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Features of heart and vascular remodeling in patients who have had coronavirus disease

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Abstract: *The aim is to study the impact of COVID-19 on the state of heart and vascular remodeling in patients with coronary heart disease and arterial hypertension. During 2024-2025, 50 people (30 men and 20 women aged 64,2±3,1 years) with coronary heart disease and arterial hypertension were examined one month after treatment for coronavirus disease. In the examined patients after the transferred coronavirus disease on the background of existing hypertension and ischemic heart disease, 52,0 % had left ventricular hypertrophy and changes in the circadian rhythm of blood pressure, in 46,0 % – thickening of the intima-media complex. Among all patients with LV hypertrophy, concentric remodeling (in 23,1 %) and hypertrophy (in 34,6 %), as well as eccentric hypertrophy (in 42,3 % of cases) were found. Such diurnal BP profiles among individuals with concentric remodeling and hypertrophy, as well as with eccentric hypertrophy, as non-dipper were found in 50,0, 33,3 and 36,4 %, night-peaker – in 16,7, 11,2 and 18,2 %, dipper – in 33,3, 55,5 and 45,4 % of the examined. An increase in the thickness of the intima-media complex in eccentric and concentric hypertrophy and in individuals with concentric remodeling was observed in 36,3; 22,2 and 50,0 % of cases. Ultrasound examinations of the heart and blood vessels, their ability to qualitatively and quickly assess the morpho-functional state, the nature of hemodynamics, the risk of possible complications should be used in the diagnosis and treatment of persons with a history of coronavirus disease at the stage of primary medical care.*

Keywords: Coronavirus disease, Prognosis, Pandemics, Hypertension, COVID-19, Cardiovascular disease, Echocardiography, Heart ventricles, Heart failure, Cardiovascular complications,

Introduction

The coronavirus pandemic has led to a significant increase in morbidity and mortality due to cardiovascular diseases (CVD) [1]. The manifestations of coronavirus disease, starting in 2019, have been almost constantly changing, but respiratory symptoms, pneumonia, thrombotic complications, acute cardiovascular pathology and myopericarditis are almost always present to varying degrees [2, 3]. The pathophysiological mechanisms associated with cardiovascular damage in coronavirus disease are still far from being fully understood [4, 5], but the role of dysregulation of the immune inflammatory response is undeniable [6]. Elderly patients with cardiovascular diseases are of particular concern in CVD, given the risk of decompensation, especially in cases of severe or prolonged disease [1, 7]. The prevalence of coronavirus disease in individuals with existing coronary heart disease (CHD) and arterial hypertension is significantly increasing [7], which is due to SARS-CoV-2 induction of an inflammatory response and progression of vascular dysfunction [6].

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The pathophysiological basis for the formation of myocardial ischemia is erosion of atherosclerotic plaque, thrombus formation, coronary artery spasm and decreased blood flow in them [7]. Activation of plasma homeostasis occurs against the background of increased platelet homeostasis with endothelial damage, which increases as CHD progresses. As Krasnova A. notes, signs of blood hypercoagulability appear: an increase in fibrinogen levels and blood clotting factors, a decrease in activated partial thromboplastic time, a decrease in the ability to anticoagulate and fibrinolysis [7].

Impaired quality of life, especially physical functioning, is one of the typical consequences of a previous coronavirus disease [8]. Minor structural and functional heart disorders that do not manifest as worsening heart failure always remain unnoticed in patients after COVID-19, but can lead to an exacerbation of the long-term course of this disease. According to Gonchar O, Ashcheulova T, 2023, in patients with coronary artery disease without hypertension after a previous coronavirus disease, concentric remodeling of the left ventricle is often found, with predominant diastolic dysfunction and a slight decrease in longitudinal systolic function [9]. It has been established that the comorbidity of coronary artery disease and COVID-19, ventricular dilatation and worsening hemodynamics, led to an increase in QT interval variability in patients [10]. Therefore, the question of the impact of COVID-19 on the course of chronic coronary artery disease is still far from being finally clarified.

Aim

To assess the impact of COVID-19 on the characteristics of cardiovascular remodeling in patients with chronic ischemic heart disease and arterial hypertension.

Materials and methods

During 2024-2025 years, 50 people with coronary heart disease and arterial hypertension were examined in outpatient settings one month after treatment for COVID-19. In accordance with the recommendations of the World Health Organization [11], the order of the Ministry of Health of Ukraine dated April 2, 2020 No. 762 “Protocol for providing medical care for the treatment of coronavirus disease (COVID-19)” [12], the clinical guideline “Clinical management of patients with COVID-19” [13], the order of the Ministry of Health of Ukraine dated April 20, 2021 No. 771 “On approval of the Protocol for providing rehabilitation care to patients with coronavirus disease (COVID-19) and convalescents” [14], a clinical diagnosis of COVID-19 was established and confirmed by detecting SARS-CoV-2 RNA in clinical laboratories earlier [15].

The inclusion criteria for the study were: patients with coronary artery disease and hypertension aged 45-65 years, who had laboratory-confirmed COVID-19 1 month ago and consulted a family doctor for outpatient care, who agreed to participate in the study [16]. Exclusion criteria: no confirmed COVID-19 disease, age > 65 years, disagreement with participation in the study.

The results of the study were obtained by the author during the research work of the Department of Family Medicine of Shupyk National University of Health of Ukraine on the topic «Development and Justification of Programs For the Prevention and Treatment of Patients With Comorbid Pathology of Organs and Systems» (state registration number 0122U-002416; term: 2022-2026 years). The study protocol was drawn up in accordance with the Declaration of Helsinki [17] and agreed with the Ethics Committee of Shupyk National University of Health of Ukraine (Protokol № 3/3 22.03.2024). Examination and treatment of patients were carried out in accordance with the “Protocol for providing medical care for the treatment of coronavirus disease (COVID-19)” [18].

