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Research article

RELATIONSHIP BETWEEN COGNITIVE IMPAIRMENT AND LEFT VENTRICULAR DIASTOLIC DYSFUNCTION IN PATIENTS WITH HEART ARRHYTHMIAS

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SUMMARY

Background: *To estimate the relationship between cognitive function of patients with heart arrhythmias and left ventricle (LV) diastolic function.*

Materials and methods: *In a one-center cross-control study we recruited 28 patients with heart arrhythmias, of whom 14 had 1800 or more premature ventricular contractions (PVCs) per 24 hours and more (group 1), and 14 had paroxysmal AF (group 2). All patients were asymptomatic for heart arrhythmias. Laboratory and instrumental methods included standard investigations: lipidograms, 24 hours ECG monitoring, transthoracic echocardiography (TTE), and, if prescribed, coronary angiography. In the TTE protocol, we followed current clinical recommendations in assessing the LV diastolic function. For cognitive function evaluation, we used the standard Montreal Cognitive Assessment (MoCA) test, with the following scoring: maximum possible score – 30 points; mild cognitive impairment – 22-27 points; moderate cognitive impairment – 10-21 points; severe cognitive impairment – 0-9 points.*

Results: *The most common heart arrhythmias (frequent PVCs, paroxysmal AF) were associated with cognitive impairment in the preponderance of patients (mean score here).*

Conclusions: *LV diastolic dysfunction is a predictor for cognitive impairment in patients with frequent PVCs and paroxysmal AF. The MoCA test can be an additional tool for this category of patients to detect the early cognitive impairment.*

Key words: *atrial fibrillation - cognitive function – heart arrhythmia – MoCA - premature ventricular contractions*

Abbreviations: *ABI - ankle brachial index; AF – atrial fibrillation; CAVI - cardio-ankle vascular index; BMI – body mass index; ECG – electrocardiography; EchoCG – echocardiography; GLS - global longitudinal strain; HF - heart failure; HFpEF – heart failure with preserved left ventricular ejection fraction; LA – left atrium; LV – left ventricle; LVEF – left ventricle ejection fraction; MoCA - Montreal Cognitive Assessment test; PVCs - premature ventricular contractions; RV – right ventricle; TTE - transthoracic echocardiography; TR – tricuspid regurgitation*

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INTRODUCTION

Assessment of left ventricular (LV) diastolic function is an integral part of the routine evaluation of cardiac patients who undergo transthoracic echocardiography (TTE). Impairment of LV diastolic function is common amongst patients with left heart disease, and is associated with significant morbidity. Approximately one half of hospitalizations for heart failure (HF) are patients with preserved LV ejection fraction (HFpEF), but impaired LV filling accounts for the main symptoms of HF. Assessment of LV diastolic function is crucial for ascertaining global cardiac function and for identifying the pathology. Impaired diastolic function entails a sequence of abnormalities extending from normal to restrictive filling, where three important physiological aspects determine the LV filling capacity: myocardial relaxation, LV ejection fraction (LVEF) and chamber sizes. In current clinical recommendations, the algorithm recommending TTE includes the assessment of LV systolic function, evaluation of the presence of diastolic dysfunction with preserved LVEF, and assessment of the LV diastolic dysfunction grade (Nagueh et al. 2016).

For patients with cardiology comorbidities, effective treatment should aim to preserve quality of life and cognitive function, which is vulnerable to deterioration secondary to impaired cardiac function (Cezareti T et al. 2025). In previous studies, we have assessed quality of life in patients with cardiological comorbidities such as HF (Galati et al. 2022, 2023), arterial hypertension (Germanova et al. 2023), and arterial pathology (Siudak et al. 2022, Germanova et al. 2023).

