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Carbohydrate metabolism disorders in patients with heart failure: data from the local registry

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Aim. To study the prevalence of carbohydrate metabolism disorders in patients with heart failure (HF) hospitalized in the city HF center.

Material and methods. According to the local registry, the study sequentially included 183 patients (99 men and 84 women) hospitalized in the Nizhny Novgorod city HF center from September 1, 2019. The examination and treatment were carried out in accordance with the current clinical guidelines. In the first 48 hours after hospitalization, the concentration of the N-terminal pro-brain natriuretic peptide, soluble stimulating growth factor 2 (sST2), neutrophil gelatinase-associated lipocalin, cystatin C, blood creatinine was determined. The glomerular filtration rate was calculated using the CKD-EPI equation. To assess the carbohydrate metabolism disorders, all patients were studied for fasting plasma glucose, glycated hemoglobin (HbA_{1c}) and fructosamine.

Statistical data processing was carried out using the R statistics package (R Core Team (2019)).

Results. The incidence of carbohydrate metabolism disorders among patients with decompensated HF was 75,89%, including previously diagnosed type 2 diabetes in 31,25%, newly diagnosed dysglycemia in 44,64% of patients. Less than one fourth of patients had normal parameters of carbohydrate metabolism according to HbA_{1c}, fructosamine and fasting plasma glucose.

The severity of carbohydrate metabolism disorders was significantly correlated with the severity of HF according to the following criteria: 6-minute walk test, HF functional class, sST2 level, and some parameters of cardiac remodeling. Among the criteria used for carbohydrate metabolism disorders, the HbA_{1c} level was most closely associated with the criteria for HF severity.

Conclusion. Carbohydrate metabolism disorders in HF patients are widespread and underdiagnosed during routine examination. The interrelation of carbohydrate metabolism parameters and indicators of HF severity is rationale for active detection of dysglycemia in these patients in order to potentially influence the prognosis.

Keywords: heart failure, carbohydrate metabolism disorders, diabetes.

Relationships and Activities: none.

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The relevance of studying the problem of carbohydrate metabolism disorders in patients with chronic heart failure (CHF) derived from high prevalence of type 2 diabetes mellitus (T2DM) and prediabetes in patients with CHF, common pathogenesis mechanisms and mutual negative impact on the quality of life and prognosis of patients. The number of patients with T2DM and CHF increases annually both in the Russian Federation and worldwide [1].

Goal: to study the prevalence of carbohydrate metabolism disorders in patients with CHF hospitalized in the city HF center (the State Budgetary Institution of Healthcare of Nizhny Novgorod Region of the City Clinical Hospital No. 38 of the city of Nizhny Novgorod), as well as the relationship between indicators of glycemic status and CHF severity.

Material and methods

The study was carried out in accordance with the Good Clinical Practice standards and the principles of the Helsinki Declaration. The study protocol was approved by the Ethics Committee of FSBEI HE PRMU of the Ministry of Health of the Russian Federation. All participants received written informed consent before enrollment.

The local registry included 183 consecutive patients with CHF of any etiology aged 18 years and older (99 men and 84 women). All patients were treated for CHF decompensation in the Nizhny Novgorod city HF center. The patients were examined and treated in accordance with the existing clinical practice guidelines [2].

Patients underwent echocardiography (EchoCG) on the Vivid3 device (Austria, 2007) by transthoracic method according to the standard protocol with a single-crystal phased sensor SP3-8. In the first 48 hours after hospitalization, the concentration of the N-terminal fragment of the brain natriuretic peptide precursor (NT-proBNP), soluble stimulating growth factor expressed by gene 2 "soluble suppression of tumorigenicity-2" (sST2), neutrophil gelatinase-associated lipocalin (NGal), cystatin C, and blood creatinine was determined, and the glomerular filtration rate was calculated using the formula CKD-EPI. All patients were examined for fasting plasma glucose, glycated hemoglobin (HbA_{1c}), and fructosamine levels. Dysglycemia in this study was understood as T2DM and prediabetes [3]. Carbohydrate metabolism disorder (T2DM and prediabetes) was verified in accordance with the clinical recommendations "Algorithms of specialized medical care for patients with diabetes mellitus" [4]. The NT-proBNP concentration in blood serum was determined by an enzyme immunoassay using a Vector-Best reagent (Russia) on enzyme immunoassay Start Fax-2100. The carbohydrate metabolism disorder incidence was analyzed in patients who met the criteria for CHF at the NT-proBNP level (>125 pg/ml) and the 6-minute walk test (6MWT) (<551 m). The analyzed group included 58 (51,8%) men and 54 (48,2%) women aged 75,0 [65,0; 80,0] years.

