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Prognostic Value of Right Ventricular Dysfunction in Patients With Decompensated Chronic Heart Failure

Aim	To determine the incidence rate and the practical significance of right ventricular dysfunction (RVD) in the development of cardiovascular complications in patients with decompensated chronic heart failure (DCHF).
Material and Methods	This prospective, single-site observational study included 171 patients older than 18 years with NYHA functional class (FC) II–IV chronic heart failure (CHF) who were hospitalized for DCHF. Standard and extended 2D and 3D echocardiography (EchoCG) was performed for all patients on admission. Additionally, functional characteristics of the right ventricle (RV) were evaluated in the 3D mode followed by autonomic 3D processing with a EchoPac station (USA). RVD was taken as a disorder of two or more RV functional parameters according to results of 2D EchoCG, or a reduced RV free wall strain according to results of 2D speckle-tracking EchoCG, or a reduced RV ejection fraction (EF) according to results of 3D EchoCG. Statistical analysis was performed with a SPSS Statistics v. 26.0 software.
Results	The incidence rate of RVD in general population of patients with DCHF was 75.4% (n=129). A higher prevalence of RVD was observed in patients with CHF with a low left ventricular (LV) EF (90.1%). Patients with RVD had a more severe clinical status (significantly higher FC and higher Clinical Condition Scale (CCS) scores), more frequent atrial fibrillation (AF), and higher concentrations of uric acid and total bilirubin. RVD significantly correlated with male sex (odds ratio (OR), 2.05; 95% confidence interval (CI), 1.01–4.19; p=0.046) and AF (OR, 3.52; 95% CI, 1.71–7.26; p<0.001). Patients with RVD had lower values of both LV and RV function. Lower LV EF and AF increased the probability of RVD by 1.06 times (95% CI, 0.90–0.98; p=0.001) and by 2.63 times (95% CI, 1.08–6.40; p=0.001), respectively. Evaluation of the predictive significance of RV parameters measured by 2D and 3D EchoCG showed only effects of RV EF (2D) and RV global longitudinal strain (GLS) (3D) on all-cause hospitalization. RVD as evaluated by accepted criteria did not influence adverse outcomes.
Conclusion	The determined incidence, correlations, and the predictive value of RVD in patients with DCHF indicated the appropriateness of assessing the RV function to optimize the management of patients regardless of the CHF phenotype.

Keywords	Right ventricle; decompensated chronic heart failure; right ventricular dysfunction
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Patients with chronic heart failure (CHF) with both reduced and preserved left ventricular ejection fraction (LVEF) develop right ventricular (RV) failure.

Among patients with CHF, the prevalence of RV failure is 21–75% [1–2]. The significance of right ventricular (RV) function evaluation in patients with CHF has been neglected for a long time due to the prevailing view that its contribution to cardiac output is insufficient, the anatomical structure is complex, and there are no available non-invasive examination techniques [3, 4]. In the Russian population, RV failure was studied in CHF and acute myocardial infarction [5] and in CHF patients with hypertrophic cardiomyopathy [6].

Studies of the RV function and its interaction with the pulmonary artery system found that RV failure was a predictor of adverse outcomes in patients with CHF with both reduced and preserved LVEF and an indicator of a more severe clinical status of patients [7, 8].

Magnetic resonance imaging (MRI) of the heart is the gold standard for evaluating RV function. However, its implementability is limited in patients with severe CHF. In this regard, three-dimensional (3D) echocardiography seems promising in this category of patients. RV volumes measured by 3D-echocardiography are closely correlated with MRI characteristics [9, 10]. 3D-echocardiography

Table 1. Demographic, clinical, and laboratory characteristics of patients with ADHF (n=171)