The Montreal Cognitive Assessment Scale (MoCA) is a test designed for screening assessment of cognitive function, with implementation in approximately ten minutes. The scale assesses various cognitive areas: attention and concentration, executive functions, memory, language, visual-constructive skills, abstract thinking, counting and orientation. Various studies have attested to impairment of cognitive function in patients with HF (Lyu et al. 2020, Gerçek et al. 2022, Silva et al. 2024),

atrial fibrillation (Hämmerle et al. 2022), and acute coronary syndrome (Gallagher et al. 2023), and in patients undergoing cardiac surgery (Bhushan et al. 2021). However, there are no studies of the relationship between cognitive function and LV diastolic dysfunction in patients with heart arrhythmias. LV diastolic dysfunction, especially in patients with reduced EF, is associated with chronic hypoxia of the brain, and with higher risk of cardiovascular complications, including stroke or transient ischemic attacks. Disturbances in the cerebral microcirculation in patients with reduced EF, with diastolic dysfunction can lead to the neurological and mental symptoms (Qin et al. 2024, Holber et al. 2022).

In this investigation, we aimed to establish the relationship between cognitive function of patients with heart arrhythmias through joint assessment of the MoCA test, and LV diastolic function.

MATERIALS AND METHODS

We performed a one-center cross-control study with involvement of 28 patients with heart arrhythmias, 14 of whom having frequent premature ventricular contractions (PVCs) at a rate of at least 1800 events per 24 hours (group 1), and 14 having paroxysmal AF (group 2). All patients were asymptomatic for heart arrhythmias, with discovery of PVCs and AF paroxysms as incidental findings of the 24-hour ECG monitoring. Laboratory and instrumental methods included standard investigations: lipidograms, 24 hours ECG monitoring, TTE, and, if prescribed, coronary angiography.

In the TTE protocol, we assessed LV diastolic function following the current clinical recommendations. Thus, the main parameters indicating presence of diastolic dysfunction for the patients with preserved EF (≥50%) were: e` velocity: septal e`<7 cm/sec, lateral e '<10 cm/sec, E/e` ratio >14, left atrium (LA) volume index >34 ml/m2, and tricuspid regurgitation (TR) peak velocity >2.8 m/sec. We ascribed LV diastolic dysfunction if more than three of these six parameters were positive, indeterminant dysfunction if three were positive, and normal function if less than three were positive. In patients with reduced LVEF (<50%), we followed another algorithm due to the current ESC recommendations for the LV diastolic function evaluation, based on the transmitral blood flow parameters E/A and E velocity, and measured deceleration time (DT) value. We next performed LV diastolic dysfunction grade evaluation, irrespective of the LVEF. It was.

For cognitive function evaluation, we used the standard Russian language MoCA test, with scoring as follows: maximum possible score – 28-30 points; mild cognitive impairment (MCI) – 22-27 points; moderate cognitive impairment, and 10-21 points; severe cognitive impairment – 0-9 points.

We followed the principles of evidence-based medicine. Written informed consent was obtained from all participants prior to their enrollment in the study. The study was performed in accordance with the principles of the Declaration of Helsinki. The research protocol was approved by the Ethics Committee of Samara State medical university. Normality of data was tested with the Shapiro–Wilk test. Comparisons between groups for normal data were performed with an independent t-test, and for abnormal data with the Mann–Whitney U-test. The effect size for the t-test was calculated as Cohen's d, and for the U-test as rank r. We calcaulted the Spearming correlation coefficients between MoCA values and diastolic parameters. Categorical variables were compared using the χ^2-test and Cramer's V. $p<0.05$ was considered significant. Analyses were performed in the statistical programs R (version 4.1) and SPSS 27.

RESULTS

The main parameters of the patients within the groups see in Table 1.

Group 2 patients with paroxysmal AF had significantly lower GLS ($p = 0.005$) and higher E/e' ($p = 0.01$) and LA volume ($p = 0.002$) compared with the Group 1 patients with extrasystolic arrhythmia. The size effect was large in all of these cases ($d \geq 1.0$, $r \geq 0.5$), indicating clinical significance of the differences.