Statistical data processing was carried out using the statistical package R [5]. To assess the normal distribution of a quantitative trait, the Shapiro-Wilk test was used, as well as visual assessment of the distribution shape. Descriptive statistics for quantitative features are presented as a median (1st quartile; 3rd quartile), and for nominative features — as a percentage. In assessing the statistical significance level of differences in subgroups, the Mann-Whitney U test was used, and the χ^2 test or the exact Fisher test for small subgroup sizes was used to analyze the frequency differences. In the case of multiple comparisons, the Beniamini-Hochberg multiple comparison correction was applied. Linear regression methods are used in the construction of regression models. The critical level of null hypotheses significance was assumed to be $p<0,05$.

Results

The prevalence of dysglycemia in the examined cohort using the criteria HbA_{1c}, fructosamine and fasting plasma glucose was 75,89%, including 31,25% of patients with previously diagnosed T2DM and 50 patients (44,64%) with first-time dysglycemia. Only 24,11% of patients had normal indicators of carbohydrate metabolism. Among patients with newly diagnosed dysglycemia, only one indicator was deviated from the norm in 26 of 112 patients (23,21%). In 24 (21,43%), 2 indicators were deviated from the norm.

For further analysis, the patients were divided into the following 2 groups: without carbohydrate metabolism disorders and with dysglycemia, including patients with a previously established diagnosis of T2DM. The patients were divided into groups with and without dysglycemia depending on the level of glycolized hemoglobin (Table 1), fructosamine (Table 2), fasting plasma glucose (Table 3).

When divided by HbA_{1c} (Table 1), the obtained data analysis revealed that patients with dysglycemia are younger than patients without carbohydrate metabolism disorders. Patients with carbohydrate metabolism disorders compared with patients with normoglycemia were statistically significantly more likely to belong to the III-IV functional class (FC) of CHF, less often had II FC of CHF, and had lower 6MWT distance indicators. The main

Table 1

Comparative characteristics of clinical, laboratory and instrumental parameters of patients with CHF depending on glycemic status by the level of HbA_{1c}

Indicator	Group 1, n=37	Group 2, n=39	p*
Age, years	77,0 [71,0; 82,0]	71,0 [64,0; 78,0]	0,012
Floor, m/w, abs./%	23/14 [62,2/37,8]	20/19 [51,3/48,7]	0,468
6MWT, m	265 [245; 350]	247 [90,0; 285]	0,016
NYHA I/II/III/IV FC, abs./%	1/11/23/2 [2,7/29,7/62,2/5,41]	0/3/25/11 [0/7,69/64,1/28,2]	0,004
NYHA I/II/III/IV FC, abs./%	12/25 [32,4/67,6]	3/36 [7,69/92,3]	0,016
EF, %	57,0 [46,0; 62,5]	53,5 [38,2; 57,0]	0,060
HFpEF/HFrEF/HFmrEF, abs./%	22/5/4 [71,0/16,1/12,9]	20/11/7 [52,6/28,9/18,4]	0,317
RSCS, points	2,00 [2,00; 3,00]	3,00 [2,00; 3,00]	0,258
LV DD, 0/1/2, abs./%	28/8/1 [75,5/21,6/2,7]	22/15/2 [56,4/38,5/5,13]	0,207
LVMMI, g/m^2	115 [102; 138]	131 [114; 152]	0,197
LALD, mm	45,0 [42,0; 48,0]	48,0 [44,0; 50,0]	0,175
RALD, mm	42,5 [37,5; 46,8]	42,0 [37,0; 44,8]	0,491
IVST, mm	13,0 [12,0; 14,0]	13,5 [11,0; 15,0]	0,804
LVPWT, mm	13,0 [12,0; 13,0]	12,0 [11,0; 14,0]	0,372
LV EDV, ml	96,0 [74,8; 127]	103 [68,5; 152]	0,569
LV ESV, ml	40,5 [27,2; 57,0]	47,5 [30,8; 81,8]	0,355
LV EDD, mm	50,0 [42,0; 53,0]	57,0 [48,0; 61,0]	0,034
LV ESD, mm	33,5 [29,2; 40,8]	44,5 [31,0; 51,0]	0,099
RV, mm	34,0 [31,0; 37,0]	34,0 [30,8; 36,2]	0,659
HbA_{1c}, %	5,30 [5,10; 5,60]	6,00 [5,82; 6,30]	<0,001
Glucose, mmol/l	5,60 [5,10; 6,00]	6,30 [5,20; 7,55]	0,031
Insulin, mME/l	1,96 [1,05; 3,53]	2,92 [1,02; 8,25]	0,143
HOMA index	0,42 [0,23; 0,92]	0,72 [0,25; 2,27]	0,409
Fructosamine, mmol/l	282 [237; 315]	305 [269; 362]	0,028
Cystatin C, mcg/ml	3,00 [2,60; 4,40]	2,80 [2,26; 3,70]	0,259
NGal, ng/ml	26,2 [21,3; 32,2]	25,9 [19,5; 34,9]	0,693
hsCRP, mg/l (lU/l in an.)	11,5 [11,5; 11,6]	11,5 [11,5; 12,4]	0,146
NT-proBNP, pg/ml	1225 [501; 2721]	1967 [959; 2809]	0,149
sST2, ng/ml	25,7 [18,4; 47,5]	41,0 [26,2; 60,9]	0,038

