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Role of Segmental and Global Left Ventricular Strain in Diagnosis of Acute Coronary Syndrome

Aim To determine the role of left ventricular segmental (SLS) and general longitudinal strain (GLS) in early diagnosis of acute coronary syndrome (ACS).

Material and methods The study included 112 patients aged 58±7 years with suspected ACS without a history of ischemic heart disease (IHD) who were admitted to the hospital within 12 h of complaint onset. The control group consisted of 20 healthy, age- and sex-matched subjects. Speckle-tracking echocardiography was performed to assess SLS and GLS on admission and discharge. Ischemia was diagnosed when the SLS was decreased to 14% or lower with a simultaneous post-systolic shortening (PSS) of these segments >20% or when the initial lengthening of the segments was followed by PSS.

Results Decreased SLS with PSS of one or more segments was observed in 51.8% of patients; 16.1% of patients had initial systolic lengthening of one or more segments followed by PSS. In 30.3% of patients, GLS was 15.5% or less; 82.3% of these patients had SLS disorders. Later, ACS was diagnosed in 72.3% of the patients. ACS was not confirmed in 4 (5.2%) of 76 (67.9%) patients with abnormal SLS changes. All these patients had low SLS values and high PSS values and did not have the initial systolic segmental lengthening. Seven of 9 (8%) patients with false-negative SLS values had distal narrowing of a coronary artery and two patients had narrowing in the middle part of the artery. All patients with ACS and decreased GSL had a hemodynamically significant narrowing of more than one coronary artery. Incidence of two and more stenosed arteries was higher in patients with PSS and low GSL. Sensitivity and specificity of SLS for diagnosis of acute ischemia were 88.9 and 84.6%, respectively.

Conclusion Assessment of LV strain has high sensitivity and specificity for diagnosis of ACS in patients with the first IHD episode. The presence of PSS associated with decreased GSL may indicate multivascular IHD.

Keywords Acute coronary syndrome; longitudinal strain; segmental post-systolic shortening

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Longitudinal left ventricular deformation (LVD) identified by tissue Doppler imaging and more sensitive speckle tracking echocardiography is one of the most important components of the left ventricular (LV) contractile function [1, 2]. Since the longitudinally-oriented LV myocardial fibers, particularly subendocardial fibers, are more responsive to pathological stimuli, a decrease in LVD may occur in earlier subclinical stages of the disease, when radial LV function and other contractile parameters are normal [3, 4]. The objective of our study was to determine the diagnostic capability of speckle tracking echocardiography (STE) in patients with suspected acute coronary syndrome (ACS) and with normal electrocardiogram (ECG), conventional echocardiography and biomarker levels.

Material and methods

The study included 112 patients (41 females) without a history of coronary artery disease (CAD) with suspected ACS, at the age of 58±7 years old. They were admitted to the myocardial infarction unit of the Yerevan Institute of Cardiology within 12 hours of symptom onset. Ambulance physicians diagnosed ACS based on patient complaints, the presence of risk factors, family history and ST-T complex changes on the ECG. 20 healthy individuals in the same sex and age range as the experimental group constituted a control group (Patient demographics and clinical measurements are listed in Table 1).

All patients underwent ECG at admission, STE at admission and discharge, and blood testing for troponin T at admission and every 3 hours. STE was performed in a GE Vivid 7 Dimension system using the M4S and 3V sensors [5].

