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Insulin resistance contribution to pathogenesis of cardiac remodeling in patients with hypertension in combination with obesity and type 2 diabetes

Statsenko M. E., Derevyanchenko M. V.

Aim. To evaluate the insulin resistance contribution to pathogenesis of left ventricular (LV) remodeling in patients with hypertension (HTN) in combination with obesity and type 2 diabetes (T2D).

Material and methods. The study included 320 patients with stage II-III HTN and stages 1-3B chronic kidney disease (CKD) aged 45-70 years: group 1 (n=102) — HTN patients only, group 2 (n=90) — patients with HTN and obesity, group 3 (n=96) — patients with HTN, obesity and T2D, group 4 (n=32) — patients with HTN and T2D. The groups were comparable in main clinical and demographic parameters. We performed a clinical examination, assessed cardiac structure, insulin levels and insulin resistance indices. We used nonparametric statistics, multiple regression, stepwise linear discriminant and canonical analyzes. Data are presented as Me [Q25; Q75], where Me is the median, Q25 and Q75-25 and 75 percentiles, respectively.

Results. LV mass index was significantly higher in the group of HTN, obesity and T2D compared with HTN patients only (107,5 [9,5; 125,6] vs 96,0 [85,1; 106,1] g/m^2, respectively). The percentage of patients with LV hypertrophy was significantly higher in groups 2, 3 and 4 compared with group 1, and also in group 3 compared with groups 2 and 4. A stepwise discriminant analysis revealed that BMI increase in HTN±T2D patients was accompanied by an increase in values of metabolic index, triglyceride-to-high-density-lipoprotein-cholesterol ratio. Canonical analysis showed that an increase in the median values of Insulin Resistance function in all groups was associated with a deterioration in the median values of Cardio function.

Conclusion. The data obtained specifies the LV geometry characteristics, as well as the insulin resistance contribution to pathogenesis of LV remodeling in HTN patients with/without obesity and/or T2D.

Key words: hypertension, visceral obesity, diabetes, insulin resistance.

Relationships and Activities: not.

Volgograd State Medical University, Volgograd, Russia.

Statsenko M. E.* ORCID: 0000-0002-3306-0312, Derevyanchenko M. V. ORCID: 0000-0002-6232-4583.

*Corresponding author: mestatsenko@rambler.ru

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Epidemiological studies showed that the risk of left ventricular (LV) remodeling and dysfunction doubled in patients with obesity and insulin resistance compared to healthy people — this tendency continued with an increase in body mass index (BMI) [1]. It was reported that insulin resistance was induced even in patients with cardiovascular disease who did not have concomitant diabetes, and that it made patients prone to diabetes [2]. Therefore, there may be a close relationship between insulin resistance caused by obesity or type 2 diabetes (T2D) and impaired cardiac structure. The pathogenesis of LV remodeling is complex: in obese patients, the secretion of inflammatory cytokines and insulin resistance increases [3]. Then, insulin resistance further contributes to insulin secretion. Insulin overproduction, as well as increased fatty acid oxidation and decreased glucose absorption leads to disruption of the intracellular transduction of the insulin signal in various tissues, including myocardium. It should be noted that activation of the sympathetic nervous system, renin-angiotensin-aldosterone system and related sodium retention and increase in plasma volume occur after an insulin resistance increase. These changes cause LV hypertrophy (LVH) and interstitial fibrosis.

When hypertension (HTN) and obesity are combined by T2D, there is a further progression of structural and functional cardiac disorders. LVH is a characteristic morphological manifestation of diabetic cardiomyopathy, usually representing a later stage of the disease, and is a common disorder in T2D patients, even in those without coronary heart disease (CAD) or HTN. Although LVH is often associated with increased afterload in patients with T2D and HTN, it can also occur regardless of pressure overload.

To date, characteristics of LV geometry in HTN patients with obesity and/or T2D have not been fully determined. Contribution of insulin resistance to myocardial remodeling in patients only with HTN, with HTN and obesity, with HTN and T2D, as well as with HTN, obesity and T2D is also unclear.

Objective: to assess the pathogenetic contribution of insulin resistance to the development of LV myocardial remodeling in patients with hypertension in combination with obesity, type 2 diabetes.