Note: * — significance of differences between groups 1 and 2.

Abbreviations: hsCRP — high-sensitivity C-reactive protein, DD — diastolic dysfunction, LVMMI — left ventricular myocardial mass index, EDV — end-diastolic volume, EDD — end-diastolic dimension, ESV — end-systolic volume, ESD — end-systolic dimension, LV — left ventricle, LALD — left atrium lateral dimension, RV — right ventricle, RALD — right atrium lateral dimension, HFrEF — heart failure with a low ejection fraction, SNpFV — heart failure with an intermediate ejection fraction, HFrEF — heart failure with reduced left ventricular ejection fraction, 6MWT — 6-minute walk test, LVPWT — left ventricular posterior wall thickness, IVST — interventricular septum thickness, FC — functional class, EF — ejection fraction, RSCS — rating scale of clinical state, HbA_{1c} — glycosylated hemoglobin, HOMA-IR — insulin resistance index (Homeostasis Model Assessment of Insulin Resistance; HOMA-IR), NGal — lipocalin associated with neutrophil gelatinase, NT-proBNP — N-terminal fragment of brain natriuretic peptide precursor, NYHA — New York Heart Association, sST2 — soluble circulating form Growth STimulation expressed gene 2.

body of patients in both groups were patients with preserved ejection fraction, but there was a tendency to higher values of ejection fraction in patients with normoglycemia. When analyzing the EchoCG parameters in patients with dysglycemia, there was a statistically significant increase in end-diastolic dimension of the left ventricle (EDDlv). Despite the absence of inter-group differences in NT-proBNP, patients with dysglycemia had a statistically significantly increased sST2.

When dividing patients by glycemic status based on the fructosamine level (Table 2), as in the division by HbA_{1c}, patients with dysglycemia had lower 6MWT values, more often referred to III-IV CHF

Table 2

Comparative characteristics of clinical, laboratory and instrumental parameters of patients with CHF depending on glycemic status when divided by fructosamine level (n=112)