Images were acquired and saved with the patient holding breath when cardiac imaging was optimal. Video images and Doppler data of the three subsequent cycles were saved to be analyzed using the EchoPAC software (GE Healthcare). The LV ejection fraction (EF) was automatically measured by the

Table 1. Patient demographics and clinical measurements

Parameter	Patients	Control	p
Males, %	67	65	ns
Age, years	58±7	56±7	ns
BMI, kg/m2	27.4±3.7	26.2±2.4	ns
SBP, mm Hg	146±11	128±12	0.04
DBP, mm Hg	94±5	78±4	0.04
Total cholesterol, mmol/L	5.4±1.3	5.1±1.1	ns
Diabetes mellitus, %	21	–	–
LVMI, kg/m2	112.2±18.9	82.3±10.3	0.03
ESVI, mL/m2	22.1±4.8	22.3±5.1	ns
EDVI, mL/m2	53.4±9.3	52.8±8.9	ns
LV ejection fraction, %	61.4±3.3	60.8±4.1	ns

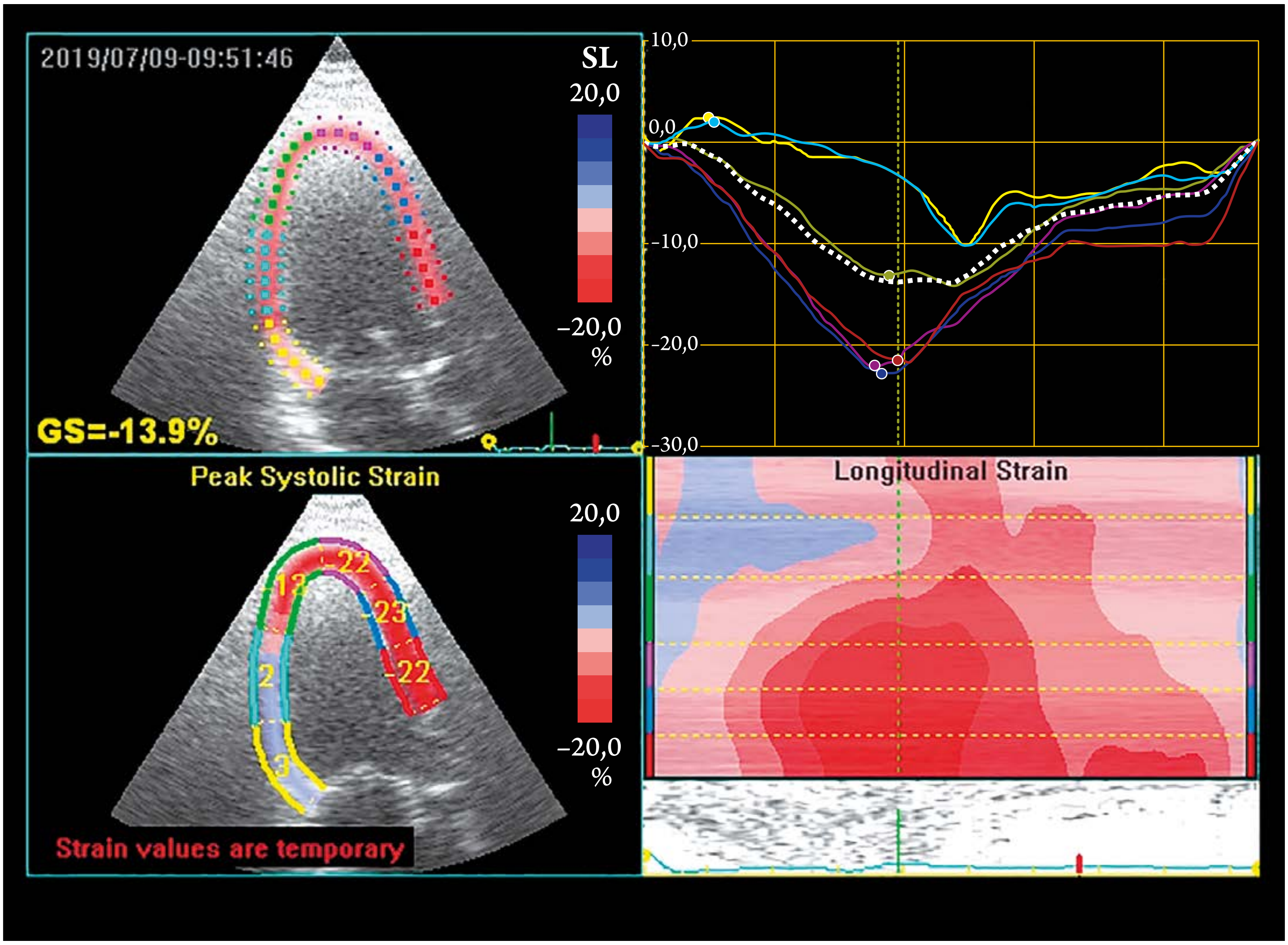
BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; LVMI, left ventricular mass index; ESVI, end-systolic volume index; EDVI, end-diastolic volume index; EF, ejection fraction; ns, nonsignificant; M, mean value; m, standard deviation. The data are expressed as M±m unless stated otherwise.