The aim of the study was to evaluate the insulin resistance contribution to pathogenesis of LV remodeling in patients with HTN in combination with obesity and T2D.

Material and methods

The open-label comparative prospective study included 320 patients with stage II-III HTN (not reached target blood pressure (BP) levels) and stages 1-3B chronic kidney disease (CKD) aged 45-70 years: group 1 (n=102) — HTN patients only, group 2 (n=90) — patients with HTN and obesity, group 3 (n=96) — patients with HTN, obesity and T2D, group 4 (n=32) — patients with HTN and T2D (Table 1). The groups were comparable in age, sex, prevalence of smoking, duration of hypertension, level of office systolic BP (SBP) and heart rate (HR). Patients of groups 3 and 4 were also comparable in T2D duration and dosage of glucose-lowering drugs. Groups 1 and 4 were considered as control groups. The exclusion criteria were as follows: uncontrolled malignant HTN; acute coronary syndrome and acute cerebrovascular accidents in the last 6 months; hemodynamically significant heart defects and rhythm disturbances; type 1 diabetes; class III obesity; severe liver failure; CKD stage >3B; alcoholism; any other diseases that could affect the results of the study.

We identified and assessed complaints, medical history, risk factors for HTN, general condition, office BP, heart rate, and anthropometric parameters (height, weight, BMI, percent of subcutaneous and visceral fat by bioelectrical impedance analysis (BIA) using an Omron BF-508, waist (WC) and thigh circumference (TC)). Abdominal obesity was identified by waist-to-thigh ratio (WTR) (WTR >0,9 in men and WTR >0,85 in women), as well as by WC value (WC ⩾102 cm in men and WC ⩾88 cm in women). Visceral obesity was diagnosed with visceral fat ⩾9% according to BIA [4]. The structural cardiac parameters were analyzed by echocardiography followed by an assessment of LV geometry — the LV mass was calculated according to American Society of Echocardiography (ASE) guidelines [5].

To determine insulin resistance, basal insulin concentration was measured (by enzyme-linked immunosorbent assay using DRG kits (USA) and clinical chemistry analyzer Uniplan (Russia)), and special indices characterizing tissue sensitivity to insulin were used [6]. The HOMA-IR index, triglyceride-to-high-density-lipoprotein-cholesterol ratio (TG/HDL-C) and metabolic index (MI) were used using parameters of carbohydrate and lipid metabolism. Based on the results obtained, insulin resistance was determined with values of HOMA-IR >2, TG/HDL-C >1,37 and MI ⩾7 [6].

Statistical processing was carried out using the statistical software package Microsoft Excel 2010 and Statistica 10.0. The normality of distributions was evaluated using the Shapiro-Wilk test. Data are presented as Me [Q25; Q75], where Me is the median, Q25 and Q75 are 25th and 75th percentiles, respectively. For qualitative traits, the incidence (%) was identified. Multiple comparisons of the characteristics of independent samples were performed using the Kruskal-Wallis test. Differences were considered significant at $p<0,05$. If there were significant diffe-

Table 1

Clinical and demographic parameters of patients (Me [25%;75%])