In outpatient settings, 50 people with chronic coronary artery disease and arterial hypertension (30 men and 20 women) aged 64,24±3,16 years were examined. All patients were examined in accordance with the order of the Ministry of Health of Ukraine dated 20.04.2021 No. 771 “Protocol for providing rehabilitation care to patients with coronavirus disease (COVID-19) and convalescents [14]. Structural and functional changes in the myocardium and features of autonomic regulation of heart rate were assessed

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using Doppler echocardiography [19], daily blood pressure monitoring [20, 21]; features of vascular remodeling – using ultrasound examination of the brachiocephalic arteries [22].

To evaluate the results of the study, methods of primary statistical and correlation analysis were used [23]. The author used ChatGPT (OpenAI, San Francisco, CA, USA) for language editing of the English text. The author reviewed and verified all AI-generated content to ensure accuracy and integrity.

Results

Against the background of existing hypertension, ischemic heart disease and previous coronavirus disease, 52,0 % of the examined patients were diagnosed with left ventricular hypertrophy. Among all individuals with LV hypertrophy, eccentric hypertrophy was observed in 42,3 %, concentric hypertrophy in 34,6 %, and concentric remodeling in 23,1 % of the examined (Fig. 1a and 1b).

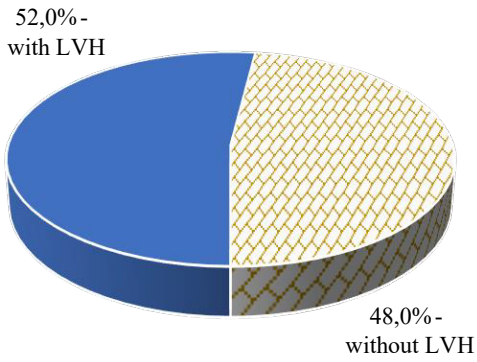

Fig. 1a. Prevalence of left ventricular hypertrophy in people who had coronavirus disease

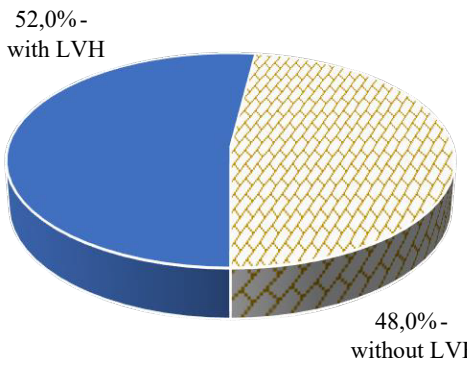

Fig. 1b. Prevalence of different types of remodeling of left ventricular in people who had coronavirus disease

Our results are comparable with the data of Gonchar O, Ashcheulova T, 2023, which showed that concentric left ventricular remodeling was detected in 59,0 % of the examined patients with CVD, including 49,0 % of patients without hypertension, diastolic dysfunction was detected in 35,0 and 25,0 % of the examined patients, respectively; a moderate increase in absolute and relative wall thickness, worsening of diastolic parameters and global longitudinal deformation were observed [9]. The diameter of the aortic root in patients tended to increase with concentric LV remodeling by 4,0 % and with eccentric hypertrophy by 1,6 %, while with concentric hypertrophy it significantly increased by 6,0 % ($p<0,05$) (Table 1).

The size of the left atrium in the examined patients increased with concentric hypertrophy by 15,0 % ($p<0,001$) and eccentric hypertrophy by 11,1 % ($p<0,001$), while with concentric remodeling it had only a tendency to increase by 2,2 %. The left atrial index in patients increased with eccentric hypertrophy by 9,2 % ($p<0,001$) and concentric hypertrophy by 13,2 % ($p<0,001$), with concentric remodeling – only by 1,1 % ($p>0.05$). The left atrial area in these individuals increased most with concentric hypertrophy by 14,5 % and eccentric hypertrophy by 14,3 % ($p<0,05$) and decreased with concentric remodeling by 9,4 % ($p>0,05$). In individuals who had undergone coronavirus disease, the left atrial area index significantly increased with eccentric hypertrophy by 19,6 % ($p<0,01$) and had a tendency to increase with concentric hypertrophy by 9,9 % and decrease with concentric remodeling by 10,0 % ($p>0,05$) (Table 1).

In the patients we examined, the LV end-diastolic size significantly increased with eccentric hypertrophy by 11,0 % and concentric hypertrophy by 9,4 % ($p<0,001$) and with concentric remodeling – decreased by 6,5 % ($p<0,05$). The index of LV end-diastolic size in these patients increased with eccentric hypertrophy by 4,7 % and concentric hypertrophy by 5,2 % ($p<0,05$) and decreased by 9,9 % ($p<0,01$) with concentric remodeling. LV end-systolic size in patients increased with eccentric hypertrophy by 15,8 % ($p<0,001$) and

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Table 1. Character of the structural and functional state of the heart in the examined patients 1 month after COVID-19