Parameter	Value
Sex, n (%)	
• Male	88 (51.5)
• Female	83 (48.5)
Age, years	70 [62; 80]
Body mass index, kg/m²	36.9 [32; 39.7]
Smoking, n (%)	35 (20.6)
CHF NYHA FC, n (%)	
• II	14 (8.2)
• III	88 (51.4)
• IV	69 (40.4)
HR, bpm	80 [70; 97]
SBP, mm Hg	133 ± 24
DBP, mm Hg	76 ± 13
SHOCS, score	7 [6; 9]
LVEF, %	44 [30; 55]
LVEF, n (%)	
• < 40 %	71 (41.5)
• 40–50 %	37 (21.6)
• >50 %	63 (36.8)
Comorbidities	
Arterial hypertension, n (%)	159 (93)
Coronary artery disease, n (%)	99 (58.2)
Myocardial infarction, n (%)	68 (39.8)
History of CVA, % (n)	20 (11.7)
Diabetes mellitus, n (%)	63 (36.8)
Atrial fibrillation, n (%)	108 (63.2)
Chronic kidney disease, n (%)	111 (65.7)
Dyslipidemia, n (%)	90 (52.6)
Laboratory findings	
Creatinine, μmol/L	105.0 [86.0; 126.4]
GFR, mL/min/1.73m²	54.2 [44.1; 67.8]
Uric acid, μmol/L	456 ± 164
Glucose, mmol/L	6.4 ± 2.2
ALT, U/L	21.0 [14.9; 34.4]
AST, U/L	25.5 [19.3; 36.0]
Total bilirubin, μmol/L	18.4 [11.7; 28.2]
NT-proBNP, pg/mL	1683 [830; 2944]
Total cholesterol, mmol/L	3.85 ± 1.12

The data are presented as the medians and interquartile intervals (Me [Q1; Q3]) or the arithmetic means and standard deviations (M ± SD). ADHF, decompensated chronic heart failure; SHOCS, Symptomatic Hospital and Outpatient Clinical Score; LVEF, left ventricular ejection fraction; CVA, cerebrovascular accident; GFR, glomerular filtration rate; ALT, alanine aminotransferase; AST, aspartate aminotransferase; NT-proBNP, N-terminal pro-brain natriuretic peptide.

Table 2. Echocardiographic characteristics of patients with DCFH

Parameter	Value
Two-dimensional echocardiography (LA, LV; n = 171)	
LVEDV, mL	129.6 ± 65.8
LVESV, mL	70 [46; 116]
LVEF, %	44 [30; 55]
LVMI, g/m²	128.3 [100.3; 151.5]
LAVI, mL/m²	44.9 [36.3; 57]
LVGLS, %	–7.6 [–13.0; –4.4]
E/e'	9.5 ± 4.9
Three-dimensional echocardiography (LV; n = 171)	
LVGLS, %	-8.8 ± 5.7
Two-dimensional echocardiography (RV, RA; n = 171)	
TAPSE, cm	1.54 ± 0.47
S', cm/s	10.4 ± 3.6
RVFAC	0.29 ± 0.11
Myocardial wall motion index (TD)	0.52 [0.38; 0.66]
RV free wall strain, %	-14.3 ± 6.8
RVGLS, %	-11.5 ± 5.7
RVEDV, mL	51 [35; 73]
RVEF, %	42.68 ± 14.36
RV basal dimension, cm	4.20 ± 0.81
RV parasternal dimension, cm	3.09 ± 0.78
RA transverse dimension, cm	4.67 ± 0.94
RA longitudinal dimension, cm	5.6 [5.2; 6.4]
RA volume, mL	83.8 ± 40.4
Right atrial pressure, mm Hg	20 [10; 20]
RV thickness, cm	0.6 [0.5; 0.6]
PASP, mm Hg	51.2 ± 17.3
E/e'	5.0 [3.3; 7.8]
Three-dimensional echocardiography (RV; n = 121)	
RVEDV, mL	87 [62; 114]
RVESV, mL	51 [33; 72]
RVEF, %	40.05 ± 12.72
RVGLS, %	-11.1 ± 6.3

ADHF, decompensated chronic heart failure; LAVI, left atrial volume index; GLS, global longitudinal strain; E/e', ratio of early diastolic transmitral velocity to early diastolic lateral mitral annular velocity; TAPSE, tricuspid annular plane systolic excursion; S', peak systolic tricuspid annular velocity; RVFAC, right ventricular fractional area change; TD, tissue Doppler; RA, right atrium; PASP, pulmonary artery systolic pressure; RVGLS, right ventricular global longitudinal strain.

was shown to be the most reliable method in a recent meta-analysis studying the accuracy of various imaging techniques (2D-echocardiography, 3D-echocardiography, radionuclide ventriculography, computed tomography, single photon emission computed tomography) to evaluate RVEF using MRI as a reference standard. RVEF was higher in 3D-echocardiography than in MRI by only 1.16% [11, 12]. There are two main guidelines for echocardiographic evaluation of RV function [13, 14].

