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METABOLIC SYNDROME COMPONENTS AND ELECTROCARDIOGRAPHIC MARKERS OF MYOCARDIAL DYSFUNCTION IN MEN WITH CORONARY ATHEROSCLEROSIS

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Abstract: Metabolic syndrome may contribute to myocardial remodeling and electrical instability in patients with coronary atherosclerosis. This study assessed electrocardiographic biomarkers of metabolic cardiomyopathy and their associations with metabolic syndrome components in 77 men aged 42–77 years. Resting 12-lead ECG and measurements of waist circumference, body mass index, blood pressure, lipid profile, glucose, and C-peptide were performed. Metabolic syndrome was identified in 80.5% of participants, while left ventricular hypertrophy, T-wave abnormalities, ST elevation, arrhythmias, and ST depression were frequently detected. Increased LDL cholesterol was associated with a 3.8-fold higher risk of ECG signs of left ventricular hypertrophy, whereas elevated C-peptide increased the risk of ST depression 3.3-fold.

Keywords: metabolic syndrome; metabolic cardiomyopathy; electrocardiography; coronary atherosclerosis; ECG biomarkers.

КОМПОНЕНТЫ МЕТАБОЛИЧЕСКОГО СИНДРОМА И ЭЛЕКТРОКАРДИОГРАФИЧЕСКИЕ МАРКЕРЫ ДИСФУНКЦИИ МИОКАРДА У МУЖЧИН С КОРОНАРНЫМ АТЕРОСКЛЕРОЗОМ

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Аннотация: Метаболический синдром может способствовать ремоделированию миокарда и нарушениям его электрической активности у пациентов с коронарным атеросклерозом. В исследовании оценены

электрокардиографические биомаркеры метаболической кардиомиопатии и их связь с компонентами метаболического синдрома у 77 мужчин в возрасте 42–77 лет. Всем пациентам проведена регистрация ЭКГ в 12 стандартных отведениях и определены окружность талии, индекс массы тела, показатели артериального давления, липидного профиля, глюкозы и С-пептида. Метаболический синдром выявлен у 80,5% обследованных, при этом часто регистрировались гипертрофия левого желудочка, изменения зубца Т, повышение сегмента ST, аритмии и депрессия ST. Повышенный уровень ЛНП-холестерина был связан с 3,8-кратным увеличением риска ЭКГ-признаков гипертрофии левого желудочка, а повышение С-пептида — с 3,3-кратным увеличением риска депрессии ST.

Ключевые слова: метаболический синдром; метаболическая кардиомиопатия; электрокардиография; коронарный атеросклероз; ЭКГ-биомаркеры.

Introduction: Metabolic syndrome is a complex cluster of abdominal obesity, elevated blood pressure, dyslipidemia, impaired glucose regulation, and insulin resistance that increases cardiovascular risk. In patients with established coronary atherosclerosis, the coexistence of metabolic abnormalities may increase myocardial stress and contribute to structural and electrical changes. Metabolic cardiomyopathy develops through interacting mechanisms that include oxidative stress, insulin resistance, hyperglycemia, lipid toxicity, inflammation, and altered myocardial energy metabolism. These processes may precede clinically evident contractile dysfunction and can be reflected by electrocardiographic abnormalities. Resting electrocardiography provides a practical method for identifying changes in ventricular repolarization, myocardial hypertrophy, rhythm, and conduction. Parameters such as the QT interval, corrected QT interval, ST-segment displacement, T-wave morphology, the TV1>TV6 pattern, and left ventricular hypertrophy may therefore provide useful information about myocardial involvement. The relationship between these ECG findings and individual

metabolic syndrome components remains clinically relevant in coronary atherosclerosis. Assessment of waist circumference, body mass index, blood pressure, lipid concentrations, glucose, and C-peptide can help characterize the metabolic background associated with cardiac electrical abnormalities. Identifying these associations may improve cardiovascular risk stratification and support earlier recognition of metabolic myocardial injury. Therefore, an integrated evaluation of metabolic and electrocardiographic parameters is important for understanding the contribution of metabolic disturbances to myocardial dysfunction in patients with coronary atherosclerosis.

Aim of the study: To evaluate electrocardiographic biomarkers of metabolic cardiomyopathy and determine their associations with individual metabolic syndrome components in men with angiographically verified coronary atherosclerosis.

