Predictive value of layer-specific speckle tracking technique combined with triglyceride-glucose index in the diagnosis of acute coronary syndrome complicated with diabetes mellitus

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Research Article

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Abstract

Background

To analyze the relationship between triglyceride-glucose (TyG) index and left ventricular systolic function and myocardial layer-specific strain in patients with acute coronary syndrome (ACS) combined with diabetes mellitus (DM) and to explore the value of layer-specific speckle tracking technique combined with TyG index in the risk assessment of patients with ACS combined with DM.

Methods

Ninety-eight patients with chest pain who underwent coronary angiography were enrolled from the Department of Cardiology in the First Hospital of Lanzhou University between October 2020 and December 2021. The TyG index was calculated based on blood test results. The two-dimensional layer-specific speckle tracking technique was used to measure the left ventricular global longitudinal strain in the endocardial layer (GLSendo), mid-myocardial layer (GLSmid) and epicardial layer (GLSepi). The multiple linear regression analysis was performed with GLSendo, GLSmid, and GLSepi as dependent variables and the TyG index as an independent variable. Then the receiver operator characteristic (ROC) curve for predicting ACS with DM was plotted based on TyG index and GLSendo.

Results

Compared with the ACS alone and control groups, the TyG index was significantly increased in ACS combined with DM group ($P < 0.05$). The left ventricular ejection fraction and the strain of each layer of the myocardium were significantly reduced in the ACS combined DM group, in which the global longitudinal strain value from the endocardium to the epicardium decreased gradually. Among them, GLSendo had significant differences between the ACS combined DM group and the ACS alone group ($P < 0.05$). The TyG index was negatively correlated with left ventricular ejection fraction and positively correlated with GLSendo, GLSmid, GLSepi, and $\Delta$LS (GLSendo-GLSdpi) ($P < 0.05$). Multiple linear regression analysis revealed a linear correlation between TyG index and GLSendo, based on which the ROC curve for predicting ACS with DM was plotted, with the area under the curve of 0.896 ($P < 0.001$).

Conclusions

The TyG index is a simple predictor that can well predict left ventricular function and myocardial strain. The combination of TyG index and layer-specific speckle tracking technology is available to identifying the high-risk population of DM in ACS patients.

Introduction
As per the guidelines issued by the American Association of Clinical Endocrinologists Society, patients with acute coronary syndromes (ACS) who present with diabetes mellitus (DM) symptoms are considered to be a special risk group (1). According to incomplete statistics, more than a quarter of ACS patients worldwide have developed DM. ACS patients who develop DM have been proved to be one of the groups with the highest recurrence rate of cardiovascular events (2). As DM has a high prevalence worldwide and has quickly become one of the most costly diseases, medical burden of ACS combined with DM has gradually become an important issue of concern.

Studies have found that long-term high insulin resistance will increase the risk of heart failure and directly worsen ventricular remodeling and myocardial systolic function (3–5). The hyperinsulinemic-euglycemic clamp test is the “gold standard” for evaluating insulin resistance. However, due to its invasiveness and high cost, there is a low acceptance in patients, which limits its wide promotion and clinical application. In 2010, Guerrero-Romero et al. (6) first proposed the TyG index that is a more convenient and economical marker for insulin resistance detection: TyG index = Ln [fasting triglyceride × fasting blood glucose/2]. This method can quickly identify patients with reduced insulin sensitivity based on conventional biochemical test results and simple calculations and has good accuracy and repeatability (7, 8). The latest guidelines issued by the European Association of Cardiovascular Imaging emphasized the importance of non-invasive imaging technology in the diagnosis, treatment, and risk assessment of ACS (9). This guideline pointed out that for all patients suspected of ACS, echocardiography should be performed immediately to assess ventricular wall motion. Compared with conventional echocardiography, two-dimensional speckle tracking echocardiography is more sensitive to detecting myocardial deformation for assessing ventricular remodeling and myocardial function changes. Based on this, this study used the TyG index to represent insulin resistance to analyze its relationship with left ventricular systolic function and myocardial strain and to explore the predictive value of the combination of the two in identifying DM risk in ACS patients.