The question of the factors leading to the development of RV failure in CHF patients remains open. It is assumed that there is a whole range of clinical phenotypes evolving from isolated LV dysfunction

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with normal pulmonary artery pressure to progressive conditions in which RV failure is a key prognostic factor [15, 16].

Associated factors and predictors of RV failure should be identified to better understand its pathophysiology, develop more effective prevention and treatment strategy in patients with CHF and RV failure, and improve the prognosis.

Objective

Determine the frequency and prognostic value of RV failure in the development of cardiovascular complications in patients with decompensated chronic heart failure (ADHF).

Material and Methods

The prospective single-center observational study included 171 patients above 18 years old with CHF II–IV functional class (FC) according to the NYHA classification and hospitalized for ADHF in the Heart Failure Center under City Clinical Hospital named after V. V. Vinogradov (Table 1).

Exclusion criteria: lung diseases, severe somatic diseases, acute coronary syndrome, severe valvular diseases, immobilization of patients.

The study was conducted in compliance with the Declaration of Helsinki. At admission, all patients signed the informed consent approved by the local ethics committee.

All patients underwent standard and advanced echocardiography (VIVID E90, GE Healthcare) in two- and three-dimensional modes. The functional characteristics of RV were additionally evaluated in three-dimensional mode and autonomously processed in EchoPac (USA) (Table 2). Automatic contouring of the endocardium at end systole and end diastole allowed constructing a three-dimensional RV model with the possibility of manual correction. The resulting model was used to automatically determine right ventricular end-diastolic (RVEDV) and end-systolic (RVESV) volumes and RVEV.

The RV failure criteria are shown in Figure 1. RV failure was defined as the presence of two and more abnormal indicators of the RV function (2D) or reduced right ventricular global longitudinal strain (RVGLS) (2D), or reduced RVEF (3D) [13, 14].

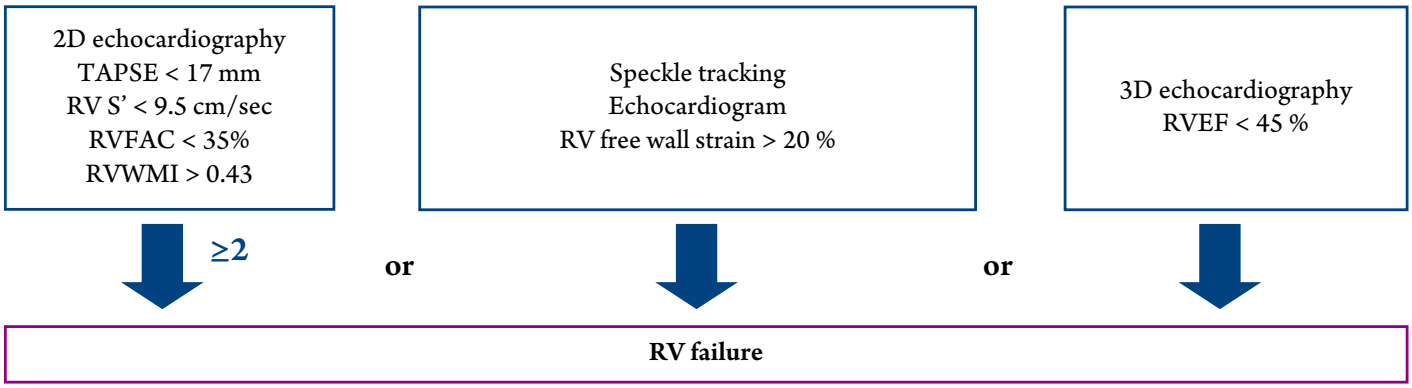
Patients were divided into two groups based on the presence of RV failure.

