ $p_{1-3}=0.04$ $p_{2-3}=0.78$
LV WMA index (M±SD)	1.00± 0.01	1.00± 0.01	1.03± 0.09	$p_{1-2}=0.25$ $p_{1-3}=0.01$ $p_{2-3}=0.01$
LV WMA index after exercise (M±SD)	1.00± 0.03	1.01± 0.04	1.14± 0.20	$p_{1-2}=0.38$ $p_{1-3}<0.001$ $p_{2-3}<0.001$
Contractile reserve (M±SD)	1.6±0.5	1.6±0.6	1.5±0.4	$p_{1-2}=0.81$ $p_{1-3}=0.58$ $p_{2-3}=0.42$
LV GLS at reat, % (M±SD)	19.1± 3.1	19.0± 2.7	17.8± 2.8	$p_{1-2}=0.98$ $p_{1-3}=0.16$ $p_{2-3}=0.15$
LV GLS after exercise, % (M±SD)	20.6± 3.7	19.6± 3.0	15.9± 4.6	$p_{1-2}=0.25$ $p_{1-3}<0.001$ $p_{2-3}=0.003$
Δ LV GLS, % (Me [Q1–Q3])	–1.6 [–3.4; 0.8]	–1.1 [–2.5; 1.9]	1.7 [–0.6; 3.5]	$p_{1-2}=0.22$ $p_{1-3}<0.001$ $p_{2-3}=0.02$

SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; VT, ventricular tachycardia;
LV WMA index, left ventricular wall motion abnormality index; LV GLS, left ventricular global longitudinal strain.
The data are expressed as the absolute number of patients (%)unless otherwise is specified.

coronary stenosis after termination of exercise, this decrease was statistically insignificant (from 17.8±2.8 to 15.9±4.6%; p=0.15).

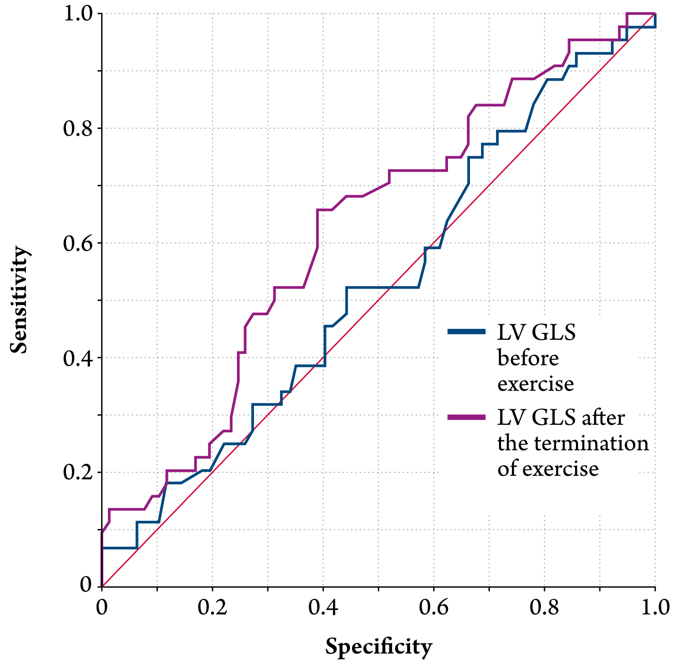
ROC analysis was performed to assess the diagnostic value of LV GLS for the detection of coronary stenosis (Figure 1). The analysis of the diagnostic value of LV GLS in the detection of coronary stenosis showed a poor and average quality of the model at rest and following exercise; the area under the curve (AUC) was 0.52±0.05 and 0.62±0.05, respectively.

The ROC curve of the evaluation of severe coronary stenosis using LV GLS is shown in Figure 2. The estimation of LV GLS before exercise revealed an average quality of the model in evaluating the severity of coronary stenosis (AUC=0.63±0.06) with the maximum sensitivity of 73% and specificity of 51% with LV GLS equal to 19.0%. The estimation of LV GLS after exercise showed a good model quality (AUC=0.76±0.06) with the sensitivity and specificity of 80 and 70%, respectively, for LV GLS of 16.9%.

LV GLS delta was higher in the group of patients with severe coronary stenosis as compared to those without coronary stenosis and with moderate coronary stenosis – 1.7% [–0.6; 3.5] versus –1.6% [–3.4; 0.8] (p<0.001) and –1.1% [–2.5; 1.9] (p=0.02), respectively. The model quality was poor (AUC=0.54±0.05) in the assessment of LV GLS delta in the detection of coronary stenosis. The ROC curve demonstrating the possibilities of LV GLS delta in assessing severe coronary stenosis is presented in Figure 3. The analysis of the diagnostic value of LV FLS in assessing severe coronary stenosis showed a good model quality (AUC=0.73±0.05) with a sensitivity and specificity of 73 and 63%, respectively, for the value of –0.3.