Methods

Participants

A total of 98 patients with chest pain who underwent coronary angiography in the Department of Cardiology of the First Hospital of Lanzhou University from October 2020 to December 2021 were enrolled, including 68 males (c = 69.4%) and 30 females (c = 30.6%). The average age was 60.9 ± 9.1 years old. Eligible patients were enrolled if they met both of the following conditions: 1) patients who first complained of chest pain; 2) sinus rhythm identified using electrocardiograph. Patients were excluded if they met any of the following conditions: 1) percutaneous coronary intervention, coronary artery bypass surgery, and another revascularization history; 2) severe heart diseases (congenital heart disease, heart valve disease, dilated cardiomyopathy, hypertrophic cardiomyopathy, etc.); 3) other endocrine system diseases; 4) serious underlying diseases (severe liver and kidney dysfunction, tumors, etc.); and 5) patients with poor echocardiography image quality and those with incomplete data during follow-up.
Grouping

According to whether DM was diagnosed (10), the subjects were divided into ACS alone group (n = 38, c = 38.8%), ACS combined with DM group (n = 38, c = 38.8 %) and control group (n = 22, c = 22.4%). Patients in the control group presented with chest pain but did not develop ACS or DM. According to the results of coronary angiography, the Gensini score of each group was collected by two senior cardiology specialists (11).

Blood testing

Fasting blood samples were collected early in the morning after overnight fasting (at least 8 hours). The blood samples were collected in strict accordance with the requirements and immediately inspected. Then, the TyG index was calculated based on the following formula: 

\[
TyG = \ln[\text{fasting triglyceride} \times \text{fasting blood glucose/2}].
\]

Imaging acquisition

ACUSON SC2000 color ultrasonic diagnostic instrument (Siemens, Germany) was used to scan images (frame rate 50 – 70 frames/s) using a 4V1c probe (frequency 1.25 – 4.5 MHz). Syngo VVI imaging software image processing workstation was employed for offline analysis of the collected imaging information.

Three leads of the electrocardiograph were connected to each patient lying on the left side. All parameters were measured as per the 2015 European and American International Guidelines (12). Electrocardiography was performed during quiet breathing. 1) Conventional echocardiography: the left atrial diameter and left ventricular end-diastolic diameter were measured through the long axis section of the left ventricle near the sternum. The forward blood flow spectrum of the mitral valve was recorded at the apical four-chamber view at 1 cm below the mitral valve tip, while the peak velocity (E, A) of the early and late diastolic blood flow spectrum of the mitral valve was recorded. The E/A value was calculated, and the tissue Doppler imaging was started. The early diastolic mean peak velocity e' at the ventricular septum and lateral wall of the mitral motion spectrum was recorded, the E/e' value was calculated, and the left ventricular ejection fraction (LVEF) was calculated by the double-plane Simpson method. 2) Layer-specific speckle tracking technique: After a routine echocardiography examination, the endocardium and epicardium were well displayed in the two-dimensional model. Apical two-, three-, and four-chamber views and left ventricular long axis views were dynamically acquired within three consecutive cardiac cycles.

Image analysis

The boundary of the left ventricular endocardium and epicardium was manually described to fully fit the entire myocardial wall. Then, the VVI imaging software was used to automatically analyze and obtain the global longitudinal strain of the left ventricular endocardium (GLSendo), the middle
myocardium (GLSmid), and the epicardium (GLSepi). The cross-wall order difference was finally calculated: $\Delta LS = GLSendo - GLSepi$.

All image acquisition and analysis were completed independently by two senior physicians from the department of ultrasound uninformed of grouping information.

**Statistical analysis**

SPSS 26.0 software was used for statistical analysis and prism 9.0 was used to draw images. Measurement data following the normal distribution are expressed as mean ± SD. One-way analysis of variance was used for intergroup comparison and Pearson correlation analysis was used for correlation analysis. Measurement data following the skewed distribution are expressed as medians ($Q_1$, $Q_3$) and Kruskal-Wallis H rank-sum test was used for intergroup comparison. Enumeration data were represented by example (%), and the Chi-square test was used for comparison between groups. Multivariate linear regression was used to analyze the correlation between the TyG index and layer-specific strain parameters and a ROC curve was drawn for the analysis of diagnostic efficacy. A value of $P < 0.05$ indicated a significant difference.