The statistical analysis was carried using SPSS Statistics v. 26.0 (IBM, USA). The Shapiro-Wilk W-test and excess and asymmetry analysis were used to verify the distribution normality. Normally distributed quantitative variables are presented as the arithmetic means (M) and standard deviations (SD). Ranked and non-normally distributed variables are presented as the medians (Me) and interquartile ranges [Q1; Q3]. The differences between quantitative indicators were estimated using the Student's t-test or Mann-Whitney U-test depending on the type of distribution. The nominal data are presented as the absolute values and percentages. Differences between the nominal variables in the contingency tables were evaluated using Pearson's chi-square test and Fisher's exact test. Prediction modeling was performed using binary logistic regression with a stepwise selection based on Wald statistics. Survival analysis was performed using Kaplan-Meier curves and the evaluation of differences using the log-rank test. The effects of independent predictors on the outcomes were assessed by Cox regression analysis. The critical level of statistical significance was $p<0.05$.

Results

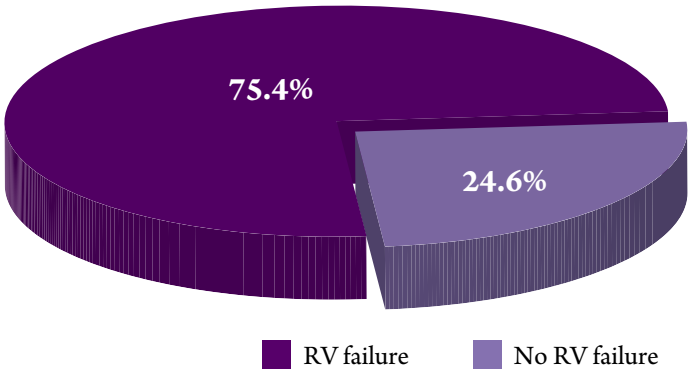
The incidence of RV failure was 75.4% in the general ADHF population (n = 129; Figure 2). The prevalence

Figure 1. RV failure criteria



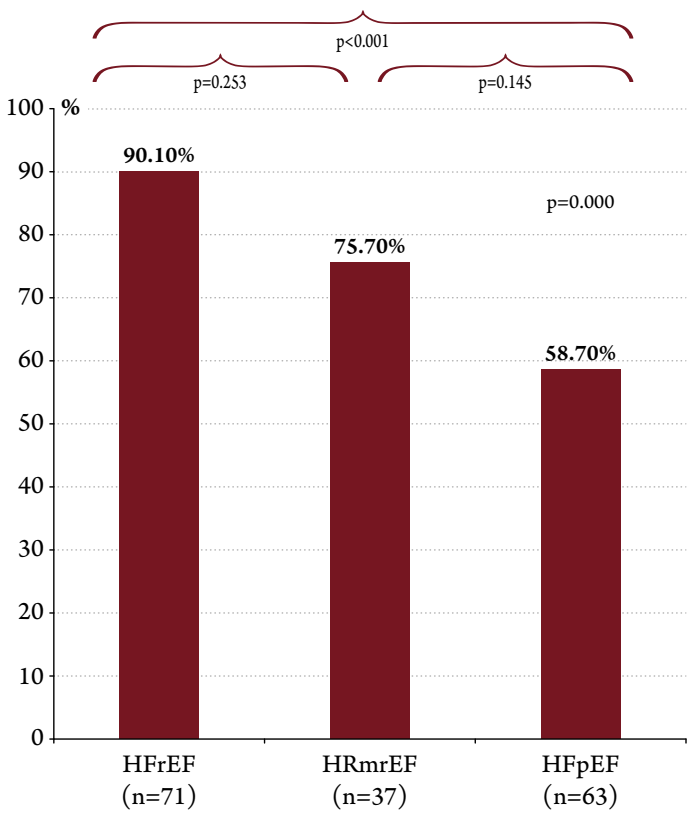
TAPSE, tricuspid annular plane systolic excursion; S', peak systolic tricuspid annular velocity; RVFAC, right ventricular fractional area change; RVWMI, right ventricular wall motion index.

Figure 2. Incidence of RV failure in thegeneral patient population (n=171)



RV, right ventricle.

Figure 3. Incidence of RV failure depending on LVEF



HFrEF, heart failure with reduced ejection fraction; HRmrEF, heart failure with a mid-range ejection fraction; HFpEF, heart failure with preserved ejection fraction.