Parameter	Group 1 HTN without obesity and T2D	Group 2 HTN+obesity	Group 3 HTN+obesity+T2D	Group 4 HTN+T2D
Number of patients, n	102	90	96	32
Men/women, (%)	34,4/65,6	37,8/62,2	32,3/67,7	34,4/65,6
Age, years	62,0 [55,0; 66,0]	62,0 [55,3; 65,8]	62,0 [58,0; 65,0]	63,0 [60,0; 66,0]
BMI, kg/m^2	26,7*,† [25,4; 28,7]	32,9†† [31,1; 36,0]	34,7§§ [32,5; 37,5]	27,2 [25,9; 28,5]
WC, cm	94,0*,† [83,0; 100,0]	105,0†† [99,3; 111,8]	107,0§§ [102,0; 116,0]	93,5 [88,3; 99,3]
TC, cm	102,0*,† [99,0; 105,0]	115,0†† [110,0; 125,0]	116,0§§ [108,0; 122,0]	103,5 [98,0; 105,3]
WTR	0,91 [0,82; 0,96]	0,91 [0,85; 0,99]	0,94 [0,88; 1,00]	0,91 [0,87; 0,96]
Proportion of patients with abdominal obesity estimated by WTR, %	51,2*,†,§	73,7**	86,3	71,9
Proportion of patients with abdominal obesity estimated by WC, %	61,0*,†,§	100,0††	100,0§§	90,6
Subcutaneous fat, %	30,7*,† [26,0; 39,2]	45,1†† [39,3; 49,4]	44,7§§ [38,1; 50,0]	35,2 [27,0; 40,1]
Visceral fat, %	10,5*,† [8,0; 13,0]	14,0†† [11,0; 16,0]	14,0§§ [13,0; 17,0]	9,5 [8,0; 11,0]
Proportion of patients with visceral obesity, %	57,5*,†	100,0††	100,0§§	50,0
Smokers, %	21,6	21,1	20,8	21,9
Proportion of patients with CKD, %	100,0	100,0	100,0	100,0
Duration of hypertension, years	12,0 [8,0; 19,0]	12,0 [7,0; 20,0]	15,0 [9,5; 20,0]	12,0 [7,0; 20,0]
Duration of diabetes, years	0†,§	0**,††	7,0 [3,0; 10,0]	7,0 [4,5; 10,0]
Office SBP, mm Hg	160 [150; 170]	160 [150; 170]	159 [150; 170]	160 [150; 164]
Office DBP, mm Hg	100†,§ [91; 103]	100**,†† [94; 108]	93 [90; 100]	90 [83; 100]
Office PP, mm Hg	60†,§ [50; 70]	60 [55; 70]	62 [60; 77]	70 [60; 75]
HR, bpm	70 [65; 75]	73 [64; 78]	70 [64; 76]	70 [65; 80]

Note: * — significance of differences between groups 1 and 2, † — significance of differences between groups 1 and e, § — significance of differences between groups 1 and 4, ** — significance of differences between groups 2 and 3, †† — significance of differences between groups 2 and 4, §§ — significance of differences between groups 3 and 4.

Abbreviations: DBP — diastolic blood pressure, BMI — body mass index, TC — thigh circumference, WC — waist circumference, WTR — waist-to-thigh ratio, PP — pulse pressure, SBP — systolic blood pressure, CKD — chronic kidney disease, HR — heart rate.

rences according to the Kruskal-Wallis test, Bonferroni-Dunn test was used. In the case of dichotomous traits, the statistical significance was estimated using the Fisher's exact test. Spearman's correlation analysis was performed to evaluate associations. To determine the dependence of one trait on several other independent traits, multiple regression analysis was used. Obtained regression model was analyzed using the coefficient of multiple determination (R^2) and the level of statistical significance. When studying the pathogenesis of HTN in patients with obesity and T2D, linear discriminant analysis and canonical analysis were used.

This study was performed in accordance with the Helsinki declaration, Good Clinical Practice standards and legislation of the Russian Federation. The regional medical ethics committee approved this study. All patients signed informed consent.

Results

Significant BMI differences between groups 1 and 2, 1 and 3, 2 and 4, 3 and 4 were revealed: BMI was higher in groups 2 and 3 ($p<0,0001$).

WC and TC were also significantly higher in groups of patients with HTN+obesity and HTN+obesity+T2D than in patients with HTN and HTN+T2D ($p<0,0001$). Higher values of WTR were noted among patients with HTN+obesity+T2D, but the differences were not significant.

Noteworthy is the high incidence of abdominal obesity in all studied groups estimated by WTR, WC, and also by visceral fat. Moreover, the percentage of patients with abdominal obesity estimated by WTR was significantly lower in group 1 compared with groups 2, 3, and 4. Using the WC values for assessing the abdominal obesity, significant differences were noted between groups 1 and 2, 1 and 3 (Table 1).