Materials and methods. The study included 77 men aged 42–77 years with coronary atherosclerosis verified by coronary angiography, stable angina of functional class II–IV, and no acute coronary syndrome. Participants were residents of Western Siberia and provided informed consent before enrollment. Patients with myocardial infarction within the previous 6 months, acute inflammatory disease, exacerbation of chronic inflammatory disease, active liver disease, renal insufficiency, or malignancy were excluded. Resting electrocardiography was recorded in 12 standard leads and subsequently coded according to the Minnesota system. The analyzed ECG markers included QT duration, corrected QT interval, ST-segment elevation above the isoelectric line, nonischemic ST depression, T-wave flattening or reduced amplitude, T-wave inversion, the TV1>TV6 pattern, left ventricular hypertrophy, and rhythm or conduction abnormalities. Metabolic syndrome and its components were assessed according to the Russian expert recommendations. Waist circumference, body mass index, systolic and diastolic blood pressure, total cholesterol, triglycerides, HDL cholesterol, LDL cholesterol, glucose, and C-peptide were evaluated. Venous

blood was collected in the morning after a 12-hour fast. Lipid and glucose concentrations were measured using enzymatic methods, while serum C-peptide was determined by enzyme-linked immunosorbent assay. Statistical analysis was performed with SPSS 11.5 using Student's t-tests, correlation, linear and logistic regression, and one-way ANOVA with Dunnett multiple comparisons between study variables. Results were interpreted using the threshold. Statistical significance was accepted at $p<0.05$.

Results. Among the 77 men with coronary atherosclerosis, metabolic syndrome was identified in 62 participants (80.5%). Abdominal obesity was present in 62 patients (80.5%), and body mass index ≥30.0 kg/m² was recorded in 48 (62.3%). Elevated systolic blood pressure ≥140 mmHg occurred in 39 men (50.6%), while elevated diastolic blood pressure was observed in 11 (14.3%). Total cholesterol exceeded the reference level in 58 participants (75.3%), reduced HDL cholesterol was found in 45 (58.4%), and elevated LDL cholesterol in 58 (75.3%). Fasting glucose exceeded 6.1 mmol/L in 21 men (27.3%), whereas C-peptide ≥0.5 ng/mL was detected in 22 (28.6%). ECG analysis identified arrhythmias in 38 patients (49.4%), left ventricular hypertrophy in 55 (71.4%), the TV1>TV6 pattern in 24 (31.2%), T-wave abnormalities in 58 (75.3%), ST-segment elevation in 44 (57.1%), ST depression in 23 (29.9%), and prolonged QT in 5 (6.5%). Correlation analysis demonstrated a positive association between QT duration and systolic blood pressure ($r=0.317$, $p<0.01$). ECG signs of left ventricular hypertrophy correlated positively with total cholesterol ($r=0.362$, $p<0.01$) and LDL cholesterol ($r=0.263$, $p<0.05$). ST depression was associated with C-peptide concentration ($r=0.262$, $p<0.01$). Patients with elevated LDL cholesterol had a 3.8-fold higher risk of ECG signs of left ventricular hypertrophy than those with normal LDL levels (OR=3.8, $p<0.05$; 95% CI 1.26–13.05). Elevated C-peptide was associated with a 3.3-fold higher risk of ST depression (OR=3.3, $p<0.01$; 95% CI 1.12–9.9). Overall, this considerable metabolic burden was accompanied by multiple electrical manifestations of myocardial involvement.

Conclusions: Metabolic syndrome and its individual components were associated with several ECG biomarkers of metabolic cardiomyopathy in men with coronary atherosclerosis. Abdominal obesity, dyslipidemia, and metabolic syndrome were accompanied by frequent ECG manifestations, particularly T-wave abnormalities, left ventricular hypertrophy, arrhythmias, and ST-segment changes. QT prolongation was positively related to systolic blood pressure, while left ventricular hypertrophy was associated with total and LDL cholesterol. Elevated C-peptide was linked to ST depression and increased its relative risk 3.3-fold. Elevated LDL cholesterol was associated with a 3.8-fold higher risk of ECG signs of left ventricular hypertrophy. These findings therefore support combined metabolic and ECG assessment for identifying myocardial involvement and overall cardiovascular risk evaluation.

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