**Results**

**Comparison of clinical baseline data and conventional echocardiographic parameters**

There were no significant differences in age, body mass index, systolic blood pressure, diastolic blood pressure, smoking history, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, total cholesterol, and left atrial diameter among the three groups ($P > 0.05$). The proportion of drinking, fasting blood glucose, TyG index, and left ventricular end-diastolic diameter in the ACS combined with DM group were significantly higher than those in the ACS alone and control groups; the proportion of males and LVEF in the ACS combined with DM group were significantly higher than those in the control group ($P < 0.05$). The Gensini score of the ACS alone group and ACS combined with DM group was significantly higher than that of the control group; however, there was no significant difference between the former two groups ($P < 0.05$; Table. 1).

**Comparison of layer-specific strain parameters**

Compared with the control group, the GLSendo was significantly decreased in the ACS group, while the GLSendo, GLSmid, GLSepi, and $\Delta LS$ were significantly decreased in the ACS group combined with DM group. Compared with the ACS alone group, the GLSendo, GLSmid, and GLSepi were significantly decreased in the ACS combined with DM group ($P < 0.05$; Table. 2, Fig. 1).

**Correlation analysis between TyG index and layer-specific strain parameters**

Pearson correlation was used to analyze the correlation between the TyG index and layer-specific strain parameters. The TyG index was negatively correlated with LVEF and positively correlated with GLSendo,
GLSmed, GLSepi, and ΔLS \( (P < 0.05; \text{Table. 3}) \). Then the TyG index as the dependent variable and LVEF, GLSendo, GLSmid, GLSepi, and ΔLS as independent variables were included in the multiple linear regression equation. GLSendo was found to be linearly correlated with the TyG index in ACS patients with DM \( (P = 0.001) \). Therefore, the regression equation was confirmed: TyG = 10.279 + 0.067 \times GLSendo.

**Logistic regression analysis of ACS combined with DM**

The TyG index and the above ultrasonic layer-specific strain parameters were incorporated into the single factor binary logistic regression model. The TyG index, GLSendo, GLSmid, and GLSepi were confirmed to be the predictors of ACS with DM \( (P < 0.05; \text{Table. 4}) \).

According to the results of the single-factor binary logistic regression analysis, the TyG index, GLSendo, GLSmid, GLSepi, and ΔLS were incorporated into the multi-factor binary logistic regression model. After correction of mixed factors, the TyG index and GLSendo were identified as the independent predictors of ACS combined with DM.

The joint predictive value of the TyG index and GLSendo for ACS with DM was reflected through the ROC curve analysis (Table. 5 and Fig. 2).

**Discussion**

As the prevalence of DM in China is increasing yearly, the proportion of DM in ACS patients is expected to further rise (13). A national study involving 63641 patients in 150 hospitals in China found that compared with ACS patients without DM, the risk of in-hospital outcomes in ACS patients with DM was significantly increased, the risk of all-cause death increased by twice, the risk of cardiovascular adverse events increased by 1.5 times (14). Moreover, it is more likely to occur contrast-induced acute kidney injury in ACS patients with DM (15, 16). Therefore, early identification of this high-risk group and assessment of their cardiac remodeling have an important effect on selecting intervention methods and improving long-term prognosis in such patients. The TyG index, as a simple indicator of insulin resistance, may reflect cardiac remodeling and dysfunction (17). Layer-specific speckle tracking technique can reveal some subtle changes in systolic function and ventricular remodeling in DM patients with preserved LVEF, which has an incremental value in predicting cardiovascular events (18). Therefore, this study attempted to analyze the correlation between the TyG index and layer-specific strain parameters and to explore the combination combined use of TyG index and layer-specific strain parameters in the diagnosis of ACS combined with DM.