Table 3. Demographic, clinical, and laboratory characteristics depending on the RV function

Parameter	RV failure (n = 129)	No RV failure (n = 42)	p
Sex, n (%)			
• Male	72 (55.8)	16 (38.1)	0.046
• Female	57 (44.2)	26 (61.9)	
Age, years	69 [62; 79]	76 [62; 82]	0.196
Smoking, n (%)	25 (19.5)	10 (23.8)	0.552
CHF duration, years	2 [0; 5]	1 [0; 3]	0.163
CHF FC (NYHA), n (%)			
• II	6 (4.7)	8 (19.0)	0.027
• III	63 (48.8)	25 (59.5)	0.229
• IV	60 (46.5)	9 (21.4)	0.005
HR, bpm	84 [72; 101]	75 [64; 81.5]	< 0.001
SBP, mm Hg	130 ± 24	142 ± 24	0.005
DBP, mm Hg	77 ± 13	76 ± 13	0.701
SHOCS, score	7 [6; 9]	6 [4; 8]	0.034
Comorbidities			
Arterial hypertension, n (%)	118 (91.5)	41 (97.6)	0.176
Coronary artery disease, n (%)	76 (59.4)	23 (54.8)	0.599
Myocardial infarction, n (%)	53 (41.1)	15 (35.7)	0.537
Diabetes mellitus, n (%)	45 (34.9)	18 (42.9)	0.352
Atrial fibrillation, n (%)	91 (70.5)	17 (40.5)	< 0.001
Chronic kidney disease, n (%)	84 (65.6)	27 (65.9)	0.979
Laboratory findings			
Creatinine, μmol/L	107 [87; 125]	100 [84; 137]	0.660
GFR, mL/min/1.73m^2	54.16 [45.58; 66.38]	55.02 [41.09; 69.00]	0.884
Uric acid, μmol/L	479 ± 163	326 ± 96	< 0.001
Glucose, mmol/L	6.2 ± 1.9	6.9 ± 3.1	0.183
ALT, U/L	22 [16; 36]	18 [13; 29]	0.032
AST, U/L	26 [21; 36]	22 [17; 39]	0.114
Total bilirubin, μmol/L	20.5 [12.9; 30.0]	11.2 [7.9; 18.2]	0.004
NT-proBNP, pg/mL	1,743 [993; 2,944]	1,397.5 [240.25; 2,917.5]	0.209
Total cholesterol, mmol/L	3.78 ± 1.11	4.08 ± 1.14	0.179

RV, right ventricle; FC, functional class; SHOCS, Symptomatic Hospital and Outpatient Clinical Score; GFR, glomerular filtration rate; ALT, alanine aminotransferase; AST, aspartate aminotransferase; NT-proBNP, N-terminal pro-brain natriuretic peptide.

of RV failure was higher in patients with HFrEF (90.1%; Figure 3).

Comparative characteristics of patients with ADHF depending on the presence of RV failure are presented in Table 3.

Patients with RV failure had more severe clinical status (statistically significantly higher CHF FC and SHOCS scores), higher incidence of atrial fibrillation (AF), and higher levels of uric acid and total bilirubin. RV failure was found to be significantly correlated with the male sex (odds ratio (OR) 2.05; 95% confidence interval (CI) 1.01–4.19; p=0.046) and AF (OR 3.52; 95% CI 1.71–7.26; p<0.001).

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The analysis of echocardiographic characteristics of patients with RV failure showed that the indicators of interest of the LV and RV function were lower (Table 4).

In order to estimate the joint influence of factors on the likelihood of RV failure, a multivariate logistic regression analysis was performed to include the following variables: age, sex, coronary artery disease (CAD), postinfarction cardiosclerosis, anemia, AF, diabetes mellitus, chronic kidney disease, dyslipidemia, body mass index, LV end-systolic dimension, LVEDV, LVESV, LVEF, interventricular septum thickness, left atrial (LA) volume, pulmonary artery systolic pressure. It was found that reduced LVEF and AF increase the chance of developing RV failure 1.06 (95% CI 0.90–0.98; p = 0.001) and 2.63 (95% CI 1.08–6.40; p=0.001) times, respectively (Table 5).