Table 2

Structural cardiac parameters of patients (Me [25%;75%])

Parameter	Group 1 HTN without obesity and T2D	Group 2 HTN+obesity	Group 3 HTN+obesity+T2D	Group 4 HTN+T2D
LVPWd, cm	1,00 [1,00; 1,05]	1,10†† [1,00; 1,20]	1,10§§ [1,00; 1,15]	1,00 [1,00; 1,10]
IVST, cm	1,0† [1,0; 1,05]	1,05 [1,00; 1,20]	1,10 [1,00; 1,20]	1,0 [1,0; 1,20]
ESD, cm	3,3 [3,0; 3,6]	3,3 [3,0; 3,6]	3,4 [3,0; 3,7]	3,3 [3,0; 3,7]
EDD, cm	4,9† [4,6; 5,1]	5,0 [4,8; 5,3]	5,1 [4,8; 5,3]	4,9 [4,6; 5,4]
LVMI, g/m^2	96,0† [85,1; 106,1]	98,6 [82,5; 118,5]	107,5 [92,5; 125,6]	101,4 [80,8; 122,5]
RWT, %	0,42 [0,39; 0,45]	0,44 [0,40; 0,46]	0,43 [0,41; 0,46]	0,40 [0,38; 0,46]
LVH, %	21,5*,†,§	53,3**	86,5§§	52,0

Note: * — significance of differences between groups 1 and 2, † — significance of differences between groups 1 and e, § — significance of differences between groups 1 and 4, ** — significance of differences between groups 2 and 3, †† — significance of differences between groups 2 and 4, §§ — significance of differences between groups 3 and 4.

Abbreviations: LVH — left ventricular hypertrophy, LVMI — left ventricular mass index, EDD — end diastolic dimension, ESD — end systolic dimension, IVST — interventricular septal thickness, RWT — relative wall thickness, LVPWd — LV posterior wall dimension.

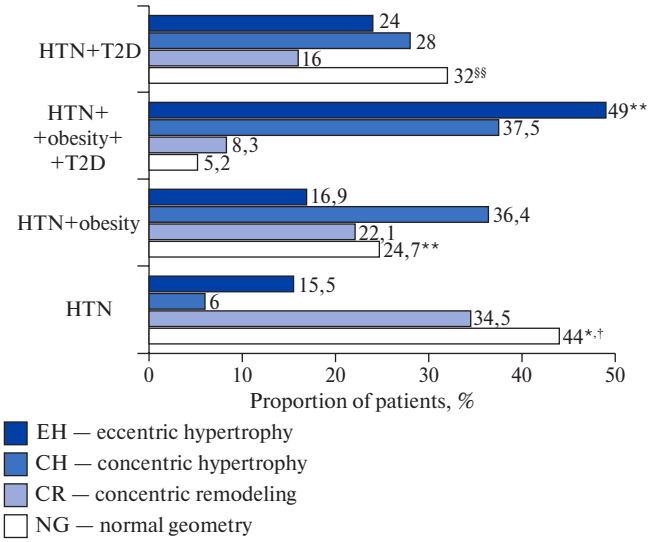

Figure 1. Types of LV remodeling in the studied groups.
Notes: * — significance of differences between groups 1 and 2, † — significance of differences between groups 1 and 3, ** — significance of differences between groups 2 and 3, §§ — significance of differences between groups 3 and 4.
Abbreviations: CH — concentric hypertrophy, CR — concentric remodeling, HTN — hypertension, NG — normal geometry, EH — eccentric hypertrophy, T2D — type 2 diabetes.

Subcutaneous and visceral fat values were significantly lower in groups 1 and 4 compared with groups 2 and 3 (p<0,0001 for both parameters). At the same time, at least half of the patients in all groups had visceral obesity, although there was no BMI obesity in groups 1 and 4: 57,5 vs 100,0 vs 100,0 vs 50,0% in groups 1, 2, 3, and 4, respectively (p<0,0001).

There were significant differences between groups 1 and 2 in comparison with groups 3 and 4 in terms of office diastolic BP (DBP) (p<0,0001). Lower DBP values are typical for patients with T2D. In this regard, higher office pulse pressure (PP) was detected in individuals of groups 3 and 4 compared with groups 1 and 2 (p=0,0009 in both comparisons).

There were correlations between WC and visceral fat extent (r=0,73, p<0,05), office SBP (r=0,13, p<0,05), office PP (r=0,19 , p<0,05), levels of serum glucose (r=0,44, p<0,05), insulin (r=0.32, p<0,05), insulin resistance indices (HOMA-IR (r=0,41, p<0,05), TG/HDL-C (r=0,28, p<0,05), MI (r=0,40, p<0,05)), structural cardiac parameters (LV posterior wall dimension — LVPWd (r=0,44, p<0,05), interventricular septum thickness — IVST (r=0,39, p<0,05), end-systolic dimension — ESD (r=0,34, p<0,05), end-diastolic dimension — EDD (r=0,36, p<0,05), LV mass index — LVMI (r=0,35, p<0,05)).