Indicators	Types of left ventricular geometry in patients			
	normal geometry	hypertrophy eccentric	concentric remodeling	concentric hypertrophy
Aortic root diameter	2,97±0,05	3,05±0,09	3,10±0,10	3,16±0,08*
Left atrial size	3,11±0,05	3,48±0,12***	3,18±0,12	3,59±0,08***
Left atrial index	1,57±0,01	1,72±0,05***	1,63±0,08	1,82±0,04***
Left atrial area	14,54±0,62	16,63±1,05	13,12±0,94	16,66±0,52*
Left atrial area index	7,59±0,24	9,12±0,47**	6,87±0,53	8,34±0,25
LV end-diastolic size	4,58±0,04	5,09±0,11***	4,24±0,16*	5,0±0,08***
LV end-diastolic size index	2,43±0,03	2,54±0,07	2,15±0,06**	2,54±0,02*
LV end-systolic size	2,84±0,06	3,23±0,16***	2,74±0,15	3,12±0,07***
LV end-diastolic volume	97,36±2,70	122,50±5,38***	83,31±7,47*	114,32±3,56***
LV end-diastolic volume index	50,80±1,04	62,14±2,70***	41,95±3,52**	57,27±1,64**
LV end-systolic volume	31,79±1,50	42,15±3,04**	30,23±3,49	40,32±2,15**
LV ejection fraction	68,78±0,86	65,12±1,89*	67,40±1,60	65,05±0,90*
LV posterior wall myocardial thickness	0,92±0,01	1,04±0,02***	0,98±0,01***	1,25±0,03***
Relative thickness of the posterior wall of the left ventricle	0,38±0,03	0,45±0,07	0,47±0,02***	0,51±0,02***
Interventricular septal thickness	1,06±0,5	1,27±0,30***	1,19±0,03	1,45±0,03***
LV myocardial mass	187,12±7,80	276,71±16,78***	187,94±15,65	307,78±13,24***
Myocardial mass index	95,83±3,54	136,07±5,58***	94,54±7,0	155,40±6,51***
Right atrial area	12,35±0,42	14,31±0,64*	10,57±0,98	13,76±0,42
Right atrial area index	6,60±0,21	7,51±0,25*	5,38±0,42*	6,84±0,27

Note: * – p<0.05, ** – p<0.01, *** – p<0.001

concentric hypertrophy by 11,1 % (p<0,001) and decreased by 14,5 % (p>0,05) with concentric remodeling. The LV end-diastolic volume in the examined patients increased with hypertrophy (eccentric – by 25,8% and concentric – by 17,4 % (p<0,001) and decreased by 14,4 % (p<0,05) with concentric remodeling. The LV end-diastolic volume index in patients increased with eccentric hypertrophy by 22,2 % (p<0,001) and concentric hypertrophy by 12,5 % (p<0,01) and decreased with concentric remodeling by 17,4 % (p<0,01). The LV end-systolic volume in patients after coronavirus disease increased with hypertrophy (eccentric – by 32,6 % and concentric – by 26,9 % (p<0,01) and decreased with concentric remodeling by 4,9 % (p>0,05). LV ejection fraction in such individuals decreased with eccentric hypertrophy by 5,3 % (p<0,05) and concentric hypertrophy by 5,4 % (p<0,05) and with concentric remodeling by 2,5 % (Table 1).

A number of researchers found that patients with chronic CHD, even without coronavirus disease, were characterized by pronounced LV remodeling (increased end-diastolic volume) and decreased systolic function (decreased ejection fraction and increased end-systolic volume) [24].

The thickness of the LV posterior wall in patients after coronavirus disease increased with eccentric hypertrophy by 14,3 % (p<0,001) and

ISSN 2786-6661
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concentric hypertrophy by 32,6% (p<0,001), and with concentric remodeling by 9,9 % (p<0,001). The relative thickness of the posterior wall of the left ventricle in patients increased with concentric remodeling by 18,5 % (p<0,001), with hypertrophy (eccentric) by 3,2 % and concentric by 25,8 % (p<0,001). The thickness of the interventricular septum in patients increased with eccentric hypertrophy by 22,5 % (p<0,001) and concentric hypertrophy by 10,5 % (p<0,001) and with concentric remodeling by 9,7 %. The mass of the left ventricle in such individuals increased with hypertrophy (concentric) by 64,4 % and eccentric by 47,9 % (p<0,001), and had only a tendency with concentric remodeling by 0,4 %. The myocardial mass index in patients increased with eccentric hypertrophy by 43,7 % (p<0,001) and concentric hypertrophy by 62,0 % (p<0,001) and decreased with concentric remodeling by 1,2 %. The thickness of the LV posterior wall in patients after coronavirus disease increased with eccentric hypertrophy by 14,3 % (p<0,001) and concentric hypertrophy by 32,6 % (p<0,001), and with concentric remodeling by 9,9 % (p<0,001). The relative thickness of the posterior wall of the left ventricle in patients increased with concentric remodeling by 18,5 % (p<0,001), with hypertrophy (eccentric) by 3,2 % and concentric by 25,8 % (p<0,001). The thickness of the interventricular septum in patients increased with eccentric hypertrophy by 22.5% (p<0.001) and concentric hypertrophy by 10,5 % (p<0,001) and with concentric remodeling by 9,7 %. The mass of the left ventricle in such individuals increased with hypertrophy (concentric) by 64,4 % and eccentric by 47,9 % (p<0,001), and had only a tendency with concentric remodeling by 0,4 %. The myocardial mass index in patients increased with eccentric hypertrophy by 43,7 % (p<0,001) and concentric hypertrophy by 62,0 % (p<0,001) and decreased with concentric remodeling by 1,2 %.

The area of the right atrium in people after coronavirus disease increased with eccentric hypertrophy by 16,2 % (p<0,05) and concentric hypertrophy by 10,8 % and decreased by 14,2 % (p>0,05) with concentric remodeling. In these patients, the right atrial area index increased with hypertrophy (eccentric hypertrophy by 16,2 % (p<0,05) and concentric hypertrophy by 5,4 % (p>0,05)) and decreased by 18,0 % (p<0,01) with concentric remodeling (Table 1).