In this study, there were more traditional cardiovascular risk factors in the ACS combined with DM group than the ACS alone group, such as drinking history (31.6% vs. 5.3%, \( P < 0.001 \)) and dyslipidemia (36.8% vs. 7.9%, \( P = 0.011 \)), and the level of triglyceride showed a significant difference between the two groups. Excessive alcohol intake may induce hypertriglyceridemia, thereby resulting in impaired fat decomposition and abnormal lipid metabolism (19). TyG index is a new biomarker for quantifying insulin resistance, which combines fasting triglyceride level with fasting blood glucose and has a good
correlation with the results of the high insulin-positive glucose clamp test and homeostasis model assessment-IR (5–7). When insulin sensitivity decreases in the body, there is an increased lipolysis in adipose tissue, leading to the increase of triglyceride level in blood and disturbing the normal metabolism of glucose in muscle, and thereby reflecting the insulin resistance of adipose tissue (20). The liver plays a central role in balancing the concentration of blood glucose. When the liver function is impaired, the activity of enzymes involved in liver glucose metabolism is reduced (21), glycogen synthesis is impaired, and hyperglycemia stimulates insulin secretion from islet β cells. Insulin feedback is inhibited by β cells, thereby driving insulin resistance. Therefore, fasting blood glucose mainly reflects insulin resistance in the liver (22). The TyG index can reflect insulin resistance from many aspects. This simple parameter avoids insulin measurement that is expensive and difficult and has a good application value. In this study, we found that the TyG index in ACS patients with DM was significantly higher than that in ACS patients without DM, indicating that the TyG index is a potential clinical indicator for early screening and diagnosing DM in ACS patients.

The left ventricular myocardium is divided into three layers: the longitudinal oblique endocardial layer, the annular arrangement of the middle myocardium, and the longitudinal oblique epicardial layer. When myocardial ischemia and hypoxia occur, morphological and functional changes first appear in the endocardial layer and gradually extend to the epicardial layer. Reimer (23) called it the “wave front” phenomenon. We found that the longitudinal strain from the endocardium to the epicardium decreased gradually. ACS patients in the two groups suffered from similar coronary artery damage and the LVEF and myocardial strain in the ACS combined with DM group were significantly reduced. Compared with the ACS group, the GLSendo was significantly reduced in the ACS combined with DM group, further reflecting the sensitivity of the endocardium to the perception of ischemic severity. This is consistent with Mandoli’s results(24). This may be because the presence of DM aggravates coronary atherosclerosis and leads to coronary microcirculation damage, causing left ventricular systolic dysfunction and further aggravating myocardial fibrosis. In addition, the abnormal activation of the renin-angiotensin-aldosterone system directly triggers oxidative stress (25). These all cause severe myocardial fibrosis and left ventricular systolic and diastolic dysfunctions.

The TyG index is correlated with hemodynamic parameters (26, 27). An elevated TyG index is associated with increased LVEDD and decreased LVEF ($P < 0.05$). Our present study shared the same conclusion, which filled a gap in China’s related fields. We also found that the TyG index is positively correlated with the left ventricular myocardial strain parameters, including GLSendo, GLSmid, GLSepi, and ΔLS ($P < 0.05$). Long-term progressive hyperglycemia can alter the body’s metabolism and thus induce myocardial injury. Long-chain fatty acids are the main substrate of energy supply in the normal myocardium (28). When the myocardium is damaged, the energy source of the myocardium turns to glucose. However, insulin resistance induces an increase in lipid uptake in the myocardium, leading to lipid deposition. Lipid deposition further triggers myocardial cell apoptosis, myocardial hypertrophy, and systolic dysfunction (29, 30). In addition, there is a direct relationship between insulin resistance and atherosclerosis. Nitric oxide (NO) generated from endothelial cells is a substance that inhibits vascular sclerosis by relaxing vascular smooth muscle and inhibiting inflammatory responses. Insulin resistance will reduce NO
production and weaken the effect of anti-vascular sclerosis. NO is also an anti-platelet aggregation inhibitor and insulin resistance increases the risk of platelet aggregation thrombosis (31). Vascular smooth muscle cells continue to grow and proliferate under the action of compensatory high insulin levels in the blood, promoting the transport of low-density lipoprotein-cholesterol to vascular smooth muscle cells and producing lipid deposition to accelerate the formation of atherosclerotic plaques (32). These factors can aggravate ACS lesions and lead to poor prognosis. Insulin resistance quantified by homeostasis model assessment is related to left ventricular systolic and diastolic functions. The significance of this study is to find that insulin resistance quantified by the TyG index, which is easy and convenient to measure, is correlated with left ventricular systolic function and deformation of myocardial layers and can predict the degree of endocardial ischemia, which is consistent with previous research results (33). Our findings provide great convenience for clinicians to quickly predict myocardial damage in ACS patients.