Both patient groups of patients showed MoCA tests scores (23.79±3.68) indicative of moderate/mild cognitive impairment, without any significant differenc between the PVC and paroxysmal AF groups ($p = 0.537$). Both groups showed impaired, LV diastolic dysfunction (LVEF 61.38±3.31%) in the patients with LV preserved EF.

Results so a strong association between heart arrhythmias (PVCs, paroxysmal AF) with cognitive function impairment, which was present in X/28 patients (%). Spearman correlation analysis revealed a significant negative association of the MoCA score with E/e' ($rs = –0.642$, $p = 0.001$) and a positive association with GLS ($rs = 0.579$, $p = 0.004$). The weaker association of MoCA score with LA volume was not statistically significant after adjustment ($rs = –0.315$, $p = 0.13$).

Clinical example

Patient H., 44 y.o., female. High education, office worker. MoCA Test: mild cognitive impairment – summary 22 points. Asymptomatic of heart arrhythmias. In 24-hours ECG monitoring, it was revealed 2 episodes of paroxysmal AF (38 and 33 seconds). LVEF is preserved (64%) (Figure 3).

After, we followed the recommendations in LV diastolic function evaluation for the patients with preserved EF (Figure 4).

Table 1. Characteristics of the groups

Parameter	Group 1 (n = 14)	Group 2 (n = 14)	Both groups (n=28)	Statistical test	Effect size
MoCA Mean ± SD	23.3±3.8	24.2±3.7	23.8±3.7	t (22.00) = -0.63, p = 0.537	Cohen's d = 0.257
Gender n (%)					
Female	9 (81.8%)	10 (76.9%)	19 (79.2%)	$\chi^2(1) = 0.09$*,	Cramer's
Male	2 (18.2%)	3 (23.1%)	5 (20.8%)	p = 0.769	V = 0.060
Age, y.o. Mean ± SD	55.4±14.8	65.7±9.7	61.0±13.1	t(22.00) = -2.06, p = 0.052	Cohen's d = 0.843
BMI Mean ± SD	28.6±5.7	31.1±5.2	29.9±5.5	t(22.00) = -1.10, p = 0.282	Cohen's d = 0.452
LVEF % Mean ± SD	62.4±3.3	60.5±3.2	61.4±3.3	t(22.00) = 1.37, p = 0.184	Cohen's d = 0.562
GLS% Mean ± SD	22.3±2.3	18.8±3.0	20.4±3.2	t(22.00) = 3.12, p = 0.005	Cohen's d = 1.278
LA strain% - reservoir Mean ± SD	36.7±9.9	27.3±8.6	31.6±10.2	t(22.00) = 2.51, p = 0.020	Cohen's d = 1.028
LA strain% - conduit Mean ± SD	22.8±10.8	16.7±6.4	19.5±9.1	t(22.00) = 1.72, p = 0.100	Cohen's d = 0.703
LA strain% - pump Mean ± SD	13.7±6.3	10.3±3.9	11.9±5.4	t(22.00) = 1.60, p = 0.125	Cohen's d = 0.654
RV strain % Mean ± SD	28.9±6.5	23.1±7.7	26.3±7.5	t(18.00) = 1.85, p = 0.080	Cohen's d = 0.833
LA volume, ml Mean ± SD	50.3±8.3	74.9±22.2	63.6±21.1	t(22.00) = -3.47, p = 0.002	Cohen's d = 1.421
LA volume index ml/m^2 Mean ± SD	27.2±5.0	37.5±9.8	32.8±9.4	t(22.00) = -3.18, p = 0.004	Cohen's d = 1.303
E\A Mean ± SD	1.1±0.4	0.9±0.3	1.0±0.4	t(21.00) = 0.93, p = 0.365	Cohen's d = 0.386
E\e' Mean ± SD	7.0±1.3	8.2±1.9	7.6±1.8	t(22.00) = -1.67, p = 0.109	Cohen's d = 0.685
TR, m/sec Mean ± SD	2.4±0.2	2.6±0.4	2.5±0.3	t(22.00) = -1.98, p = 0.060	Cohen's d = 0.813
Relative thickness of the LV wall Median [Q1; Q3]	0.33 [0.28; 0.34]	0.40 [0.35; 0.42]	0.35 [0.32; 0.42]	U = 32.50, Z = -2.26, p = 0.024	rank-biserial r = 0.545
Myocardial mass index g/m^2 Mean ± SD	58.18±13.28	80.31±15.58	70.17±18.17	t(22.00) = -3.70, p = 0.001	Cohen's d = 1.518

