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EVALUATION OF LEFT VENTRICULAR DEFORMATION IN PATIENTS WITH HEART FAILURE AND PRESERVED EJECTION FRACTION

**Khusainova Munira Alisherovna, Assistant
Department of Propaedeutics of Internal Diseases
Samarkand State Medical University**

Abstract: Heart failure with preserved ejection fraction represents a complex clinical syndrome in which patients develop symptoms of heart failure despite maintaining normal left ventricular ejection fraction. The present study explored myocardial mechanical performance using speckle-tracking echocardiography to identify subtle functional abnormalities that are not visible during routine cardiac examination. Quantitative strain analysis revealed impaired longitudinal myocardial function and evidence of left ventricular stiffness in patients with preserved systolic function. These findings suggest that advanced echocardiographic imaging can detect myocardial impairment at an earlier stage and may improve individualized management of patients with chronic heart failure.

Keywords: heart failure with preserved ejection fraction, myocardial mechanics, speckle-tracking imaging, ventricular stiffness, longitudinal strain, diastolic function, cardiac remodeling, left ventricle, echocardiography, cardiovascular imaging.

ОЦЕНКА ДЕФОРМАЦИИ ЛЕВОГО ЖЕЛУДОЧКА У ПАЦИЕНТОВ С СЕРДЕЧНОЙ НЕДОСТАТОЧНОСТЬЮ С СОХРАНЕННОЙ ФРАКЦИЕЙ ВЫБРОСА

**Хусаинова Мунира Алишеровна
ассистент кафедры пропедевтики внутренних болезней
Самаркандский государственный медицинский университет**

Аннотация: Сердечная недостаточность с сохраненной фракцией выброса представляет собой сложный клинический синдром, при котором симптомы сердечной недостаточности развиваются при сохраненной сократительной

способности левого желудочка. В настоящем исследовании оценивались механические свойства миокарда с помощью speckle-tracking эхокардиографии для выявления ранних функциональных нарушений, недоступных при стандартном обследовании сердца. Анализ показателей деформации выявил снижение продольной сократимости миокарда и признаки повышения жесткости левого желудочка при сохраненной систолической функции. Полученные результаты подтверждают, что современные методы эхокардиографической визуализации позволяют раньше диагностировать скрытые изменения миокарда и способствуют более эффективному ведению пациентов с хронической сердечной недостаточностью.

Ключевые слова: сердечная недостаточность с сохраненной фракцией выброса, механика миокарда, speckle-tracking эхокардиография, продольная деформация, диастолическая функция, ремоделирование сердца, левый желудочек, сердечно-сосудистая визуализация, хроническая сердечная недостаточность, миокард.

Introduction: Heart failure with preserved ejection fraction (HFpEF) accounts for nearly half of all cases of chronic heart failure and has become an important public health challenge because of its increasing prevalence and unfavorable prognosis. Unlike heart failure with reduced ejection fraction, patients with HFpEF often present with normal left ventricular systolic function despite experiencing significant symptoms, including exertional dyspnea, fatigue, and reduced exercise capacity. The development of HFpEF is associated with impaired myocardial relaxation, increased ventricular stiffness, chronic inflammation, endothelial dysfunction, and progressive myocardial fibrosis. These pathological changes gradually lead to elevated left ventricular filling pressure and left atrial remodeling before obvious structural abnormalities become detectable by conventional echocardiography. Standard echocardiographic measurements, particularly left ventricular ejection fraction, are frequently insufficient for identifying early myocardial dysfunction. Recent advances in cardiovascular imaging have

introduced 2D speckle-tracking echocardiography, which enables quantitative assessment of myocardial deformation and provides additional information regarding ventricular mechanics. Global longitudinal strain has emerged as one of the most sensitive markers of subclinical myocardial dysfunction and has shown promising diagnostic and prognostic value in patients with HFpEF. Comprehensive evaluation of myocardial deformation may facilitate earlier diagnosis, improve cardiovascular risk assessment, and support individualized treatment strategies aimed at preventing disease progression and improving long-term clinical outcomes.

Aim of the study: To evaluate myocardial deformation and left ventricular diastolic function using 2D speckle-tracking echocardiography in patients with chronic heart failure and preserved ejection fraction and to determine the diagnostic value of myocardial strain parameters for the early detection of cardiac dysfunction.

Materials and methods. A prospective observational study was conducted in a tertiary cardiology center and included 56 patients with chronic heart failure and preserved left ventricular ejection fraction diagnosed according to current clinical recommendations. A control group of 15 healthy individuals with no evidence of cardiovascular disease was also examined. All participants underwent a comprehensive clinical evaluation, laboratory testing, 12-lead electrocardiography, and standard transthoracic echocardiography. Functional status was assessed using the 6-minute walk test, and heart failure severity was classified according to the New York Heart Association (NYHA) functional classification. Conventional echocardiographic examination included measurements of left ventricular dimensions, end-diastolic volume, end-systolic volume, ejection fraction, left atrial size, transmitral Doppler flow, tissue Doppler velocities, and indices of diastolic function. Myocardial deformation was analyzed using 2D speckle-tracking echocardiography with dedicated software to determine global longitudinal strain, strain rate, and regional myocardial deformation. Images were acquired from apical 2-chamber, 4-chamber, and long-axis views following standard imaging

recommendations. Statistical analysis was performed using appropriate software. Continuous variables were expressed as mean $\pm$ standard deviation, while comparisons between groups were performed using suitable statistical tests. Statistical significance was defined as $p < 0.05$.

Results. The study demonstrated that conventional echocardiographic parameters remained within normal limits in most patients despite clinically significant symptoms of heart failure. The mean left ventricular ejection fraction was preserved at more than 60%, confirming the diagnosis of HFpEF. However, assessment of myocardial deformation revealed significant impairment of global longitudinal strain compared with healthy individuals. Patients also exhibited reduced strain rate, indicating early abnormalities of myocardial contractility that were not detected by conventional echocardiographic measurements. Diastolic dysfunction was identified in all examined patients, with impaired relaxation representing the most common filling pattern, whereas pseudonormal filling was observed in individuals with more advanced functional impairment. Segmental analysis demonstrated the greatest reduction of myocardial deformation in the basal anteroseptal and basal anterolateral regions of the left ventricle. Furthermore, worsening functional class was associated with progressive deterioration of strain parameters, suggesting a close relationship between myocardial mechanics and clinical severity of heart failure. These findings indicate that 2D speckle-tracking echocardiography provides valuable additional information beyond standard echocardiography by detecting subtle myocardial dysfunction before deterioration of left ventricular ejection fraction becomes apparent. Early identification of these abnormalities may contribute to improved diagnosis and more effective management of patients with HFpEF.

Conclusions: Patients with heart failure and preserved ejection fraction demonstrate impaired myocardial deformation despite maintaining normal left ventricular ejection fraction. 2D speckle-tracking echocardiography is a sensitive imaging technique capable of detecting early abnormalities of myocardial mechanics and diastolic function before structural cardiac changes become

clinically evident. Evaluation of global longitudinal strain and strain rate provides important diagnostic and prognostic information, improving cardiovascular risk assessment and supporting individualized treatment decisions. Routine incorporation of myocardial deformation analysis into echocardiographic evaluation may facilitate earlier diagnosis, optimize patient management, and improve long-term clinical outcomes in HFpEF.

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