The assessment of the prognostic value of the RV function parameters of interest using 2D and 3D echocardiography showed only the effect of RVEF (2D) and RVGLS (3D) on all-cause hospitalization (Table 6). RV failure assessed

Table 4. Echocardiographic characteristics of patients with ADHF based on RV performance

Parameter	RV failure (n = 129)	No RV failure (n = 42)	p
Two-dimensional echocardiography (LA, LV; n = 171)			
LVEDV, mL	133.46 ± 66.52	117.49 ± 62.73	0.177
LVESV, mL	74.5 [48; 127]	50 [37; 89]	0.011
LVEF, %	40 [29; 52]	53 [44; 57]	< 0.001
LVMI, g/m²	132.1 [100.4; 155.4]	115.1 [88.0; 149.7]	0.173
LAVI, mL/m²	46.2 [38.0; 62.8]	38.5 [30.2; 48.3]	0.017
GLS, %	–6.6 [–10.9; –3.0]	–13.0 [–16.9; –10.0]	< 0.001
E/e'	9.54 ± 4.82	9.35 ± 5.10	0.874
Three-dimensional echocardiography (LV; n = 171)			
GLS, %	-7.66 ± 5.58	-12.50 ± 4.29	< 0.001
Two-dimensional echocardiography (RV, RA; n = 171)			
TAPSE, cm	1.38 ± 0.37	2.02 ± 0.42	< 0.001
S', cm/s	9.36 ± 2.84	14.77 ± 3.32	< 0.001
RVFAC	0.26 ± 0.10	0.42 ± 0.10	< 0.001
RV wall motion index (TD)	0.52 [0.39; 0.64]	0.52 [0.37; 0.73]	0.828
RV free wall strain, %	-12.57 ± 5.24	-21.03 ± 7.96	< 0.001
GLS, %	-9.87 ± 4.24	-18.28 ± 6.25	< 0.001
RVEDV, mL	56 [38; 77]	41 [27; 56]	0.001
RVESV, mL	17 [12.25; 23]	33 [21; 47]	0.000
LVEF, %	38.7 ± 12.9	54.8 ± 11.5	< 0.001
RV basal dimension, cm	4.34 ± 0.76	3.60 ± 0.73	< 0.001
RV parasternal dimension, cm	3.19 ± 0.78	2.67 ± 0.65	0.001
RA transverse dimension, cm	4.87 ± 0.93	4.05 ± 0.68	< 0.001
RA longitudinal dimension, cm	5.95 [5.4; 6.6]	5.1 [4.6; 5.4]	< 0.001
RA volume, mL	91.44 ± 39.07	48.13 ± 24.89	< 0.001
RV pressure, mm Hg	20 [20; 20]	10 [5; 20]	< 0.001
RV thickness, cm	0.55 [0.50; 0.60]	0.60 [0.50; 0.60]	0.735
PASP, mm Hg	53.46 ± 15.74	44.37 ± 20.24	0.011
E/e'	5.38 [3.80; 8.20]	4.65 [2.65; 6.40]	0.137
IVC diameter, cm	2.40 ± 0.47	1.98 ± 0.43	< 0.001
Three-dimensional echocardiography (RV; n=121)			
RVEDV, mL	94 [69; 122]	64 [58; 99]	0.007
RVESV, mL	59.5 [38; 80]	30 [27; 42]	< 0.001
RVEF, %	36.8 ± 11.9	52.4 ± 7.2	< 0.001
RVGLS, %	-9.32 ± 5.11	-17.92 ± 5.67	< 0.001

ADHF, decompensated chronic heart failure; RV, right ventricle; LVMI, left ventricular mass index; LAVI, left atrial volume index; GLS, global longitudinal strain; E/e', ratio of early diastolic transmitral velocity to early diastolic lateral mitral annular velocity; TAPSE, tricuspid annular plane systolic excursion; S', peak systolic tricuspid annular velocity; RVFAC, right ventricular fractional area change; TD, tissue Doppler; RA, right atrium; PASP, pulmonary artery systolic pressure; IVC, inferior vena cava; RVGLS, right ventricular global longitudinal strain.