Assessment of structural cardiac parameters (Table 2) revealed that LVPWd was significantly higher in the group of HTN+obesity+T2D compared with HTN+T2D patients (1,10 [1,00; 1,15] vs 1,00 [1,00; 1,10] cm, respectively). IVST and EDD were higher in group 3 compared with group 1 (1,10 [1,00; 1,20] vs 1,0 [1.0; 1,05] cm (p=0,024) and 5,1 [4,8; 5,3] vs 4,9 [4,6; 5,1] cm (p=0,015), respectively). LVMI increased with the combination of HTN with obesity and T2D and was significantly higher in the group of HTN+obesity+T2D compared with the group of HTN (107,5 [92,5; 125,6] vs 96,0 [85,1; 106,1] g/m^2, respectively). We determined correlations between LVMI and WC (r=0,56) in group 1, as well as between LVMI and WC (r=0,50), visceral fat extent (r=0,57) and glucose level (r=0,57) in group 5.

The results of a regression analysis regarding HTN+obesity patients revealed an association between LVMI and WC (LVMI=-35,4+1,2*WC;

Table 3

Parameters of insulin resistance of patients (Me [25%; 75%])

Parameters	Group 1 HTN without obesity and T2D	Group 2 HTN+obesity	Group 3 HTN+obesity+T2D	Group 4 HTN+T2D
Insulin, μIU/ml	9,8*,† [6,0; 12,5]	16,6 [12,6; 24,2]	16,8 [13,0; 24,0]	12,7 [8,6; 18,6]
HOMA-IR	2,28*,†,§ [1,49; 3,14]	4,58 [2,80; 6,40]	5,30 [4,22; 7,47]	3,97 [2,45; 5,40]
TG/HDL-C	1,17*,† [0,75; 1,62]	1,50 [1,20; 1,91]	1,57 [1,32; 2,16]	1,30 [0,90; 1,78]
MI	8,72*,† [6,34; 9,97]	10,50†† [7,91; 13,52]	13,59§§ [10,36; 18,43]	9,24 [7,16; 13,85]

Note: * — significance of differences between groups 1 and 2, † — significance of differences between groups 1 and e, § — significance of differences between groups 1 and 4, ** — significance of differences between groups 2 and 3, †† — significance of differences between groups 2 and 4, §§ — significance of differences between groups 3 and 4.

Abbreviations: MI — metabolic index, TG/HDL-C — triglyceride-to-high-density-lipoprotein-cholesterol ratio.

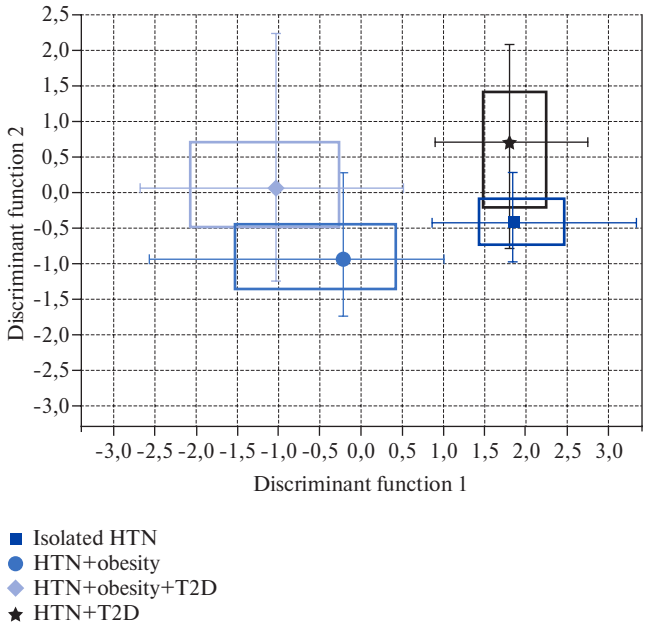

Figure 2. Distribution of the patients depending on the values of discriminant functions.