Notes: LV – left ventricle; RV – right ventricle; LA – left atrium; TR – tricuspid regurgitation; BMI – body mass index

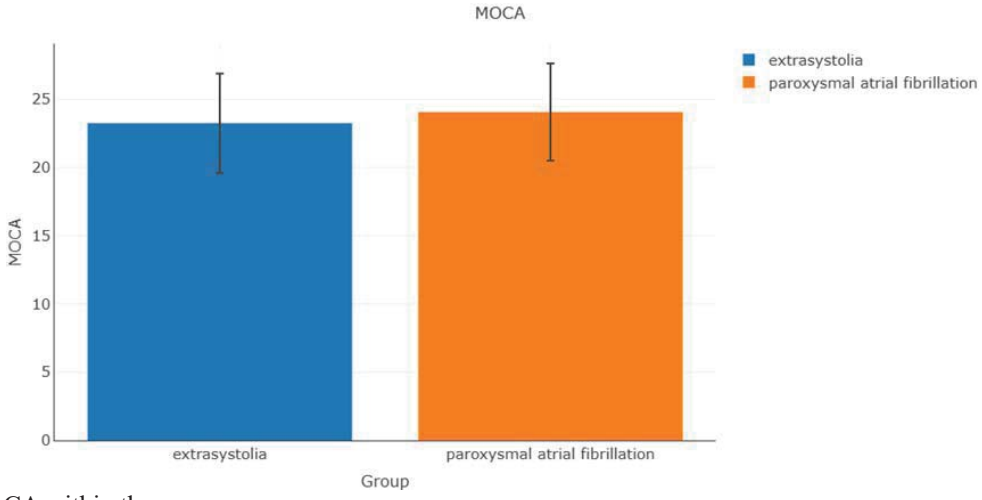

Figure 1. MoCA within the groups

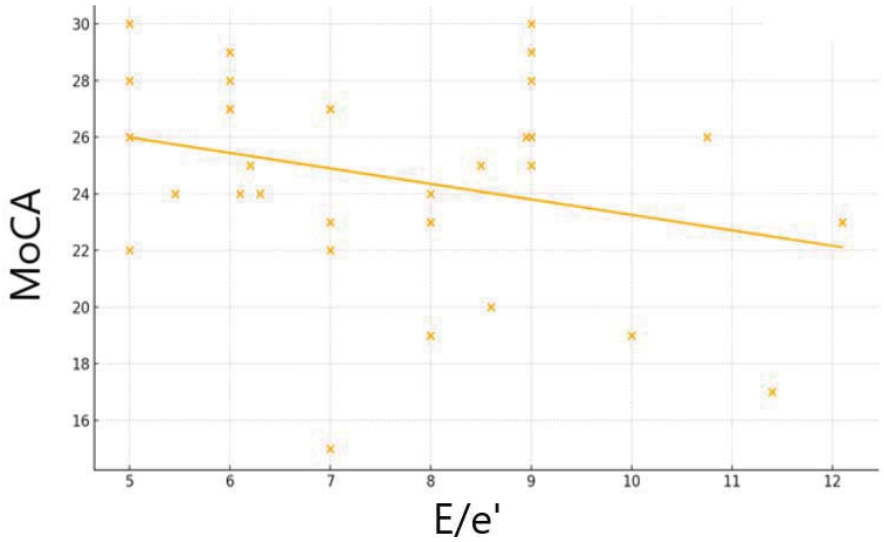

Figure 2. Correlation between MoCA total score and E/e' ratio. Regression line and 95% CI were constructed using bootstrapping