Indicator	Group 3, n=34	Group 4, n=78	p*
Age, years	76,5 [67,2; 82,0]	73,5 [64,0; 79,8]	0,136
Floor, m/w, abs./%	15/19 [44,1/55,9]	43/35 [55,1/44,9]	0,386
6MWT, m	275 [250; 400]	250 [180; 299]	0,008
NYHA I/II/III/IV FC, abs./%	4/8/19/3 [11,8/23,5/55,9/8,82]	1/14/47/16 [1,28/17,9/60,3/20,5]	0,050
NYHA I/II/III/IV FC, abs./%	12/22 [35,3/64,7]	15/63 [19,2/80,8]	0,112
EF, %	54,0 [46,0; 61,0]	55,0 [40,0; 60,0]	0,779
HFpEF/HFrEF/HFmrEF, abs./%	19/5/7 [61,3/16,1/22,6]	43/16/14 [58,9/21,9/19,2]	0,776
RSCS, points	2,50 [2,00; 3,00]	2,50 [2,00; 3,00]	0,669
LV DD, 0/1/2, abs./%	25/8/1 [73,5/23,5/2,94]	52/23/3 [66,7/29,5/3,85]	0,852
LVMMI, g/m^2	121 [108; 142]	124 [105; 150]	0,754
LALD, mm	46,0 [42,8; 50,0]	47,0 [43,0; 50,0]	0,489
RALD, mm	41,0 [36,8; 44,2]	42,0 [38,0; 47,0]	0,428
Pulmonary hypertension 0/1, abs./%	18/16 [52,9/47,1]	24/54 [30,8/69,2]	0,044
IVST, mm	13,0 [12,0; 15,0]	13,0 [11,2; 15,0]	0,845
LVPWT, mm	13,0 [11,0; 14,0]	12,0 [11,0; 13,8]	0,543
LV EDV, ml	90,0 [78,0; 104]	104 [69,0; 151]	0,291
LV ESV, ml	39,0 [31,0; 51,0]	46,0 [28,0; 82,0]	0,273
LV EDD, mm	50,0 [44,0; 53,5]	54,0 [47,0; 61,0]	0,070
LV ESD, mm	35,5 [28,5; 40,8]	38,0 [30,8; 50,0]	0,229
RV, mm	33,0 [30,0; 37,8]	34,0 [31,2; 38,0]	0,464
HbA_{1c}, %	5,30 [5,05; 5,65]	5,70 [5,40; 6,00]	0,010
Glucose, mmol/l	5,55 [4,90; 5,97]	6,00 [5,10; 7,10]	0,033
Insulin, mME/l	1,47 [0,75; 2,66]	2,32 [1,00; 4,60]	0,060
HOMA index	0,34 [0,20; 0,63]	0,64 [0,24; 1,20]	0,126
Fructosamine, mmol/l	244 [230; 260]	309 [289; 344]	<0,001
Cystatin C, mcg/ml	3,00 [1,90; 4,40]	2,80 [2,23; 3,63]	0,595
NGal, ng/ml	22,5 [18,6; 28,2]	25,6 [17,8; 33,5]	0,317
hsCRP, mg/l	11,5 [10,2; 14,0]	11,5 [11,5; 13,4]	0,648
NT-proBNP, pg/ml	1426 [534; 2646]	1375 [621; 2922]	0,653
sST2, ng/ml	28,0 [21,2; 54,2]	38,8 [22,4; 58,1]	0,197

Note: * — significance of differences between groups 3 and 4.

Abbreviations: hsCRP — high-sensitivity C-reactive protein, DD — diastolic dysfunction, LVMMI — left ventricular myocardial mass index, EDV — end-diastolic volume, EDD — end-diastolic dimension, ESV — end-systolic volume, ESD — end-systolic dimension, LV — left ventricle, LALD — left atrium lateral dimension, RV — right ventricle, RALD — right atrium lateral dimension, HFrEF — heart failure with a low ejection fraction, SNpFV — heart failure with an intermediate ejection fraction, HFrEF — heart failure with reduced left ventricular ejection fraction, 6MWT — 6-minute walk test, LVPWT — left ventricular posterior wall thickness, IVST — interventricular septum thickness, FC — functional class, EF — ejection fraction, RSCS — rating scale of clinical state, HbA_{1c} — glycosylated hemoglobin, HOMA-IR — insulin resistance index (Homeostasis Model Assessment of Insulin Resistance; HOMA-IR), NGal — lipocalin associated with neutrophil gelatinase, NT-proBNP — N-terminal fragment of brain natriuretic peptide precursor, NYHA — New York Heart Association, sST2 — soluble circulating form Growth STimulation expressed gene 2.

FC, and the frequency of IV CHF FC was 2 times higher than in normoglycemia. Signs of pulmonary hypertension were found statistically significantly more often in the dysglycemia group and there was a tendency to increase in EDDlv.