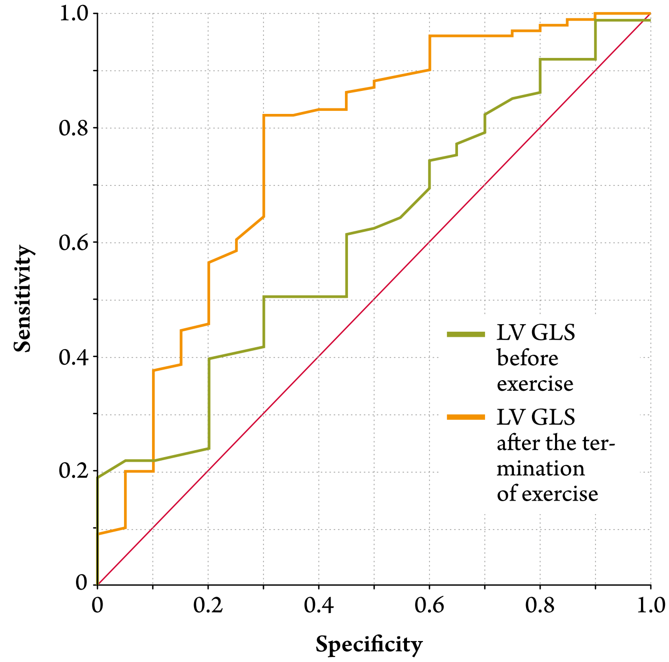
In the group of hemodynamically significant coronary diseases, 14 patients had LV GLS lower than 16.9%, while

Figure 1. ROC curve showing the possibilities of LV GLS before and after the termination of exercise in evaluating coronary stenosis



LV GLS before exercise: AUC=0.52±0.05; 95 % CI 0.42–0.63 (p=0.59). LV GLS after the termination of exercise: AUC=0.62±0.05; 95 % CI 0.52–0.72 (p=0.02). GLS – global longitudinal strain; LV – left ventricle; CI – confidence interval.

Figure 2. ROC curve showing the possibilities of LV GLS before and after the termination of exercise in evaluating severe coronary stenosis



LV GLS before exercise: AUC=0.63±0.06; 95 % CI 0.47–0.73 (p=0.12). LV GLS after the termination of exercise: AUC=0.76±0.06; 95 % CI 0.63–0.89 (p<0.001). GLS, global longitudinal strain; LV, left ventricle; CI, confidence interval.

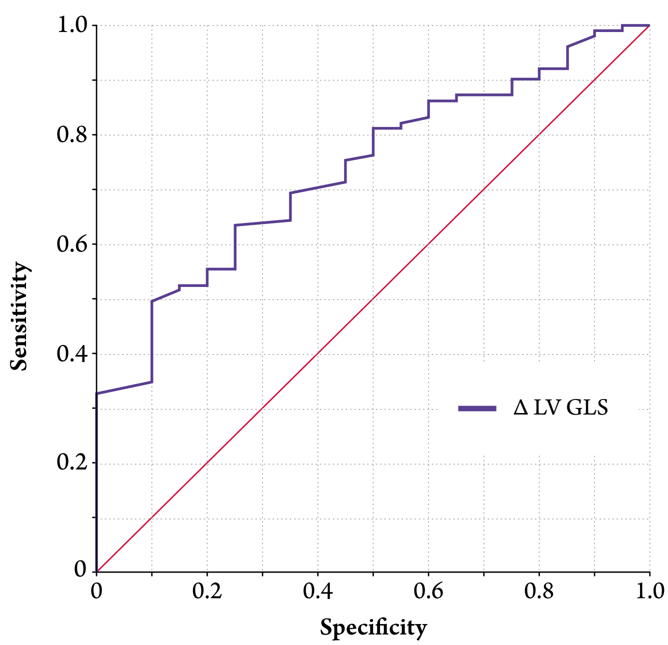
in 6 patients, LV GLS was greater than 16.9%. Variations between clinical and anthropometric characteristics and stress echocardiography findings were not statistically significant between patients. The only statistically significant difference between these patients was the LV WMA index – patients with LV GLS <16.9% had statistically significantly higher values than patients with LV GLS >16.9% (1.19±0.23 versus 1.04±0.04; p=0.04).

Changes in LV GLS in three patient groups are shown in Figure 4.

As shown in Figure 4, the most significant increase in LV GLS during treadmill stress echocardiography was observed in a patient without coronary stenosis. The minimum increase was detected in a patient with moderate coronary stenosis, and a patient with severe coronary stenosis had a decrease in LV GLS.