We also found that the cut-off value of TyG index was 9.03 indicating the area under the curve of ACS combined with DM was 0.808, with a good sensitivity (84.2%). It may be due to the advantages of the TyG index based on fasting blood glucose. Layer-specific speckle tracking technology provides more specific and detailed information on myocardial ischemia. In this study, the TyG index was combined with layer-specific strain parameters to identify the risk of DM in ACS patients, with good sensitivity (81.6%) and specificity (80.0%). Such an easy-to-obtain biomarker combined with non-invasive ultrasound imaging technology can extremely help clinicians to identify high-risk groups early, quickly assess a patient's conditions, and predict prognosis.

The limitations of this study are as follows: 1) As reported in other echocardiography-based studies (24), layer-specific strain parameters were acquired by software automatic analysis. Image quality and operator experience showed an impact on evaluating the severity of myocardial injuries; and 2) the sample size of this study was small and further prospective studies should be conducted.

Conclusions

The TyG index is a simple and easy marker for quantifying insulin resistance, which can well predict cardiac function and ventricular remodeling. The combined use of TyG index and layer-specific speckle tracking technology has a certain value in identifying the high-risk population of DM in ACS patients.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the First Hospital of Lanzhou University (LDYYLL2021-16). The patients had signed informed consent forms. All methods were carried out in accordance with relevant guidelines and regulations under the Declaration section.

Consent for publication
Not applicable.

**Availability of data and materials**

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

**Competing interests**

The authors declare that they have no competing interests.

**Funding**

The study was supported by the Natural Science Foundation of Gansu Province (20JR10RA679).

**Authors' contributions**

JL: Writing - Original Draft, Methodology, Formal analysis; LZ: Supervision, Data Curation; YZ: Visualization; AD: Project administration, Writing - Review & Editing. All authors read and approved the final manuscript.

**Acknowledgements**

Not applicable.