biplane Simpson's method after tracing the LV endocardium in the four- and two-chamber views and determining the end-diastolic volume (EDV) and end-systolic volume (ESV).

The LV mass was calculated using the area-length method [5], and its index was calculated afterward. The general and local contractility of LV was estimated in the 16 segment model [5].

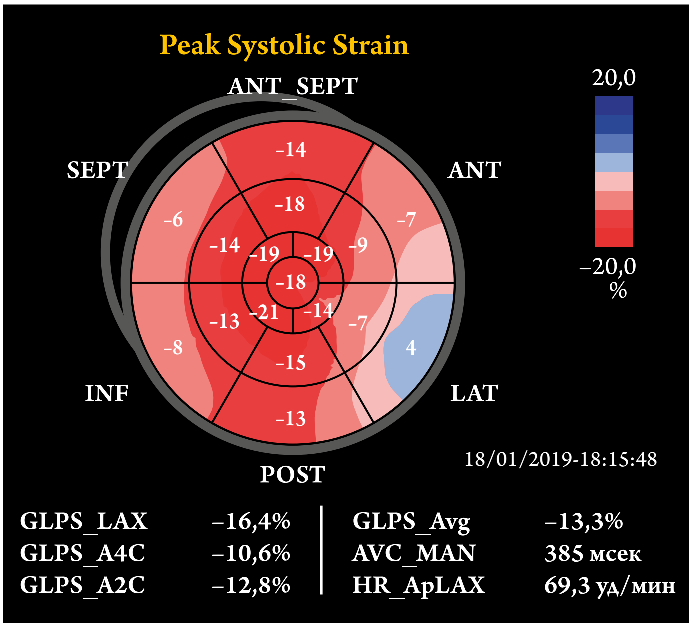
Global longitudinal deformation (GLD) and segmental longitudinal deformation (SLD) were measured in the speckle tracking mode after standard apical slices were acquired and saved, and LVD was calculated using EchoPAC. The markers were placed on the lateral and medial mitral annulus and the LV apex, after which the program automatically traced the LV walls. Manual correction was made if necessary, after which SLD and the global 17 segment model of the systolic GLD were determined. The LV segments were considered ischemic with a decrease in the systolic peak of SLD by 14% or more, and the simultaneous presence of post-systolic shortening (PSS) of ≥20% in these segments and an initial segmental lengthening prior to PSS (Figures 1–3) [6].

Figure 1. Graphic representation of the segmental left ventricular deformation (adapted from [6])



AVC, aortic valve closure; GS, a global deformation of left ventricular segments in the three-chamber view. The upper right graph shows a post-systolic shortening of the posterobasal and posteromedial segments with initial systolic lengthening.

Figure 2. The 17-segment model of the global systolic left ventricular deformation (adapted from [6])



GLPS_Avg, the average of the global longitudinal deformation of the left ventricle at a systolic peak.

The initial systolic lengthening of the segments as an indicator of ischemia in the presence of PSS was defined as a positive deformation of these segments in the first third of systole. The intra- and interstudy variability of LV GLD was estimated in 10 subjects (5 patients and 5 healthy individuals) to be 4% and 6%, respectively.