The main clinical and laboratory-instrumental characteristics of patients with CHF, depending on glycemic status when divided by fasting plasma glucose level, are presented in Table 3. Patients with dysglycemia were statistically significantly younger, had a statistically significantly greater left ventricular dilatation according to the results of EDDlv and end-systolic dimension of the left ventricle. In the dysglycemia group, there was a tendency to increase

Table 3

Comparative characteristics of clinical, laboratory and instrumental parameters of patients with CHF depending on glycemic status when divided by fasting plasma glucose level (n=112)

Indicator	Group 5, n=52	Group 6, n=60	p*
Age, years	77,0 [67,8; 82,0]	71,0 [64,0; 78,2]	0,047
Floor, m/w, abs./%	27/25 [51,9/48,1]	31/29 [51,7/48,3]	1,000
6MWT, m	265 [238; 350]	260 [145; 300]	0,142
NYHA I/II/III/IV FC, abs./%	3/13/32/4 [5,77/25,0/61,5/7,69]	2/9/34/15 [3,33/15,0/56,7/25,0]	0,068
NYHA I/II/III/IV FC, abs./%	16/36 [30,8/69,2]	11/49 [18,3/81,7]	0,189
EF, %	54,5 [45,8; 60,0]	55,0 [39,8; 60,0]	0,615
HFpEF/HFrEF/HFmrEF, abs./%	31/7/10 [64,6/14,6/20,8]	31/14/11 [55,4/25,0/19,6]	0,411
RSCS, points	2,00 [2,00; 3,00]	3,00 [2,00; 3,00]	0,085
LV DD, 0/1/2, abs./%	41/10/1 [78,8/19,2/1,92]	36/21/3 [60,0/35,0/5,0]	0,099
LVMMI, g/m^2	120 [105; 139]	130 [106; 154]	0,272
LALD, mm	47,0 [42,5; 50,0]	47,0 [43,2; 50,0]	0,624
RALD, mm	42,0 [39,0; 48,5]	42,0 [37,0; 46,0]	0,521
IVST, mm	13,0 [11,5; 14,5]	14,0 [12,0; 15,0]	0,176
LVPWT, mm	12,0 [11,0; 13,0]	12,0 [11,0; 14,0]	0,428
LV EDV, ml	100 [71,0; 127]	89,0 [70,0; 152]	0,540
LV ESV, ml	42,0 [31,0; 57,0]	46,0 [26,0; 82,0]	0,498
LV EDD, mm	49,5 [44,0; 54,0]	56,0 [48,2; 61,0]	0,011
LV ESD, mm	35,0 [29,0; 40,0]	42,0 [31,0; 51,0]	0,048
RV, mm	33,0 [31,0; 38,0]	34,0 [31,0; 39,0]	0,687
HbA_{1c}, %	5,20 [5,00; 5,68]	5,90 [5,60; 6,20]	<0,001
Glucose, mmol/l	5,15 [4,88; 5,60]	6,60 [6,10; 7,43]	<0,001
Insulin, mME/l	1,50 [0,78; 2,83]	3,15 [1,00; 7,32]	0,009
HOMA index	0,35 [0,17; 0,63]	0,84 [0,28; 2,22]	0,006
Fructosamine, mmol/l	275 [244; 304]	305 [267; 348]	0,002
Cystatin C, mcg/ml	2,80 [2,05; 3,26]	2,80 [2,24; 3,71]	0,337
NGal, ng/ml	21,9 [17,6; 27,7]	28,3 [19,1; 34,5]	0,034
hsCRP, mg/l (lU/l in an.)	11,5 [9,65; 13,6]	11,5 [11,5; 14,0]	0,031
NT-proBNP, pg/ml	1024 [498; 2516]	1788 [798; 2962]	0,064
sST2, ng/ml	28,6 [21,2; 47,6]	41,0 [22,8; 80,5]	0,023

Note: * — significance of differences between groups 5 and 6.