The presence of hypertrophy (eccentric and concentric), as well as concentric remodeling in people with Covid-19 on the background of existing hypertension and ischemic heart disease led to significant features of the daily blood pressure profile (Table 2).

Among individuals without LV hypertrophy, the over-dipper daily blood pressure profile occurred in 8,3 %, night-peaker in 12,5 %, non-dipper in 25,0 %, and dipper in 54,2 % of the examined individuals; however, the presence of any type of hypertrophy led to an increase in the prevalence of night-peaker to 15,4 % and non-dipper to 30,8 % (Fig. 2a and 2b).

Non-dipper daily blood pressure profiles were diagnosed in 36,4; 33,3 and 50,0 %, night-peaker – in 18,2; 11,2 and 16,7 %, dipper – in 45,4; 55,5 and 33,3 % of those examined with hypertrophy (eccentric and concentric) and in patients with concentric remodeling.

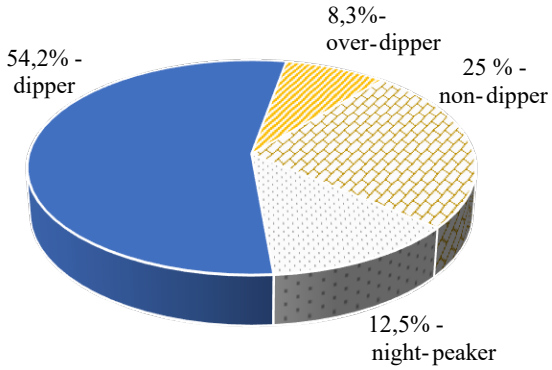

Fig. 2a. Prevalence of daily blood pressure profiles in individuals without LV hypertrophy who have undergone coronavirus disease

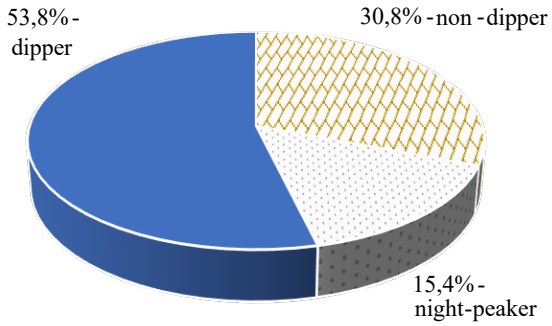

Fig. 2b. Prevalence of daily blood pressure profiles in individuals with LV hypertrophy who have undergone coronavirus disease

ISSN 2786-6661
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Table 2. Features of the daily blood pressure monitoring in patients after suffering from coronavirus disease

Indicators daily blood pressure monitoring	Types of left ventricular geometry in patients after coronavirus disease			
	normal geometry	hypertrophy eccentric	concentric remodeling	concentric hypertrophy
Systolic blood pressure during the day	121,15±2,21	130,78±4,31*	131,54±3,36***	137,57±4,89*
Diastolic blood pressure during the day	78,17±1,37	83,74±2,11	89,20±3,31**	87,55±2,56**
Hypertension time index SBP during the day	11,29±3,58	21,31±7,56	11,78±6,13	42,56±8,35***
Daytime DBP hypertension index	12,46±3,79	24,53±5,62	23,12±9,54	37,16±8,21**
Daytime SBP variability	12,05±0,54	13,04±1,11	14,03±0,64	13,40±0,32
Daytime BP variability	9,69±0,35	11,646±1,21	11,56±0,85	10,08±0,43
Systolic blood pressure at night	114,68±1,79	122,19±5,52	120,48±3,76	131,29±6,17**
Diastolic blood pressure at night	70,48±2,05	72,05±2,34	76,89±2,72	79,14±3,52*
Nocturnal SBP Hypertension Time Index	11,37±3,54	23,34±8,15	21,84±9,24	45,84±10,62***
Nocturnal DBP hypertension time index	14,13±3,75	27,85±7,64	25,06±9,26	39,35±9,67**
Nocturnal blood pressure variability	9,79±0,72	10,53±0,84	9,78±1,14	10,85±1,21
Variability of DBP at night	7,81±0,62	7,52±0,48	8,72±1,04	9,08±0,76
Minimum SBP per day	90,80±2,35	93,56±4,34	96,16±4,23	95,18±5,60
Average SBP per day	119,79±1,67	128,83±4,25*	129,48±3,34*	136,86±4,59***
Maximum SBP per day	153,92±3,24	167,31±5,36*	174,09±7,11**	177,56±5,38***
Minimum daily blood pressure	53,18±1,59	53,24±3,18	53,07±3,51	52,84±3,23
Average DBP per day	77,10±1,34	81,07±2,11	86,75±3,09**	86,36±2,81***
Maximum DBP per day	102,61±1,54	113,10±4,04**	115,04±4,38**	119,82±4,24***
Minimum average blood pressure per day	67,23±1,18	69,53±3,24	67,45±4,73	75,61±4,03
Average blood pressure per day	91,37±1,75	97,07±3,29	101,26±3,46**	99,53±4,58*
Maximum average blood pressure per day	116,57±2,14	124,29±4,43	129,75±5,14	125,19±5,34
Minimum pulse pressure per day	22,42±1,39	23,74±1,95	20,52±1,47	23,07±3,82
Average pulse pressure per day	42,52±1,37	44,94±3,68	41,58±1,17	48,71±4,10*
Maximum pulse pressure per day	69,41±2,58	73,61±6,19	80,67±6,84	89,47±8,02**
Minimum heart rate	56,52±1,76	56,25±2,68	54,26±2,38	54,18±3,24
Average heart rate	73,78±1,35	72,45±2,78	73,09±2,78	72,54±3,36
Maximum heart rate	119,06±358,	116,81±6,24	120,94±5,17	116,37±8,41
Hypertension area index SBP per day	0,47±0,18	0,23±560,	0,34±0,15	0,31±0,28
Hypertension area index of DBP per day	27,42±2,54	18,65±3,27	24,84±4,37	17,58±3,08*