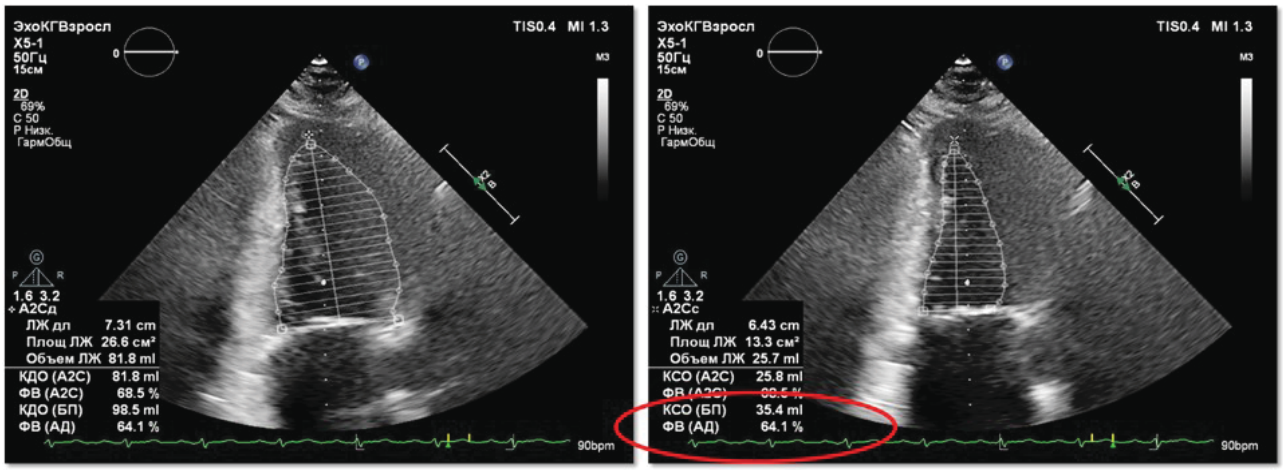

Figure 3. Patient H., 44 y.o. LV systolic function evaluation in TTE. LVEF 64% (measured by Simpson method)

Due to that more than 50% of parameters were positive, patient H. had diastolic dysfunction. The grade also was estimated – it was II (see Figure 5).

In this clinical example, we observed the early appearance mild cognitive impairment in young patient, who was asymptomatic in AF and had normal EF. However, it was diagnosed the diastolic dysfunction of the II grade as a marker of forming HF.

DISCUSSION

PVCs and AF are the most common heart arrhythmias all over the world. AF is associated with the higher risk of the vascular complications, especially the stroke (up to 7 times higher than in population), which is based on the different mechanisms, mostly cardioembolic. However, previous investigations also described the importance of increasing of hemodynamic parameters as additional mechanisms of the stroke appearance in this category of patients, in whom the first pulse wave spreading after a long pause between ventricular contractions in AF can bring an additional mechanical damage to the arterial vessels wall, especially in the area of atheromas (Germanova et al. 2023). Moreover, we demonstrated the higher risk of arterial thrombotic and thromboembolic complications in patients with frequent PVCs in the quantity 700 and more per day (Germanova et al. 2020, 2022). The complex of the hemodynamic changes in heart arrhythmias we described by the term “hydraulic shock”. It can become a key trigger of cardiovascular complications appearance in patients with multiple atherosclerosis. Due to all these facts, prevention and early diagnosis of heart arrhythmias plays a very important role, especially within asymptomatic individuals. In a prevalent number of the cases, the primary changes in TTE can be associated with the appearance of the diastolic dysfunction. Progressing of the HF is leading to the chronic insufficiency of microcirculation, including cerebral. In addition, if even the major complications do not happen, this chronic ischemia causes the structural and functional changes in the cerebral cells, which clinically appears as the cognitive impairment.