Abbreviations: hsCRP — high-sensitivity C-reactive protein, DD — diastolic dysfunction, LVMMI — left ventricular myocardial mass index, EDV — end-diastolic volume, EDD — end-diastolic dimension, ESV — end-systolic volume, ESD — end-systolic dimension, LV — left ventricle, LALD — left atrium lateral dimension, RV — right ventricle, RALD — right atrium lateral dimension, HFrEF — heart failure with a low ejection fraction, SNpFV — heart failure with an intermediate ejection fraction, HFrEF — heart failure with reduced left ventricular ejection fraction, 6MWT — 6-minute walk test, LVPWT — left ventricular posterior wall thickness, IVST — interventricular septum thickness, FC — functional class, EF — ejection fraction, RSCS — rating scale of clinical state, HbA_{1c} — glycosylated hemoglobin, HOMA-IR — insulin resistance index (Homeostasis Model Assessment of Insulin Resistance; HOMA-IR), NGal — lipocalin associated with neutrophil gelatinase, NT-proBNP — N-terminal fragment of brain natriuretic peptide precursor, NYHA — New York Heart Association, sST2 — soluble circulating form Growth STimulation expressed gene 2.

the NT-proBNP level and a significant increase in the sST2 level, a highly sensitive C-reactive protein, and the NGal level.

The most significant differences in the criteria for the severity of CHF, such as 6MWT, prevalence of FC III-IV, EchoCG criteria for LV dilatation (EDDlv), sST2 level, occurred when patients were divided into groups with and without carbohydrate metabolism disorders according to the HbA_{1c} level. Therefore, when analyzing the CHF etiological factors and the therapy conducted before hospitalization, we also took as a basis the division by the HbA_{1c} level (Table 4). In patients with carbohydrate metabolism disorders, the ischemic etiology of CHF was statistically significantly more frequent, and there was a tendency to increase the

Table 4

Comparative characteristics of group 1 and 2 patients depending on carbohydrate metabolism disorders

Indicator	Group 1, n=37	Group 2, n=39	p*
Age, years	77,0 [71,0; 82,0]	71,0 [64,0; 78,0]	0,012
Floor, m/w, abs./%	23/14 [62,2/37,8]	20/19 [51,3/48,7]	0,468
Duration of hospitalization, bed days	9,00 [8,00; 14,0]	11,0 [8,00; 14,0]	0,345
HD, abs./%	35/94,6	39/100	0,234
CAD (angor pectoris), abs./%	17/47,2	24/61,5	0,311
Anamnesis of MI, abs./%	11/29,7	18/46,2	0,216
DCM, abs./%	2/5,41	3/7,69	1,000
DM, abs./%	0/0	35/89,7	<0,001
Paroxysmal/permanent AF, abs./%	8/14 [21,6/37,8]	12/14 [30,8/35,9]	0,641
Anamnesis of TIA/ACA, abs./%	5/13,5	6/15,4	1,000
Ischemic etiology of HF, abs./%	21 [56,8%]	32 [82,1%]	0,032
Anemia, abs./%	14 [37,8%]	10 [25,6%]	0,370
COPD, abs./%	8/21,6	10/25,6	0,887
Pneumonia, abs./%	3 [8,11%]	4 [10,3%]	1,000
Anamnesis of oncological diseases, abs./%	6/16,2	12/30,8	0,222
Obesity 0/I/II/III, abs./%	22/9/3/3 [59,5/24,3/8,11/8,11]	20/12/4/3 [51,3/30,8/10,3/7,69]	0,910
Anamnesis of TG, abs./%	4 [10,8%]	8 [20,6%]	0,166
Joint diseases, abs./%	13 [35,1%]	7 [17,9%]	0,150
CKD 0/1/2/3a/3b/4/5, abs./%	2/3/9/9/8/6/0 [5,41/8,11/24,3/24,3/ 21,6/16,2/0]	0/0/18/11/6/3/1 [0/0/46,2/28,2/15,4/7,69/2,56]	0,094
GFR, ml/min/1,73 $m^2_{(CKD-EPI)}$	55,5 [36,3; 65,3]	55,0 [46,1; 69,6]	0,296
GFR <60 ml/min/1,73 $m^2_{(CKD-EPI)}$, abs./%	22 [59,5%]	23 [59,0%]	1,000
Number of concurrent diseases	5,00 [3,00; 6,00]	5,00 [4,00; 7,00]	0,142
SBD, mmHg	140 [118; 150]	130 [120; 160]	0,742
DBP, mmHg	80,0 [70,0; 90,0]	80,0 [80,0; 90,0]	0,406
HR, bpm	80,0 [78,0; 94,0]	89,0 [76,0; 101]	0,754

Note: * — significance of differences between groups 1 and 2.