Note: * – $p<0.05$, ** – $p<0.01$, *** – $p<0.001$

ISSN 2786-6661
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Daytime systolic (SBP) and diastolic (DBP) blood pressure in the examined subjects increased with eccentric hypertrophy by 8,0 ($p<0,05$) and 5,9 % ($p>0,05$) and concentric hypertrophy by 13,6 ($p<0,001$) and 11,9 % ($p<0,01$), and with concentric remodeling by 8,5 % ($p<0,001$) and 13,9 % ($p<0,01$). In the examined patients with hypertrophy (eccentric – by 88,2 and 93,2 % ($p>0,05$) and concentric – by 2,7 ($p<0,001$) and 1,9 ($p<0,001$) times, with concentric remodeling – by 0,2 and 82,0 %, the daily indices of hypertension time of SBP and DBP increased. There were tendencies to increase the daily variability of SBP (Var SBPd) and DBP (Var DBPd) in patients after coronavirus disease with concentric (hypertrophy – by 20,8 and 22,1 % and remodeling – by 12,5 and 3,9 %), with eccentric hypertrophy – by 8,9 and 19,1 %.

Certain features of nocturnal systolic and diastolic blood pressure were characteristic of our subjects. They were characterized by a probable increase in nocturnal systolic and diastolic blood pressure during hypertrophy (concentric – by 14,5 % ($p<0,01$) and 11,1 % ($p<0,05$) and a tendency to increase during eccentric – by 6,2 % and 1,6 %), as well as during concentric remodeling – by 5,1 % and 8,6 %. The time indices of hypertension, systolic and diastolic blood pressure at night, increased with concentric hypertrophy by 2,9 ($p<0,001$) and 1,7 ($p<0,01$) times, while with eccentric hypertrophy by 99,7 and 97,5% ($p>0,05$) and concentric remodeling by 88,6 and 77,6% ($p>0,05$). In such patients, nocturnal variability of SBP (VarSBPn) and DBP (VarDBPn) changed in different directions (with eccentric hypertrophy, VarSBPn decreased by 3,3% ($p>0,05$) and VarDBPn increased by 6,6 % ($p>0,05$); with concentric hypertrophy, they increased by 10,1 and 16,5 % ($p>0,05$), with remodeling – by 0,7 and 12,0 % ($p>0,05$). VarSBPd and (VarSBPn) were within normal limits in 76,6 and 70,0 % of the examined; while VarDBPd - only in 20,0 %, and VarDBPn – 6,6 %.

Daily systolic blood pressure (minimum (min SBP), average (serum SBP) and maximum (max SBP) in the examined patients increased with eccentric hypertrophy – by 4,9; 7,5 ($p<0,05$) and 8,6 % ($p<0,05$), with concentric hypertrophy – by 4,9; 14,3 ($p<0,001$) and 15,3 % ($p<0,001$), with concentric remodeling – by 5,9; 8,1 ($p<0,05$) and 13,1% ($p<0,01$). Minimum, average and maximum diastolic blood pressure (DBP per day) in patients increased with eccentric hypertrophy – by 0,3 and 5,1 % and 10,2 % ($p<0,01$) and changed in different directions with concentric hypertrophy and concentric remodeling. With concentric hypertrophy and remodeling, the minimum DBP per day decreased by 0,2 and 0,1 % and the average DBP per day increased by 12,1 ($p<0,001$) and 12,6 % ($p<0,01$) and the maximum DBP per day increased by 16,9 % ($p<0,001$) and 12,1 % ($p<0,01$). The daily minimum, average and maximum mean arterial pressure in patients after the coronavirus disease increased with eccentric hypertrophy by 2,9; 5,7 and 6,6 %, with concentric hypertrophy by 11,8; 8,2 ($p<0,05$) and 7,9 %, with concentric remodeling by 0,9; 10,7 ($p<0,01$) and 11,2 %. The minimum, average and maximum pulse blood pressure (BP per day) in such individuals increased with eccentric hypertrophy by 4,2; 5,8 and 5,9 % and with concentric hypertrophy by 3,8; 15,8 ($p<0,05$) and 29,1 % ($p<0,01$). With concentric remodeling, the minimum and average BP per day decreased by 6,8 and 1,1 % and the maximum BP per day increased by 15,8 %, but these changes were not significant. The differences in heart rate per day were not significant, so we did not analyze them in detail. The daily indices of hypertension area of systolic and diastolic blood pressure in patients decreased with eccentric hypertrophy by 52,5 and 32,0 % and with concentric hypertrophy by 32,6 and 35,7% ($p<0,05$), while with 25,1 and 9,3% – with concentric remodeling ($p>0,05$).

Patients a month after the coronavirus disease in the presence of eccentric and concentric hypertrophy, concentric remodeling were characterized by certain features of the morpho-functional state of the vessels, which are presented in Table 3. An increase in the intimate media complex (IMC) was observed in 46,0 % of the examined, however, there were certain differences in different types of LV remodeling: with concentric remodeling – in 50,0 % of the examined, with eccentric – in 36,3% and concentric hypertrophy – in 22,2 % (Fig. 3a and 3b).