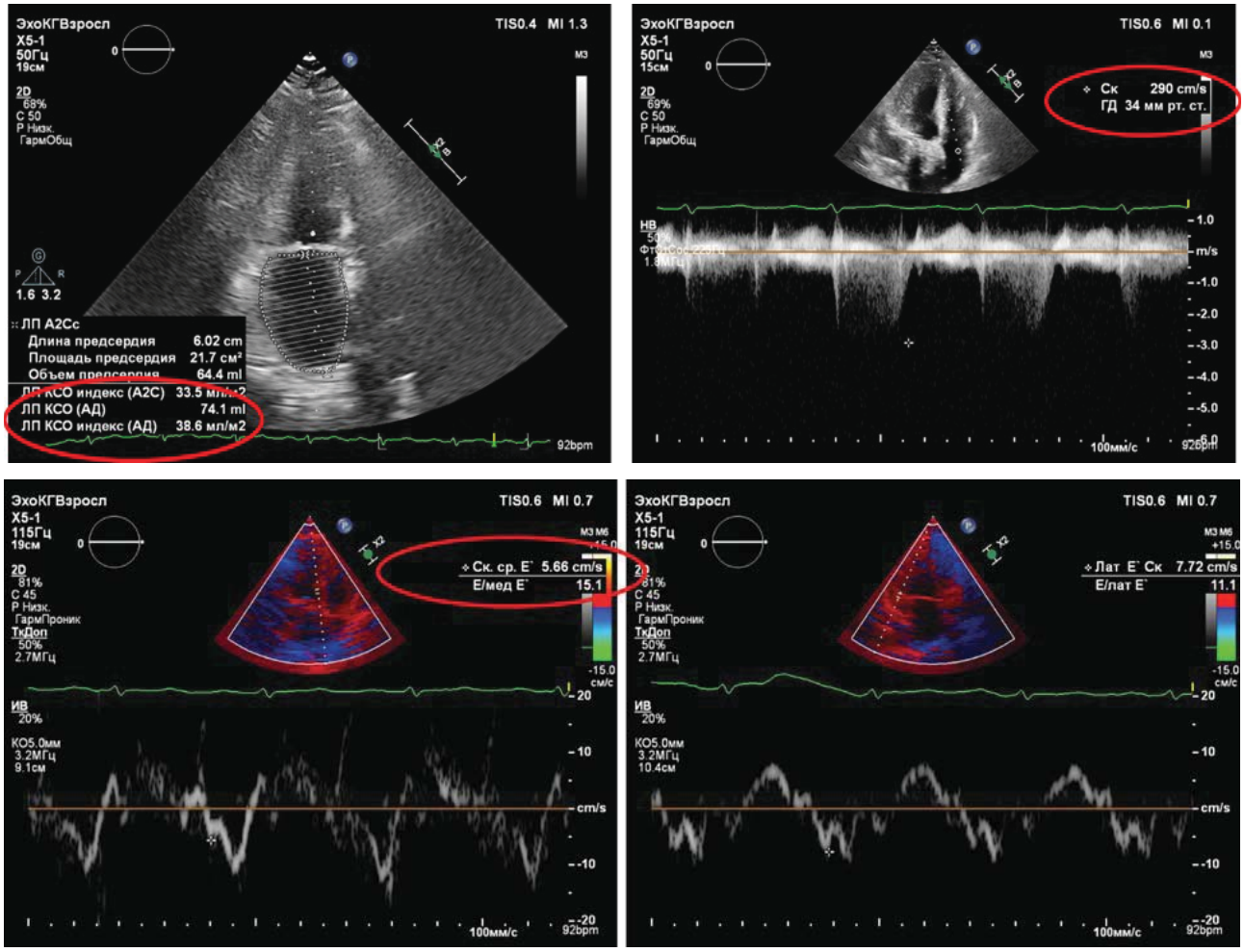

Figure 4. Patient H., 44 y.o. LV diastolic function evaluation in TTE. LA volume index > 34 ml/m2, TR peak velocity > 2.8 m/sec, e' velocity: septal e' <7 cm/sec, lateral e'<10 cm/sec, E/e' ratio >14