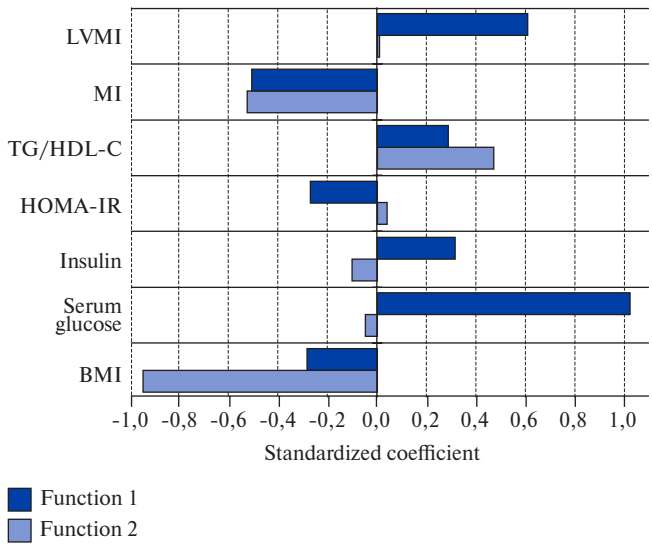

Figure 3. Distribution of the patients depending on the values of standardized coefficients.

Abbreviations: LVMI — left ventricular mass index, BMI — body mass index, MI — metabolic index, TG/HDL-C cholesterol — triglyceride-to-high-density-lipoprotein-cholesterol ratio.

adjusted R^2=0,33, p<0,001); in the group of HTN+obesity+T2D — between LVMI and the obesity extent (LVMI=77,3-7,2*BMI+2,2*WC; adjusted R^2=0,77, p=0,041; LVMI=114+1,78*visceral obesity+0,22*BMI; adjusted R^2=0,76, p=0,047); in the group of HTN+T2D — between LVMI and parameters of carbohydrate and lipid metabolism (LVMI=57,5+11,5*fasting glucose-9,75*HDL-C+18,4*VLDL-C; adjusted R^2=0,30, p<0,01).

The percentage of people with LVH was significantly higher in groups 2, 3, and 4 compared with group 1 (Table 2), as well as in group 3 compared with groups 2 and 4. The distribution of groups by types of LV remodeling is shown in Figure 1.

Insulin levels were significantly lower in patients with HTN compared with HTN+obesity and HTN+obesity+T2D participants (9,8 [6,0; 12,5] vs 16,6 [12,6; 24,2] and 16,8 [13,0; 24,0] μIU/ml, respectively) (Table 3).

HOMA-IR and TG/HDL-C ratio were significantly lower in patients with HTN compared with persons of groups 2, 3 and 4 (2,28 [1,49; 3,14] vs 4,58 [2,80; 6,40], 5,30 [4,22; 7,47] and 3,97 [2,45; 5,40] and 1,17 [0,75; 1,62] vs 1,50 [1,20; 1,91] и 1,57 [1,32; 2,16], respectively) (Table 3).

The MI value increased with the combination of HTN with obesity and/or T2D, reaching significant differences between groups 1 and 2, 1 and 3, 2 and 3, 3 and 4 (Table 3).

To identify the pathogenesis of HTN in commination obesity and T2D, a stepwise discriminant analysis was performed. Figure 2 shows that the shift of groups with HTN+obesity±T2D to negative values for 1 function is associated not only

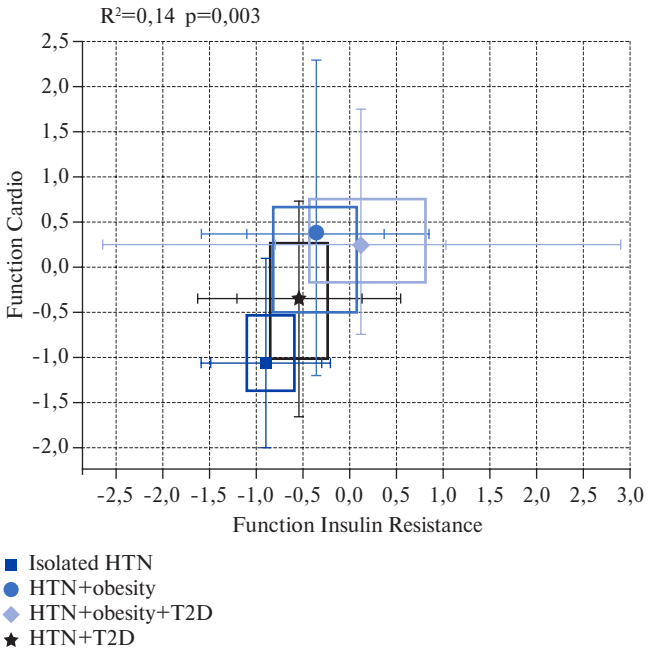

Figure 4. Distribution of the patients depending on the values of the canonical functions Insulin Resistance and Cardio.