Table 5. Results of the multivariate logistic regression analysis

Predictor	B	SE	p	OR	95% CI
Constant	3.674	1.072	0.033	–	–
AF	0.968	0.453	0.001	2.63	1.08–6.40
LVEF	–0.063	0.019	0.001	0.94	0.90–0.98

CI, confidence interval; OR, odds ratio; AF, atrial fibrillation; LVEF, left ventricular ejection fraction.

Table 6. Multivariate Cox regression analysis

Predictor	Regression coefficient	Standard error	p	Exp(B)	95% CI
RVEF, (2D echocardiography) %	0,046	0,019	0,018	1,047	1,008—1,087
RVGLS, (3D echocardiography) %	0,128	0,049	0,009	1,137	1,032—1,253

Included variables: left ventricular ejection fraction; left ventricular global longitudinal strain; left atrium volume index, all indicators of function and size of the right atrium and right ventricle according to echocardiography, systolic pressure in the pulmonary artery.

CI, confidence interval ; RVGLS, right ventricular global longitudinal strain; LVEF, right ventricular ejection fraction; 2D echocardiography, two-dimensional echocardiography; 3D echocardiography, three-dimensional echocardiography.

by the accepted criteria did not affect adverse outcomes (Figure 4).

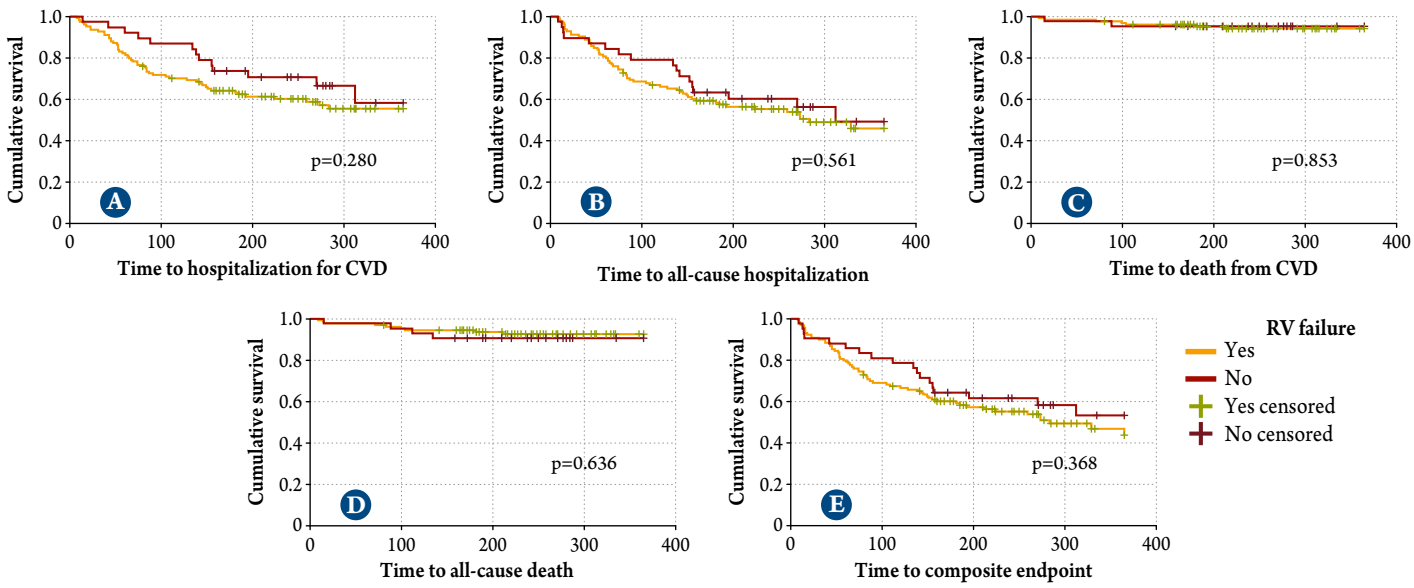
Discussion

In our study, a high incidence of RV failure (75.4%) was found in the general patient group irrespective of the CHF phenotype. The prevalence of RV failure in the study group was slightly higher than in the foreign studies, which was probably due to the examination of the RV at admission with ADHF and a different approach to the assessment of RV failure. Bosch et al. [17] used an abnormal value of one of the following indicators as the criterion of RV failure: RVGLS, TAPSE, RV S', or RV fractional area change (RVFAC). RV failure was identified according to the criteria in 30–40% of patients with chronic heart failure with preserved ejection fraction (HFpEF) and 60% of patients with chronic heart failure with reduced ejection fraction (HFrEF) [17].