Based on the obtained data, the LV GLS and LV WMA indexes were statistically significantly different between the group of severe coronary stenosis and the groups without coronary disease and with moderate coronary stenosis. The evaluation of changes in the LV WMA index showed no statistically significant increase in the groups without coronary disease and with moderate coronary stenosis, while in the group of severe coronary stenosis, there was a statistically significant increase. The evaluation of changes in LV GLS revealed

Figure 3. ROC curve demonstrating the possibilities of LV GLS delta in assessing severe coronary stenosis



AUC=0.73±0.05; 95 % CI 0.63–0.84 (p<0.001). GLS – global longitudinal strain; LV – left ventricle; CI – confidence interval.

a statistically significant increase in the group without coronary disease, a statistically insignificant increase in LV GLS in the group of moderate coronary stenosis, and

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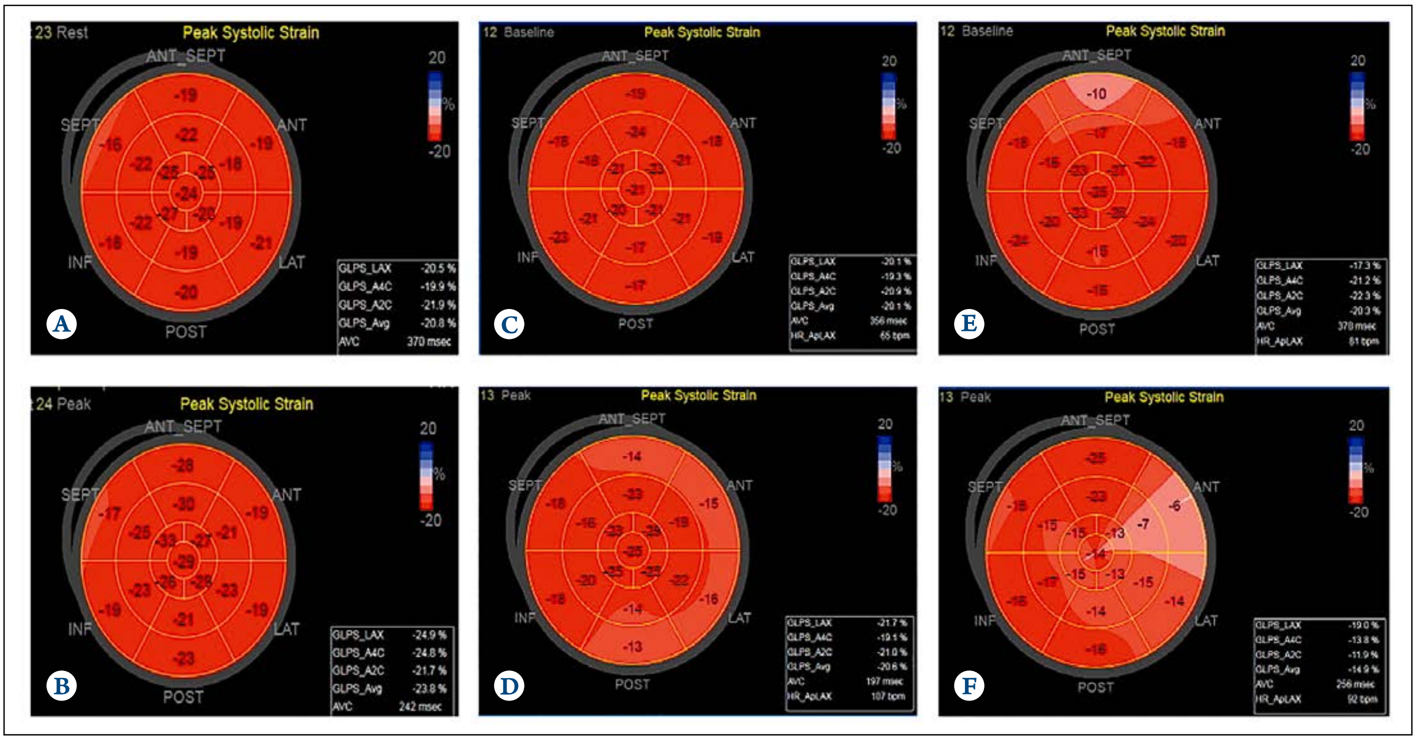
Figure 4. Clinical example of LV GLS evaluation at rest and following termination of exercise in speckle tracking treadmill echocardiography



A, B – without coronary disease; C, D – 60% right coronary artery stenosis;
E, F – multi-vessel coronary disease. LV GLS – left ventricular global longitudinal strain

a statistically insignificant decrease in LV GLS in the group of severe coronary stenosis. The assessment of the diagnostic value of the LV GLS and LV WMA indexes in detecting severe coronary stenosis showed that LV GLS was more sensitive than the LV WMA index (80 and 66%, respectively), but less specific (70 and 88%, respectively). In individual patients with severe coronary stenosis, it was not possible to reduce LV GLS.