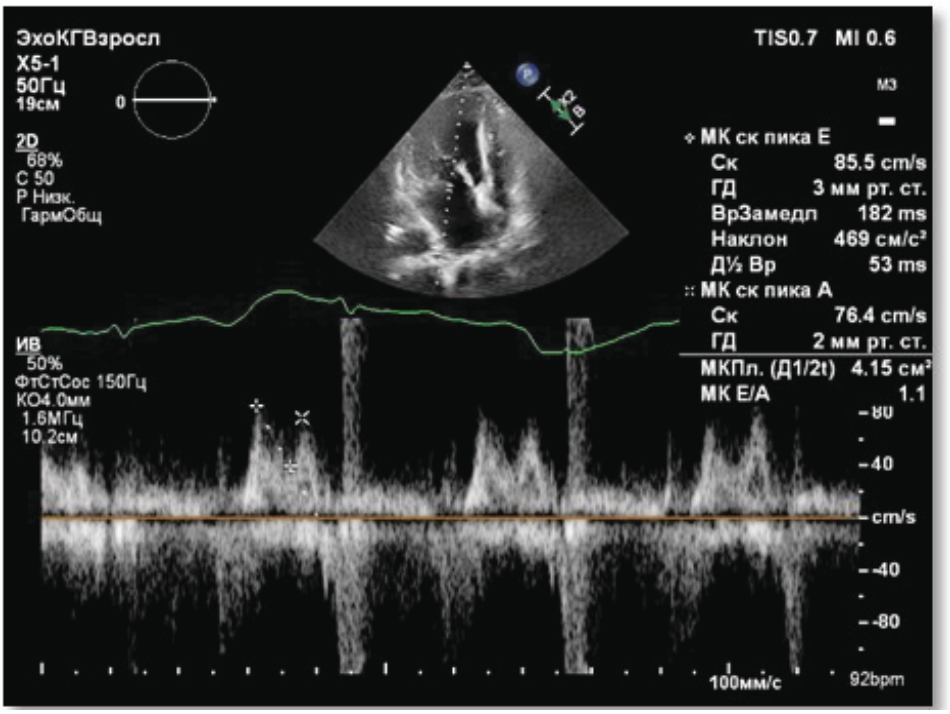

Figure 5. Patient H., 44 y.o. LV diastolic dysfunction grade evaluation in TTE. E/A 1,1. Diastolic dysfunction grade II

In our research, we studied the relationship between the diastolic dysfunction in patients with the most common heart arrhythmias – PVCs and paroxysmal AF, who were asymptomatic. In both groups, we observed the cognitive impairment. The obtained results indicate that LV diastolic dysfunction, reflected by E/e' and reduced GLS, is closely associated with the severity of cognitive impairment in patients with AF compared with extrasystoles. Early diagnosis of arrhythmia, adequate treatment of the other cardiovascular pathology, as well as prevention of complications, with timely performed coronary angiography and angioplasty, if indicated, contribute to maintaining a quality of life of this category of patients.

CONCLUSIONS

- LV diastolic dysfunction is the predictor for cognitive impairment of patients with frequent PVCs and paroxysmal AF.
- LV diastolic dysfunction, reflected by E/e' and reduced GLS, is closely associated with the severity of cognitive impairment in patients with AF compared with extrasystoles.
- International MoCA Test can be used to assess the cognitive functions in patients with heart arrhythmias. This test can be an additional tool in the list of investigations for this category of patients to estimate the early cognitive impairment for the further correction of the therapy, if it is necessary.

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Contribution of individual authors:

Olga Germanova: search and analysis of literature, collection of clinical data, data interpretation, writing the first draft.

Yulia Reshetnikova, *Ksenia Ermolayeva, Giuseppe Tavormina* & Giuseppe Galati: search and analysis of literature, data interpretation, and editing.

All authors approved the final manuscript.

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