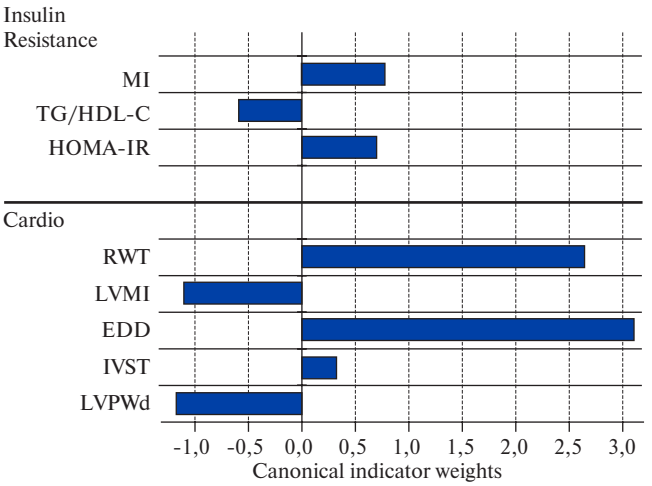

Figure 5. Relative contribution of parameters of insulin resistance and cardiac structure in the patients.
Abbreviations: LVMI — left ventricular mass index, EDD — end diastolic dimension, ESD — end systolic dimension, IVST — interventricular septal thickness, MI — metabolic index, RWT — relative wall thickness, LVPWd — LV posterior wall dimension, TG/HDL-C cholesterol — triglyceride-to-high-density-lipoprotein-cholesterol ratio.

with BMI increase, but also with an increase of insulin resistance severity. Thus, it was shown that the BMI increase in patients with HTN±T2D was accompanied by an increase in MI and TG/HDL-C ratio.

Combination of HTN with T2D, regardless of the obesity presence/absence, the maximum discriminant contribution is made by fasting serum glucose and LVMI; MI, insulin level, and TG/HDL-C ratio are somewhat less important (Figure 3). Thus, glycemia increase is associated with raised insulin resistance and is characterized by LVMI increase. In the space of two discriminant functions, the groups were located in different areas (Figure 2).

The data obtained suggest that the differences were most pronounced regarding not only metabolic parameters, but also the structural cardiac parameters. The analysis in this system is rather difficult, therefore, at the next stage, the contribution of insulin resistance to cardiac remodeling in groups of patients with HTN, HTN+obesity, HTN+obesity+ +T2D, HTN+T2D was studied.

When assessing the distribution of patients in the function space of Insulin Resistance and Cardio, a set of canonical functions with R^2=0,14 was obtained (p=0,003) (Figure 4).

According to the structure of Insulin Resistance function, its shift towards higher values is associated with an increase in MI and HOMA-IR (Figure 5).

According to the structure of Cardio function, the greatest contribution to LV remodeling is made by the EDD, LV relative wall thickness (RWT), as well as LVPWd and LVMI (Figure 5).

An analysis of the distribution of patients in the function space of Insulin Resistance and Cardio (Figure 4) shows that an increase in the median values of Insulin Resistance function in all groups is associated with a deterioration in the median Cardio function values. Moreover, patients with HTN+obesity+T2D were the most heterogeneous sample with a wide scatter in extreme values, which is probably due to the individual course of comorbidities and a worsening prognosis in this category of patients.

Discussion

Significant differences in BMI between groups 1 and 2, 1 and 3, 2 and 4, 3 and 4 are due to the design of the study. With an increase in BMI, the percentage of subcutaneous and visceral fat and WTR increased.