Discussion

In our study, although LV GLS values at rest were lower in the group of patients with severe coronary stenosis than in other patient groups, the difference was statistically insignificant. This is consistent with several trials in which patients with coronary stenosis had reduced LV GLS at rest according to echocardiography [17, 18].

In stress echocardiography, LV GLS after exercise was statistically significantly lower in the group of patients who had severe coronary stenosis than in the two other groups. This is consistent with the findings of Aggeli et al. [19], who showed that, in dobutamine stress echocardiography, LV GLS values were significantly different in patients with and without coronary stenosis at peak stress (18.95±4.34 and 23.16±3.30%, respectively; $p<0.001$). In the study carried out by Uusitalo et al. [20], in dobutamine stress echocardiography, differences between groups of patients with and without coronary stenosis were similarly established only following stress (17.2±4.0 and 19.8±2.1%, respectively; $p=0.01$).

Stress echocardiography can be used to evaluate changes in longitudinal systolic strain in response to stress. In our study, an increase in LV GLS was recorded following exercise in the groups without coronary stenosis (from 19.1±3.1 to 20.6±3.7%; $p=0.04$) and those having moderate coronary stenosis (from 19.0±2.7 to 19.6±3.0%; $p=0.25$). In several studies, patients without coronary stenosis experienced an increase in LV GLS at peak stress during stress echocardiography [19, 21, 22]. In estimations of LV GLS in treadmill stress echocardiography using tissue Doppler imaging, Pirtskhalava et al. [22] registered an increase at peak exercise in the group of patients without CAD (from 20.0±1.7 to 21.6±4.1%; $p=0.03$). Similar data were published by Aggeli et al. [19], who registered an increase in LV GLS in patients without coronary stenosis (from 21.59±2.33 to 23.16±3.30%) [19, 22].

Our data show that an increase in LV WMA index, used as a visual evaluation of WMA in stress echocardiography, was observed only in patients with severe coronary stenosis. Visual evaluation of LV WMA is a primary criterion of transient myocardial ischemia in stress echocardiography. However, several recent studies showed a significant decrease in the frequency of positive tests in stress echocardiography when using the visual evaluation of WMA as a criterion of transient myocardial ischemia [23, 24]. Due to the constant search for new indicators to assess the functional significance of the degree of coronary stenosis in stress echocardiography, much attention is paid to evaluating the LV longitudinal systolic strain. In a recently published meta-analysis by Gupta et al. [25], it was shown that assessment of myocardial strain during stress echocardiography is not only feasible but has a higher diagnostic accuracy in detecting clinically significant CAD than visual evaluation of WMA only. Although our data showed a decrease in LV GLS compared to the baseline in the group of patients with severe coronary stenosis, it was not statistically significant (17.8±2.8 versus 15.9±4.6%; p=0.15). Nevertheless, according to ROC analysis, LV GLS of less than 16.9% following the termination of exercise predicted severe coronary stenosis with 80% sensitivity and 70% specificity (AUC=0.76±0.06). An LV GLS of 16.9% is very close to that found in the study by Mansour et al. [11], in which semi-lying ergometry stress echocardiography was performed with continuous recording of echocardiographic data. The higher sensitivity and specificity as evaluated by Mansour et al. [11] and Gupta et al. [25] than as obtained in our study are probably due to the peculiarities of treadmill stress echocardiography. In this type of exercise, data used to calculate LV GLS are recorded immediately following the termination of exercise and not at the peak as was performed in the study by Mansour et al. and other studies included in the meta-analysis by Gupta et al., in which most stress tests were pharmacological [11, 25]. This assumption can be indirectly confirmed in the study carried out by Yu et al. [26], in which LV GLS was shown to be reduced in patients with multi-vessel coronary disease at the first steps of dobutamine stress test (10 μg/kg/min), even before the appearance of visible WMAs.

Since there is a certain trend in the LV GLS and LV WMA index changes, the evaluation of these two indicators may allow the most accurate assessment of the LV wall motion. This supposition was confirmed by Ng et al. [27], who showed that the visual assessment of WMAs and LV GLS are generally matched, while their combination in dobutamine had the highest sensitivity, specificity, and diagnostic accuracy in evaluating severe coronary stenosis.

Conclusions

1. Left ventricular global longitudinal strain of less than 16.9% following exercise predicts severe coronary stenosis with 80% sensitivity and 70% specificity (AUC=0.76±0.06; 95% confidence interval 0.63–0.89; p<0.001).
2. In 70% of patients with severe coronary artery stenosis, left ventricular global longitudinal strain is reduced at baseline and decreases in response to stress.
3. In patients with normal coronary arteries, left ventricular global longitudinal strain increases in speckle tracking treadmill stress echocardiography.

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