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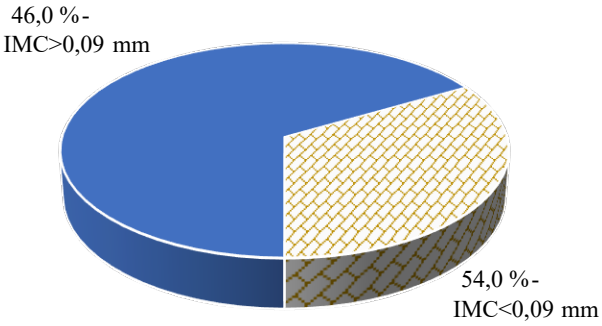

Fig. 3a. Prevalence of morphological changes functional state of blood vessels in people, who have had coronavirus disease

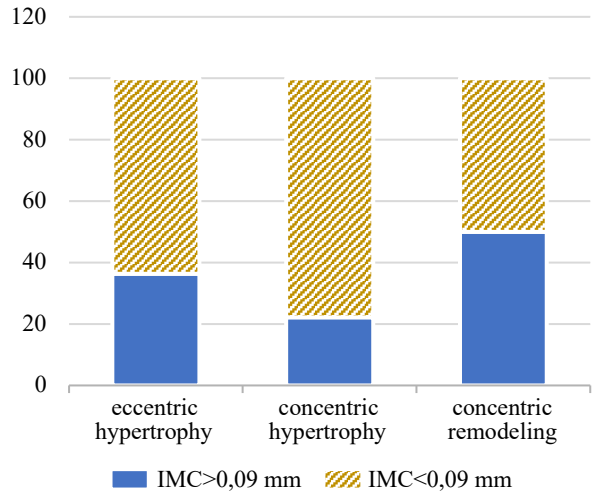

Fig. 3b. Prevalence of morphological changes functional state of blood vessels in people with various types of cardiac remodeling, who have had coronavirus disease

In the examined subjects with normal and increased IMC, the non-dipper daily BP profile was found in 29,4 and 35,0 %, in 11,7 and 20,0 % of cases – night-peaker, in 52,9 and 40,0 % – dipper, in 5,2 and 5,0 % – over-dipper.

With all types of LV remodeling, the diameters of the right common carotid arteries (RCCA) increased in patients (with concentric hypertrophy – by 12,4% (p<0,001), with eccentric hypertrophy – by 3,3 % and with concentric remodeling – by 0,7 % (p>0,05); resistance indices of the RCCA (with concentric hypertrophy – by 5,0 %, with eccentric hypertrophy – by 0,9 %, and decreased with concentric remodeling – by 3,5 % (p>0,05). With concentric hypertrophy – by 10,1 %, with eccentric hypertrophy – by 1,5 % and with concentric remodeling – by 3,5 % had a tendency to decrease the maximum blood flow velocities in the RCCA (Table 3).

There was a tendency to increase the diameters of the left common carotid arteries (LCCA) of patients with eccentric hypertrophy and concentric remodeling by 3,5 %, and by 2,5 % – with concentric hypertrophy. The maximum blood flow velocities and resistance indices on the left common carotid arteries in the examined patients decreased significantly only with concentric hypertrophy – by 14,7 (p<0,001) and 2,6 % (p>0,05) and had a tendency with concentric remodeling – by 5,6 and 2,9 % and eccentric hypertrophy – by 5,9 and 3,4 % (p>0,05).

In individuals after coronavirus disease, the diameters of the right internal carotid arteries increased with eccentric hypertrophy by 4,1 % and concentric hypertrophy by 8,8 % (p<0,05) and with concentric remodeling by 5,5 %, but this was only a trend. The maximum blood flow velocities in the right internal carotid arteries in the examined patients decreased with eccentric hypertrophy by 7,7 %, with concentric hypertrophy by 4,4 % and remodeling by 2,0 %, but these differences were not significant (Table 3).

In the examined patients with concentric hypertrophy – by 1,5 % and with concentric remodeling – by 0,3 %, the diameters of the left internal carotid arteries tended to increase, and with eccentric hypertrophy – to decrease by 0,7 %. The maximum blood flow velocity and resistance indices in the left internal carotid arteries decreased in patients after coronavirus disease with eccentric hypertrophy – by 10,5 (p<0,05) and 4,3 % (p>0,05) and concentric hypertrophy – by 5,5 and 0,5 % (both p>0,05), and with concentric remodeling they increased by 1,1 and 0,9 % (both p>0,05).

The diameters of the right vertebral arteries in the examined individuals did not change with eccentric hypertrophy and increased with concentric hypertrophy – by 0,5 % and with concentric remodeling – by 5,8 %. At the same time, the maximum blood flow velocities and resistance indices in the right vertebral arteries in these patients decreased with eccentric hypertrophy – by 12,4 (p<0,05) and 1,5 %, with

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Table 3. Structural and functional state of extracranial arteries in patients after coronavirus disease