All patients underwent coronary angiography followed by coronary stent implantation if the diagnosis of ACS was confirmed.

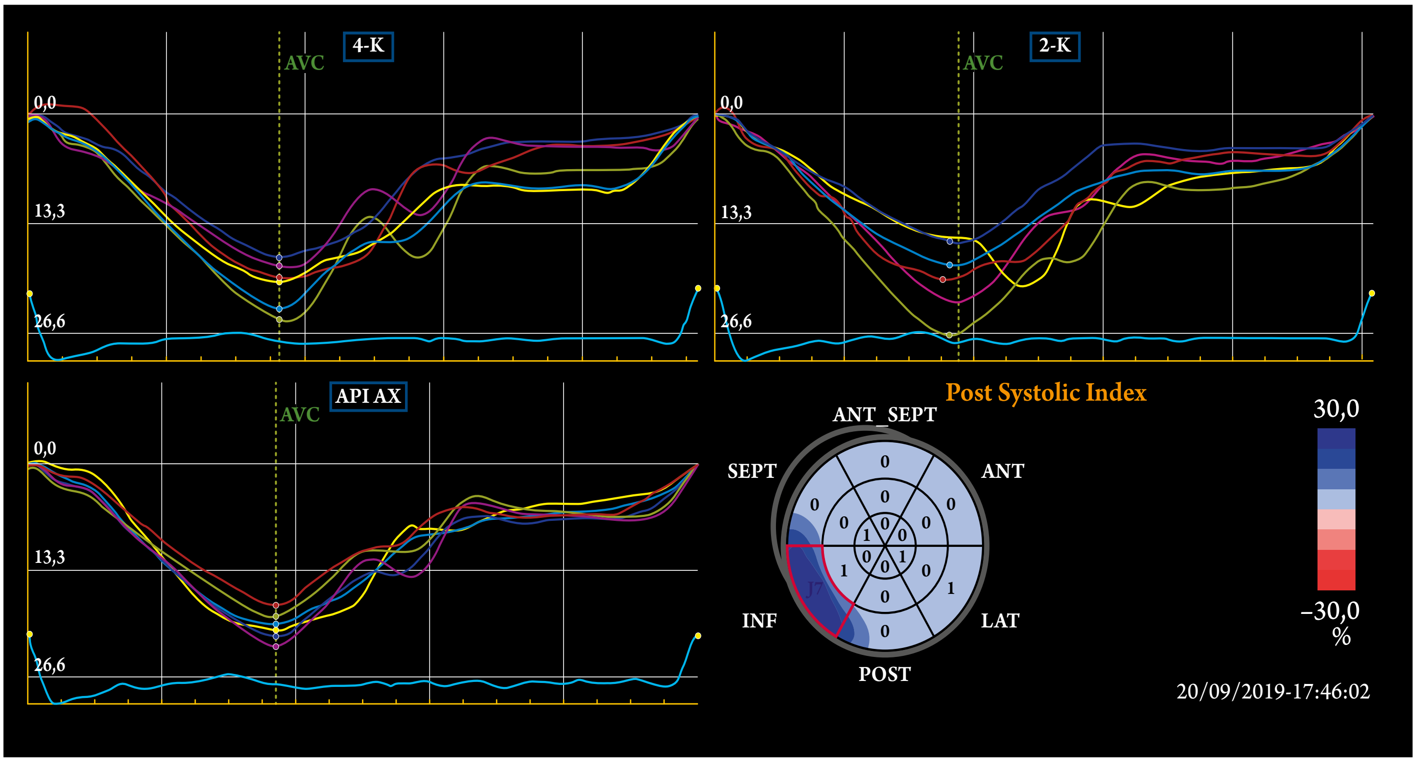
The statistical analysis was performed using the SPSS 21.0 software package. The variables were studied to determine a normal distribution and equal deviations using the Kolmogorov-Smirnov test. Continuous parameters are expressed as the mean and standard deviation (M±SD) and categorical parameters as absolute values and percentages. The data were analyzed using the parametric Student's test and the non-parametric Mann–Whitney U-test. The differences were considered statistically significant at $p < 0.05$. The study complies with the principles of the Declaration of Helsinki. The local ethics committee approved the study protocol. All subjects signed informed consent.