In our study, RV failure was associated in patients with ADHF with male sex and AF. Patients were characterized by higher SHOCS scores and higher NYHA FCs.

The literature presents mainly data on RV failure in patients with HFpEF, mainly compensated form. In the study by Kanagala et al. [18], which included 183 patients with HFpEF, MRI scan showed RV failure in 19% of patients. Patients with RV failure were more likely to have reduced systolic blood pressure (BP), AF, X-ray signs of pulmonary congestion, and elevated

Figure 4. Adverse outcome analysis Kaplan-Meier curves



A – repeated hospitalization for CVD; **B** – repeated all-cause hospitalization; **C** – death from CVD; **D** – all-cause death; **E** – composite endpoint.

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cardiothoracic index. RV failure was associated with more dilated RV and LV and reduced EF (irrespective of heart rhythm). There were no statistically significant differences depending on the presence of RV failure shown by biochemical blood test results and CHF FC [18].

AF and reduced LVEF were predictors of RV failure in the study group, which was consistent with the findings by foreign authors. In the study by Melenovsky et al. [19], which included patients with compensated chronic HFpEF, male sex, high pulmonary artery pressure, AF, reduced LVEF, coronary artery disease, reduced systemic BP were the predictors of RV failure. RVFAC less than 35% was considered RV failure.

In our study, RV failure identified by the accepted criteria had no statistically significant effect on the achievement of endpoints, such as hospitalization and death due to cardiovascular diseases (CVD) and all causes within 1 year. However, the effect of abnormal RV function indicators, such as RVEF (2D) and RVGLS (3D), on the frequency of all-cause hospitalization was shown within 1 year of follow-up.

The study by Guendouz et al. [20], which included 118 patients with CHF, showed the prognostic value of RVGLS in the development of such adverse outcomes as death, emergency heart transplantation, emergency implantation of mechanical circulatory support devices, ADHF.

Cenkerova et al. [21] demonstrated in the pilot study that annual all-cause mortality (41.7% and 4.8%, respectively; p=0.004) and mortality from CVDs (33.3% and 0%, respectively; p=0.002) was significantly higher in patients with chronic HFpEF and systolic RV failure than in patients without RV failure. The same trend was observed in chronic HFrEF (33.3% and 5.9%, respectively; p=0.057; 20.8% and 0%, respectively; p=0.06). The authors defined RV failure as peak systolic tricuspid annular velocity (S') < 10.8 cm/s. Thus, RV failure was the only independent predictor of annual all-cause mortality in patients with chronic HFpEF (risk ratio 11.5; 95% CI 2.2–59.5; p=0.004).

Our findings established the potential prognostic effect of RVEF (2D) and RVGLS (3D) on repeated all-cause hospitalization within 1 year. However, given the small sample of patients and the duration of follow-up, a large prospective clinical trial is needed to study the effect of the RV failure parameters on long-term adverse outcomes.

Given the prognostic value of RV failure according to the world literature and our findings, its contribution to the clinical status of patients, assessing RV failure using 2D and 3D echocardiography in patients with ADHF seems promising in clinical practice.

Limitations

Limitations are associated with a relatively small sample of patients due to reduced rates of the heart imaging, especially the right heart, with echocardiography in patients with obesity, narrow intercostal spaces, and with the complexity of examinations in the supine position, with breath hold for 3D reconstruction of the heart in patients with ADHF. The follow-up was relatively short and lasted for 1 year.

Conclusion

The established prevalence, correlations, and prognostic value of right ventricular dysfunction in patients with decompensated chronic heart failure demonstrate the feasibility of assessing the right ventricular performance. This is necessary to improve the management of such patients irrespective of the chronic heart failure phenotype. Using the proposed criteria of right ventricular dysfunction as well as conventional echocardiography will extend the diagnostic algorithm and personify the management of such patients to prevent complications and improve their prognosis.

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