Structural and functional state of extracranial vessels	Types of left ventricular geometry in patients after coronavirus disease			
	normal geometry	hypertrophy eccentric	concentric remodeling	concentric hypertrophy
Diameter of the RCCA	0,71±0,01	0,73±0,03	0,71±0,02	0,80±0,02***
Maximum blood flow velocity of the RCCA	87,60±2,38	86,15±2,09	84,45±4,12	78,77±3,24
RCCA resistance index	0,72±0,11	0,73±0,12	0,70±0,11	0,76±0,08
Diameter of the LCCA	0,70±0,11	0,72±0,20	0,72±0,12	0,72±0,14
Maximum blood flow velocity of the LCCA	90,68±2,15	85,32±2,46	85,75±4,34	77,41±3,15**
LCCA resistance index	0,74±0,11	0,71±0,11	0,72±0,11	0,72±0,02
Diameter of the RICA	0,50±0,11	0,52±0,12	0,53±0,12	0,55±0,02*
Maximum blood flow velocity of the RICA	74,28±1,34	68,45±2,26	72,64±2,75	70,79±4,65
RICA resistance index	0,72±0,11	0,73±0,12	0,73±0,02	0,67±0,11
Diameter of the LICA	0,53±0,01	0,51±0,11	0,52±0,02	0,52±0,12
Maximum blood flow velocity of the LICA	75,23±1,35	67,93±2,16*	76,18±2,52	71,17±3,44
LICA resistance index	0,73±0,11	0,70±0,12	0,74±0,04	0,73±0,13
Diameter of the RVA	0,35±0,11	0,36±0,11	0,38±0,12	0,36±0,12
Maximum blood flow velocity of the RVA	46,45±1,02	40,80±2,12*	44,85±3,15	37,62±2,45*
RVA resistance index	0,72±0,11	0,71±0,12	0,69±0,01	0,71±0,12
Diameter of the LVA	0,35±0,11	0,36±0,11	0,34±0,12	0,36±0,01
Maximum blood flow velocity of the LVA	46,64±1,38	39,28±2,16	42,050±3,19	38,54±2,18
LVA resistance index	0,73±0,11	0,71±0,01	0,72±0,12	0,70±0,02
Intimate media complex	0,09±0,003	0,085±0,004	0,093±0,022	0,098±0,016

Note: * – p<0.05, ** – p<0.01, *** – p<0.001

concentric hypertrophy – by 19,9 (p<0,05) and 1,3 % and with concentric remodeling – by 3,7 %.

The diameters of the left vertebral arteries in patients increased with eccentric hypertrophy by 2,5 % and concentric hypertrophy by 3,9 % and decreased with concentric remodeling by 2,6 %. At the same time, the maximum blood flow velocities and resistance indices in the left vertebral arteries decreased with eccentric hypertrophy by 15,7 and 2,4 %, concentric hypertrophy by 17,3 and 3,2 % and with concentric remodeling by 9,0 and 1,5 %, but these changes were not statistically significant.

In patients after coronavirus disease, the intimate media complex (IMC) increased with concentric hypertrophy by 10,0 % and remodeling by 1,0 % and decreased with eccentric hypertrophy by 5,5 % (p>0,05).

Discussion

Coronavirus disease is one of the greatest challenges for healthcare systems worldwide [1, 25]. Previous studies have shown that coronavirus disease can cause cardiovascular complications, such as acute coronary syndrome and myocardial infarction, myocarditis and Takotsubo cardiomyopathy, various rhythm and conduction disorders, thromboembolism (PE), and heart failure [25, 26, 27]. Although the prevalence of complications in COVID-19 is not known in detail, it has been shown that the presence of cardiovascular disease in the anamnesis is associated with a more severe course of infection [28]. Wu et al., 2019 showed a significant increase in mortality from COVID-19 in patients with existing CVD, which was 10,5 % versus 2,3 % [29].

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As Mahmoud-Elsayed HM et al., 2020 indicated, in patients with coronavirus disease, LV systolic function was hyperdynamic or normal in 89,0 %, while RV dilation was present in 41,0 %, and RV dysfunction was present in 27,0 % of those examined. RV systolic dysfunction is associated with PE, with elevated D-dimer and C-reactive protein levels in 20,0 % of cases [30].

Dweck MR et al., 2020 showed that more than half of patients with COVID-19 had cardiovascular abnormalities, most commonly left ventricular, although some individuals had myocardial infarction, myocarditis, and Takotsubo cardiomyopathy. Right ventricular (RV) abnormalities were more common in severe COVID-19 and were likely associated with severe pneumonia and PE [31]. While Szekely Y et al., 2020 emphasized that the most common abnormality in patients with COVID-19 was RV dilatation and/or dysfunction, followed by LV diastolic dysfunction. LV contractility [ejection fraction (EF)] remained normal in 90,0 % of the examined [32]. In patients with severe conditions, further deterioration of RV parameters was visualized, which could be associated with increased pulmonary resistance [26]. The study by Szekely Y. and Topilsky Y,2022 showed a significant decrease in both systolic and diastolic LV function; even subclinical changes in LV function are associated with a worse prognosis in other heart diseases [32].

As emphasized by Manuylov S, Mykhaylovska N, 2024, in people with coronary artery disease after a previous coronavirus disease, significant changes in cardiac remodeling indicators, an increase in the severity of LV hypertrophy, LV diastolic dysfunction and end-systolic pressure, and a decrease in LV ejection fraction were found, in contrast to people without Covid-19. The authors indicated that a previous coronavirus disease in people with coronary artery disease is associated with the risk of dilatation and hypertrophy of the LV myocardium, its diastolic dysfunction [33].

Our study showed that against the background of coronary artery disease, arterial hypertension and a previous coronavirus disease, 52,0 % of patients had left ventricular hypertrophy; eccentric and concentric hypertrophy were observed in 22,0 and 18, 0%, respectively. In patients with LV hypertrophy, the DBPP dipper was found in 53,8 %, non-dipper – in 30,8 %, night-peaker – in 15,4 % of cases. In individuals with eccentric and concentric LV hypertrophy, the diurnal BP profile dipper was most often found – in 45,4; 55,5 % of the examined. The intima-media complex >0,09 mm was found in eccentric and hypertrophy and concentric remodeling – in 36,3 and 50,0 %. Among individuals with thickened ICM, the DBPP dipper was diagnosed in 40,0 %, non-dipper – in 35,0 %, night-peaker – in 20,0 %, over-dipper – in 5,0 % of cases.