The practical significance of identifying a high percentage of patients with abdominal obesity in patients only with HTN and HTN in combination with T2D in groups of people with normal and excess BMI is the need to assess not only BMI for obesity diagnosis, but also WC, WTR, as well as visceral fat content.

Significantly higher values of office PP are characteristic of patients with a combination of HN and T2D due to a decrease of office DBP, which is a sign of increased arterial stiffness and subclinical target organ damage [7].

Significant correlations between BMI, WC, TC, WTR, subcutaneous and visceral fat levels and structural cardiac parameters obtained in the study confirms the pathogenetic role of obesity in the progression of target organ damage. It should be noted that in addition to the general trend of correlation analysis, the relationship features in each of the studied groups were revealed, which indicates a different significance level of pathogenesis components with the combination of HTN with obesity and T2D.

A significantly higher percentage of LVH among people with HTN and/or obesity and T2D (21,5% in patients only with HTN; 53,3% — with a combination of HTN and obesity; 52% — with a combination of HTN and T2D; 86,5% — with a combination of HTN, obesity and T2D) is associated with LV remodeling due to the negative contribution of both obesity and T2D, which is most pronounced in their combination [8]. The results of the study are consistent with data of Mancusi C, et al. (2017), where a multivariate logistic analysis with 8815 HTN patients, divided by BMI, revealed that obesity is associated with a higher prevalence of LVH by 6,9 times (95% confidence interval 5,84-8,17, p=0,0001), regardless of significant associations with the female gender, age, diabetes, office SBP, antihypertensive and antiplatelet therapy [9]. According to the review by Sakamoto M, et al. (2018), the basis of structural and functional cardiac impairment in patients with HTN in combination with obesity and/or T2D are the following mechanisms: chronic inflammation, oxidative stress in the heart and blood vessels, which in turn leads to vascular endothelial damage, LVH and interstitial fibrosis [10]. The prevalence of LV concentric hypertrophy in our study was significantly higher already with combination of HTN with obesity or T2D and is comparable to the group with HTN, obesity and T2D. The results are consistent with data of Orhan AL, et al. (2010), which showed that among obese individuals, concentric hypertrophy is more common than eccentric [11].

Perhaps this is due to chronic overload of the left atrium due to an increase in plasma volume caused by obesity and LV diastolic dysfunction [11]. However, in the group of HTN patients with obesity and T2D, patients with LV eccentric hypertrophy were significantly more frequent, which indicates the most unfavorable type of LV remodeling and is associated with overload not only by pressure but also by volume [12].

Thus, among patients with HTN, obesity, and T2D, compared with patients with HTN and without obesity and/or T2D, the most unfavorable types of LV remodeling significantly more often occurred: concentric and eccentric LVH.

Intracellular metabolic disorders and increased oxidative stress due to hyperglycemia, insulin resistance and chronic inflammation are pathogenetic mechanisms involved in the development of LV remodeling caused by T2D [10, 13]. These mechanisms lead to structural cardiac changes, such as LVH and interstitial fibrosis, as a result of which HF subsequently develops.

Results of regression analysis confirm the contribution of these pathogenetic components to LV remodeling.

In combination of HTN with obesity and/or T2D, insulin levels significantly increased in comparison with individuals only with “HTN in parallel with insulin resistance indices. The results are consistent with data of Seravalle G, et al. (2016) [14].

Thus, insulin resistance leads to a number of negative pathophysiological processes that can initiate destabilization of cells and tissues, including the heart, causing structural and functional disorders and increasing the risk of cardiovascular events [15].

The canonical analysis revealed the contribution of insulin resistance to the progression of structural cardiac changes in groups of individuals only with hypertension, with HTN in combination with obesity and/or T2D. It was noted that the Insulin Resistance function plays the greatest role in the group of T2D patients. Moreover, among participants with HTN, obesity and T2D compared with patients with HTN and T2D, the decrease in Cardio function was more significant, which indicates the additional contribution of obesity to the pathogenesis of cardiovascular damage. The heterogeneity of the sample of patients with HTN, obesity, and T2D with a wide scatter in extreme values probably due to the individual course of comorbidities and a worsening prognosis in this category of patients.

Conclusion

The data obtained specifies the LV geometry characteristics, as well as the insulin resistance contribution to pathogenesis of LV remodeling in HTN patients with/without obesity and/or T2D.

Relationships and Activities: not.

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