Results

At admission, 26 (23.2%) patients had local contractility abnormalities. All of these patients were diagnosed with ACS. The original values of EF, GLD, and local contractility index analyzed after the diagnosis of ACS were not significantly different in patients with MI and unstable angina.

58 (51.8%) patients had a documented decrease in SLD and PSS of one or more segments, while 18 (16.1%) patients had an initial systolic lengthening of one or more segments followed by PSS. In 34 (30.3%) patients, GLD was as much as 15.5 or more, 28 (82.3%) of them had

Figure 3. Segmental calculation of a degree of post-systolic segment shortening (adapted from [6])



Postsystolic shortening of the inferobasal segment of the left ventricle 37%.

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segmental abnormalities of LVD. In the control group, segment PSS was detected in 9 (45%) individuals, yet was not accompanied by an end-systolic decrease in SLD and/or initial systolic elongation of those segments. PSS was <20% in the control group. ACS was diagnosed based on the elevation of the troponin T levels to diagnostic levels in 81 (72.3%) patients.

Of the 76 (67.9%) patients with SLD abnormalities, ACS was not confirmed in 4 (5.2%), all had reduced end-systolic SLD values and high PSS but did not have initial systolic segmental lengthening. Of the nine (8%) patients with false-negative SLD values, seven had a distal narrowing of a coronary artery, and two patients had a narrowing in the mid coronary artery. The proximal narrowing was not observed in these patients. All patients with ACS and a decrease in GLD had hemodynamically significant narrowing of more than one coronary artery. The diagnostic value of the segmental LVD was 88.9% sensitivity, 84.6% specificity; the positive predictive significance was 94.7%, and the negative predictive value was 71%.

Thus, the high sensitivity and specificity achieved using LVD values allows for the rapid diagnosis of ACS immediately after patients are admitted to the intensive care unit. Patients with PSS and low absolute values of GLD were more likely to have hemodynamically significant stenosis of two or more coronary arteries. 36 (32%) patients with ACS developed myocardial infarction.

Discussion

The determination of GLD has gradually become an integral part of echocardiographic examinations due to the significant diagnostic and predictive value of this method in various pathological conditions [7, 8] and the ability to detect preclinical myocardial dysfunction of the left ventricle in addition to other heart chambers [9, 10].

The recent studies on LVD in CAD have established that the post-systolic shortening of LV segments as shown by speckle tracking can serve as a reliable marker of ischemia in the absence of other pathological conditions, such as left bunch branch block or an implanted pacemaker [6, 11–15].

We found that PSS values >20% of one or two segments combined with a decrease in end-systolic deformation of these segments with possible early systolic straining, is a reliable indicator of ischemia in patients with suspected ACS. According to our data, PSS has high sensitivity and specificity, as well as a high predictive value of positive and negative test results.

We also identified PSS in healthy individuals in the control groups, but measured at <20%; all of the individuals had high peaks of systolic deformation.

Our study was limited by a relatively small number of patients studied, patients with no history of cardiovascular diseases, which could also affect the specificity of the method for the LVD in early diagnosis of ACS. A potential drawback of the study was the lack of a comparable number of individuals with arterial hypertension and diabetes mellitus in the control group, which could contribute to the presence of higher values of deformation.

Conclusion

The examination of the left ventricle deformation in suspected acute coronary syndrome is an informative diagnostic method with high sensitivity and specificity in patients encountering coronary artery disease for the first time. The presence of post-systolic segment shortening with a concomitant decrease in global longitudinal deformation may indicate a multivessel coronary artery disease.

No conflict of interest is reported.

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