Szekely Y. and Topilsky Y, 2022 emphasize that the availability of echocardiographic examination and ultrasound examination of vessels, their ability to qualitatively and quickly assess the morpho-functional state of the heart and vessels, the nature of hemodynamics, and the risk of possible complications are significant advantages and must be used in the treatment of people with previous coronavirus disease [34].

Conclusions

Against the background of existing hypertension, ischemic heart disease, and previous coronavirus disease, 52,0 % of patients had left ventricular hypertrophy, 46,0 % had changes in vascular remodeling, and 52,0 % had disturbances in the circadian rhythm of blood pressure (night-peaker – 15,4 % and non-dipper – up to 30,8 %). Among all individuals with LV hypertrophy, eccentric was observed in 42,3 %, concentric – 34,6 %, concentric remodeling – 23,1 % of the examined. The non-dipper daily BP profile was diagnosed in 36,4; 33,3 and 50,0 %, night-peaker – in 18,2; 11,2 and 16,7 %, dipper – in 45,4; 55,5 and 33,3 %; thickening of the intima-media complex – in 36,3; 22,2 and 50,0 % of the examined with eccentric and concentric hypertrophy and with concentric remodeling. In patients with coronary artery disease with arterial hypertension, a month after the transferred coronavirus disease, diverse changes in the intima-media complex were observed (decrease in eccentric hypertrophy by 5,5 % and increase in concentric hypertrophy by 10,0 % and concentric remodeling by 1,0 %). In patients with thickened

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ICM, the non-dipper daily blood pressure profile was found in 35,0 %, night-peaker in 20,0 %, dipper in 40,0 %, and over-dipper in 5,0 % of the examined. Ultrasound examinations, their ability to qualitatively and quickly assess the morpho-functional state of the heart and vessels, the nature of hemodynamics, and the risk of possible complications should be used in the diagnosis and treatment of persons with transferred coronavirus disease at the stage of primary medical care.

Perspectives of subsequent scientific research

Further research will be aimed at developing an algorithm for the diagnosis and treatment of coagulopathy in people who have had coronavirus disease.

The results of the study were obtained by the authors during the research work of the Department of Family Medicine of Shupyk National University of Health of Ukraine on the topic «Development and Justification of Programs For the Prevention and Treatment of Patients With Comorbid Pathology of Organs and Systems» (state registration number 0122U-002416; term: 2022-2026 years).

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Conflicts of Interest

The author certify the absence of conflicts of interest.

Consent to publication

Informed consent was obtained from all subjects in accordance with the Declaration of Helsinki and ethical commission submission.

AI Disclosure

No AI tools were used in the preparation of this manuscript.

Author Contributions (CRediT taxonomy)

Conceptualization: Olga Vozniuk (ORCID: 0009-0001-4995-8581);
Methodology: Olga Vozniuk;
Software: Olga Vozniuk;
Validation: Olga Vozniuk;
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Writing – Review & Editing: Olga Vozniuk;
Visualization: Olga Vozniuk;
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Особливості ремоделювання серця та судин у хворих, що перенесли коронаровірусну хворобу

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Анотація: *Мета – вивчити вплив COVID-19 на стан ремоделювання серця та судин у пацієнтів з ішемічною хворобою серця та артеріальною гіпертензією. Протягом 2024-2025 років було обстежено 50 осіб (30 чоловіків і 20 жінок у віці 64,24±3,16 роки) з ішемічною хворобою серця та артеріальною гіпертензією через місяць після лікування коронаровірусної хвороби. У обстежених хворих після перенесеної коронаровірусної хвороби на тлі існуючих гіпертензії та ішемічної хвороби серця по 52,0 % зустрічались гіпертрофія лівого шлуночка та зміни циркадного ритму артеріального тиску, в 46,0 % – потовщення комплексу інтима-медіа. Серед всіх пацієнтів з гіпертрофією ЛШ зустрічались концентричні ремоделювання (у 23,1 %) та гіпертрофія (у 34,6 %), а також ексцентрична гіпертрофія (у 42,3 % випадків). Такі добові профілі АТ серед осіб з концентричними ремоделюванням і гіпертрофією, а також з ексцентричною гіпертрофією, як non-dipper зустрічалися у 50,0, 33,3 та 36,4%, night-peaker – у 16,7, 11,2 та 18,2%, dipper – у 33,3, 55,5 та 45,4% обстежених. Зростання товщини комплексу*

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інтима- медіа при ексцентричній і концентричній гіпертрофіях та у осіб з концентричним ремоделюванням спостерігалося у 36,3; 22,2 і 50,0 % випадків. При її збільшенні товщини КІМ у пацієнтів суттєво зростали поширеність dipper – у 40,0 %, non-dipper – у 35,0 %, тоді як night-peaker та over-dipper зустрічались у 20,0 і 5,0 % обстежених. Ультразвукові дослідження серця і судин, їх здатність якісно й швидко оцінити морфо- функціональний стан, характер гемодинаміки, ризик можливих ускладнень мають використовуватись при діагностиці та лікуванні осіб з перенесеною коронаровірусною хворобою на етапі первинної медичної допомоги.

Ключові слова: Коронавірусна хвороба, Серцево-судинні захворювання, Ехокардіографія, Шлуночки серця, Серцева недостатність, Серцево-судинні ускладнення, прогноз