**References**


Tables

Table. 1 Clinical baseline data and echocardiographic parameters of three groups
<table>
<thead>
<tr>
<th>Variable</th>
<th>Control group (n=22)</th>
<th>ACS alone group (n=38)</th>
<th>ACS combined with DM</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographic</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, yrs</td>
<td>58.0±9.3</td>
<td>62.0±9.0</td>
<td>61.6±8.9</td>
<td>0.233</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>10(45.5)</td>
<td>28(73.7)</td>
<td>30(78.9)*</td>
<td>0.019</td>
</tr>
<tr>
<td><strong>Medical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>24.4±1.8</td>
<td>24.1±3</td>
<td>24.9±2.6</td>
<td>0.374</td>
</tr>
<tr>
<td>SBP, mmHg</td>
<td>136.4±15.9</td>
<td>139.7±17.8</td>
<td>148.2±28.9</td>
<td>0.102</td>
</tr>
<tr>
<td>DBP, mmHg</td>
<td>76.6±12.1</td>
<td>80.8±10.8</td>
<td>82.2±14.4</td>
<td>0.252</td>
</tr>
<tr>
<td><strong>Risk factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoking, n (%)</td>
<td>4(18.2)</td>
<td>7(18.4)</td>
<td>14(36.8)</td>
<td>0.179</td>
</tr>
<tr>
<td>Drinking, n (%)</td>
<td>0(0)</td>
<td>2(5.3)</td>
<td>12(31.6)* △</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Dyslipidemia, n (%)</td>
<td>6(27.3)</td>
<td>3(7.9)</td>
<td>14(36.8) △</td>
<td>0.011</td>
</tr>
<tr>
<td>Hypertension, n (%)</td>
<td>11(50.0)</td>
<td>25(65.8)</td>
<td>29(76.3)</td>
<td>0.115</td>
</tr>
<tr>
<td>Gensini score</td>
<td>0(0.0)</td>
<td>29(11.3, 59.5)*</td>
<td>35.5(14.8, 54.3)*</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Laboratory findings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDL-C, mmol/L</td>
<td>1.1(1.1, 1.2)</td>
<td>1.1(1.1, 1.2)</td>
<td>1.0(0.9, 1.1)</td>
<td>0.134</td>
</tr>
<tr>
<td>LDL-C, mmol/L</td>
<td>2.5±0.8</td>
<td>2.5±0.7</td>
<td>2.3±0.8</td>
<td>0.682</td>
</tr>
<tr>
<td>TC, mmol/L</td>
<td>3.8(3.1, 4.7)</td>
<td>3.5(3.0, 4.2)</td>
<td>3.5(2.9, 4.1)</td>
<td>0.457</td>
</tr>
<tr>
<td>TG, mmol/L</td>
<td>1.7(1.2, 2.5)</td>
<td>1.3(1.0, 1.8)</td>
<td>2.0(1.2, 2.7) △</td>
<td>0.004</td>
</tr>
<tr>
<td>FBG, mmol/L</td>
<td>5.1(4.7, 7.4)</td>
<td>5.1(4.6, 6.9)</td>
<td>8.5(7.0, 12.1)* △</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>TyG index</td>
<td>9.0±0.7</td>
<td>8.7±0.5</td>
<td>9.6±0.7* △</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Echocardiographic parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAD, mm</td>
<td>34.4±3.6</td>
<td>34.6±3.8</td>
<td>35.6±4.3</td>
<td>0.415</td>
</tr>
<tr>
<td>LVEDD, mm</td>
<td>43.3±4.2</td>
<td>43.6±3.7</td>
<td>46.4±5.7* △</td>
<td>0.012</td>
</tr>
<tr>
<td>LVEF, %</td>
<td>59.5±5.2</td>
<td>56.7±6.6</td>
<td>54.2±7.4*</td>
<td>0.013</td>
</tr>
<tr>
<td>E/A ratio</td>
<td>0.9(0.8, 1.3)</td>
<td>0.8(0.7, 0.9)</td>
<td>0.8(0.7, 1.1)</td>
<td>0.062</td>
</tr>
<tr>
<td>E/e' ratio</td>
<td>7.3(5.9, 9.4)</td>
<td>8.4(6.6, 9.6)</td>
<td>8.7(7.1, 11.2)</td>
<td>0.076</td>
</tr>
</tbody>
</table>
Data are expressed as mean±SD, n (%), or median (Q1,Q3). SBP=systolic blood pressure; DBP=diastolic blood pressure; HDL-C=high-density lipoprotein cholesterol; LDL-C=low-density lipoprotein cholesterol; TC=total cholesterol; TG=triglyceride; FBG=fasting blood-glucose; TyG index=triglyceride-glucose index; LAD=left atrial diameter; LVEDD=left ventricular end-diastolic diameter; LVEF=left ventricular ejection fraction; E wave=early diastolic inflow velocity; A wave=late diastolic inflow velocity; e’=average peak velocity of early diastolic at the ventricular septum and lateral wall; *P < 0.05, vs. control group; △P < 0.05, vs. ACS alone group.

Table. 2 Layer-specific strain parameters in each group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control group(n=22)</th>
<th>ACS alone group(n=38)</th>
<th>ACS combined with DM group(n=38)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLSendo</td>
<td>-20.2±1.9</td>
<td>-18.6±2.5*</td>
<td>-15.0±3.8△</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>GLSmid</td>
<td>-15.3±1.6</td>
<td>-14.5±2.0</td>
<td>-11.9±3.1△</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>GLSepi</td>
<td>-11.4±2.1</td>
<td>-11.0±1.9</td>
<td>-8.6±2.9△</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ΔGLS</td>
<td>-8.8±2.5</td>
<td>-7.6±2.2</td>
<td>-6.8±2.0*</td>
<td>0.010</td>
</tr>
</tbody>
</table>

GLSendo=endomyocardial global longitudinal strain; GLSmid=mid-myocardial global longitudinal strain; GLSepi=epimyocardial global longitudinal strain; ΔGLS=GLSendo-GLSepi; *P < 0.05, vs. control group; △P < 0.05, vs. ACS alone group.