Abbreviations: HD — hypertensive disease, DBP — diastolic blood pressure, DCM — dilated cardiomyopathy, CAD — coronary artery disease, MI — myocardial infarction, ACA — acute cerebrovascular accident, SBD — systolic blood pressure, DM — diabetes mellitus, GFR — glomerular filtration rate, HF — heart failure, TIA — transient ischemic attack, AF — atrial fibrillation, CKD — chronic kidney disease, COPD — chronic obstructive pulmonary disease, HR — heart rate, TG — thyroid gland.

frequency of stage 2-3a chronic kidney disease in the dysglycemia group. The relationship between glycemic status and CHF therapy was not revealed.

Discussion

The high prevalence of dysglycemia (75,89% of patients) in the examined cohort of patients with CHF is comparable both with the results of registers in which the T2DM prevalence is on average 27% compared to 31,25% in our study [6], and with the results of clinical trials in which the prevalence of dysglycemia reached 80% [7-10].

In our study, patients with dysglycemia were statistically significantly younger than patients without carbohydrate metabolism disorders. This does not align with the data on number of clinical trials in which patients with dysglycemia were older [7-10]. Nevertheless, the average age of our patients corresponds to data of international and national epidemiological studies, including EPOCHA-CHF [1, 6].

In our study, patients with impaired carbohydrate metabolism were statistically significantly more likely to have an ischemic etiology of CHF. According to the literature, the ischemic etiology of CHF and the presence of dysglycemia are interrelated, although this may not represent a clear cause-effect mechanism, but rather reflect the general pathogenesis components. Thus, in the Swedish Heart Failure Registry, T2DM was more common in patients with CHD than in patients without it (30% vs 19%) [11].

The severity of carbohydrate metabolism disorders in our study was statistically significantly correlated with the severity of CHF, which does not contradict the data of both heart failure registers and clinical trials that demonstrated that dysglycemia compared to normoglycemia is associated with an increased risk of general and cardiovascular mortality, and in a number of studies, the highest risk of death was observed in patients with newly diagnosed T2DM [7, 8, 10].

When analyzing our data, attention was drawn to a statistically significantly higher level of sST2 in patients with dysglycemia compared to patients without lipid metabolism disorders when divided by the HbA_{1c} level. At the same time, patients with and without dysglycemia did not significantly differ in the NT-proBNP level.

ST2 and NT-proBNP reflect the course of two different but overlapping biological processes, so the markers provide independent and complementary information. As markers of hemodynamic instability or cardiomyocyte stretching, NT-proBNP/BNP are more suitable for the identification of CHF, but are less important for prognosis. ST2 is the most powerful and clinically significant prognostic marker of cumulative cardiovascular events and mortality rate, the degree of sST2 increase does not depend on CHF etiology, as well as on age, gender, heart rate, body mass index, hemoglobin level, and the presence of atrial fibrillation [12].

In our study, among the criteria used for carbohydrate metabolism disorders, the HbA_{1c} level was most closely associated with the criteria for CHF severity.

Some recommendations emphasize that the use of fasting plasma glucose determination, a 2-hour glucose tolerance test, or HbA_{1c} level is equally appropriate [13]. A number of studies substantiate the predominant value of HbA_{1c} as more associated with cardiovascular risk [14].

The stronger association found between HbA_{1c} and emerging cardiovascular diseases may be explained by the ability of HbA_{1c} to reflect average glycemia. Fructosamine values reflect shorter-term glycemic levels than HbA_{1c} — 2-3 weeks. Fructosamine may be a tool of choice when it is necessary to assess glycemic control in patients with severe chronic kidney disease (stages 4 and 5) [15], anemia or hemoglobinopathy [16].

Study limitations. The results of this study should be interpreted in the context of several constraints. This follow-up includes only hospitalized patients with CHF. The patients did not undergo a glucose tolerance test, which could be the reason for underestimating the true prevalence of carbohydrate metabolism disorders.

Conclusion

Thus, according to the local registry, dysglycemia was observed in almost 3/4 of patients with CHF. The severity of carbohydrate metabolism disorders was statistically significantly correlated with CHF severity according to such criteria as 6MWT, CHF FC, sST2 level, and some parameters of heart remodeling. Among the criteria used for carbohydrate metabolism disorders, the HbA_{1c} level was most closely associated with the criteria for CHF severity. Patients with any CHF etiology need to clarify the carbohydrate metabolism status.

Relationships and Activities: none.

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