Table. 3 Correlation analysis of the TyG index and layer-specific strain parameters

<table>
<thead>
<tr>
<th>Variable</th>
<th>r</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LVEF</td>
<td>-0.235</td>
<td>0.020</td>
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<tr>
<td>GLSendo</td>
<td>0.323</td>
<td>0.001</td>
</tr>
<tr>
<td>GLSmid</td>
<td>0.273</td>
<td>0.006</td>
</tr>
<tr>
<td>GLSepi</td>
<td>0.217</td>
<td>0.032</td>
</tr>
<tr>
<td>ΔGLS</td>
<td>0.240</td>
<td>0.017</td>
</tr>
</tbody>
</table>

GLSendo=endomyocardial global longitudinal strain; GLSmid=mid-myocardial global longitudinal strain; GLSepi=epimyocardial global longitudinal strain; ΔGLS=GLSendo-GLSepi; *P < 0.05, vs. control group; △P < 0.05, vs. ACS alone group.

Table. 4 Predictors of ACS combined with DM for one-way binary logistic regression analysis
<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>Wald</th>
<th>P</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>TyG index</td>
<td>1.977</td>
<td>19.261</td>
<td>&lt;0.001</td>
<td>7.219</td>
<td>2.986</td>
</tr>
<tr>
<td>GLSendo</td>
<td>0.409</td>
<td>19.596</td>
<td>&lt;0.001</td>
<td>1.506</td>
<td>1.256</td>
</tr>
<tr>
<td>GLSmid</td>
<td>0.475</td>
<td>18.664</td>
<td>&lt;0.001</td>
<td>1.608</td>
<td>1.296</td>
</tr>
<tr>
<td>GLSepi</td>
<td>0.437</td>
<td>16.224</td>
<td>&lt;0.001</td>
<td>1.549</td>
<td>1.252</td>
</tr>
<tr>
<td>ΔGLS</td>
<td>0.262</td>
<td>6.295</td>
<td>0.012</td>
<td>1.299</td>
<td>1.059</td>
</tr>
</tbody>
</table>

TyG index=Triglyceride-glucose index; GLSendo=endomyocardial global longitudinal strain; GLSmid=mid-myocardial global longitudinal strain; GLSepi=epimyocardial global longitudinal strain; ΔGLS=GLSendo-GLSepi; ACS=acute coronary syndrome; DM=diabetes mellitus

Table. 5 ROC curve analysis of the TyG index and GLSendo in ACS combined with DM patients

<table>
<thead>
<tr>
<th>Parameters</th>
<th>AUC</th>
<th>sensitivity/%</th>
<th>specificity/%</th>
<th>P value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>TyG index</td>
<td>0.808</td>
<td>0.842</td>
<td>0.700</td>
<td>&lt;0.001</td>
<td>0.718</td>
</tr>
<tr>
<td>GLSendo</td>
<td>0.816</td>
<td>0.553</td>
<td>0.095</td>
<td>&lt;0.001</td>
<td>0.727</td>
</tr>
<tr>
<td>Combined</td>
<td>0.896</td>
<td>0.868</td>
<td>0.783</td>
<td>&lt;0.001</td>
<td>0.828</td>
</tr>
</tbody>
</table>

AUC=area under the curve; 95% CI=95% confidence interval; TyG index=triglyceride-glucose index; GLSendo=endomyocardial global longitudinal strain; ROC curve= receiver operator characteristic curve.

Figures

(a) ![Image](image1.png)
(b) ![Image](image2.png)
(c) ![Image](image3.png)
(d) ![Image](image4.png)
(e) ![Image](image5.png)
(f) ![Image](image6.png)
Left ventricular endomyocardial global longitudinal strain curve in the control group (a, b, c) and the ACS combined with DM group (e, f, g). a, d: Apical two-chambers view of the heart; b, e: apical three-chambers view of the heart; c, f: apical four-chambers view of the heart. The endomyocardial global longitudinal strain in the ACS combined DM group was significantly reduced.

Figure 2

ROC plot for diagnosing DM in ACS patients.