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ABSTRACT

Purpose of the study: development and implementation into practice of optimal rehabilitation schemes for COVID-19, aimed at shortening the hospital period by effectively treating CVD and preventing complications.

Materials and methods. According to these algorithms, patients were examined with a confirmed diagnosis of COVID-19 with pneumonia, hospitalized in the intensive care unit of the Zangiota №2 specialized clinic for the treatment of patients with coronavirus infection. The echocardiography study was conducted in 54 patients diagnosed with COVID-19 who were admitted to intensive care units consecutively, 2 patients were excluded from the study due to poor visualization of the heart during echocardiography.

Results. In patients with a severe course of the disease, including those on mechanical ventilation, a significant decrease in acceleration time of pulmonary flow was observed, which indicated an increase in the afterload on the right ventricle. Clinical worsening of the disease was observed in 23% of patients, and repeated echocardiography showed a further deterioration of the right ventricle parameters, probably associated with an increase in pulmonary artery pressure. The severity of right ventricle diastolic dysfunction in patients with COVID-19 was associated with an increased level of D-dimer, C reactive protein, and Interleukin-6.

Conclusion. In contrast to the functional parameters of the left ventricle, all parameters of the right ventricle hemodynamics were worse in patients with COVID-19, especially with an increased level of IL-6 and D-dimer, against the background of a worsening of the clinical course of the disease. Echocardiography with the determination of right ventricular function and

indicators of pulmonary hypertension will make it possible to effectively carry out dynamic monitoring of the course of the disease and can be of decisive importance in determining timely treatment.

Key words: COVID-19, the cardiovascular system, rehabilitation, echocardiography

INTRODUCTION

In patients with cardiovascular disease (CVD), special vigilance should be exercised against the background of COVID-19 infection, to pay equal attention not only to treating the infection, but also to controlling risk factors for cardiovascular diseases. CVD patients with COVID-19 are at high risk of destabilization due to a combination of stressors, systemic infection and inflammation. Early studies showed that people with comorbid diseases such as hypertension, diabetes mellitus suffer from increased morbidity and mortality from COVID-19 [3,6]. At the same time, mortality from COVID-19 increases up to five times in people with CVD [7]. Clinical and laboratory symptoms of heart disease are detected with COVID-19 quite often; some patients had chest pain and palpitations even in the absence of typical respiratory symptoms [2]. The most common cardiac manifestations of infection are cardiac arrhythmias and myocardial damage [4,5]. In patients admitted to the intensive care and intensive care units, arrhythmias were detected from 16.7% to 44.4% of cases [4,5].

The tactics of respiratory support and rehabilitation undoubtedly remain the main task with COVID-19. Nevertheless, COVID-19 has unpredictable effects on the cardiovascular system, the consequences of which can be adverse not only during the acute period of the disease, but also during the rehabilitation period. Unfortunately, respiratory failure, the main manifestation of the disease that medical personnel struggle with, often distracts from cardiac disorders in patients, which inevitably leads to the undermining of timely diagnosis and treatment of cardiovascular diseases. With a large admission of patients during the pandemic, these problems are also due to the lack of profile specialists and the impossibility of routine use of diagnostic methods.

Purpose of the study: development and implementation into practice of optimal rehabilitation schemes for COVID-19, aimed at shortening the hospital period by effectively treating CVD and preventing complications.

Materials and methods

In the Specialized Clinic Zangiota №2 for the treatment of patients with coronavirus infection, schemes for the management of patients with CVD have been introduced into practice. Based on the analysis of the frequency and structure of cardiac manifestations, as well as the treatment of patients with COVID-19, guidelines have been developed. In the algorithms for the diagnosis of CVD (Table

1), the following are highlighted: clinical, instrumental, laboratory diagnostics, available in the conditions of specialized clinics.

Table 1

Algorithms for diagnostic CVD in COVID-19

CLINICAL DIAGNOSTICS:
Identifying symptoms: Ischemic heart disease, acute coronary syndrome (ACS), myocardial infarction (MI), hypertension, hypertensive crisis, arrhythmia, myocarditis, acute cardiovascular failure, chronic heart failure (CHF)
INSTRUMENTAL DIAGNOSTICS
Measurement of blood pressure (BP) in order to detect hypertension and / or hypertensive crisis: • If necessary, daily monitoring of blood pressure (taking into account the influence of stress factors) **12-lead ECG:** • Analysis of the S-T segment, T wave, Q-T interval • Signs of ischemia and damage in the myocardium • Cardiac arrhythmias, Q-T lengthening → 24-hour ECG monitoring, in order to identify life-threatening arrhythmias **EchoCG:** • Identification of violations of systolic and diastolic dysfunction • Violationsoflocalcontractility • Dilationofheartchambers • Signsofpericarditis
LABORATORY DIAGNOSTICS
With clinical and ECG signs of ACS, MI, myocarditis: 1. markers of myocardial damage: troponin 2. lipidprofile. 3. Creactiveprotein (CRP) *
Differential diagnosis: * Infectious damage to the heart from the coronavirus can also lead to clinical manifestations indicative of a heart attack. ● Patients with COVID-19 in the absence of myocardial injury may exhibit symptoms imitating cardiovascular ones, including chest pain, shortness of breath, and shock.

Identification of CVD allows timely medical rehabilitation of patients. The developed algorithms (Table 2) on the specificity of the use of drugs allow not only to improve the condition of patients, but also make it possible to prevent possible cardiovascular complications.

Table 2

Algorithms for therapeutic rehabilitation of patients with cvd at COVID-19

Patients with stable CVD are advised to continue treatment with previous cardiac medications. At the same time, taking into account possible changes in hemodynamics and hemostasis, a differentiated approach to the choice of drugs: - if, against the background of anticoagulants in patients with hypertension, there is a decrease in blood pressure, it is necessary to make an individual adjustment of the dose of antihypertensive drugs;

Given the possible side effects of statins (rhabdomyolysis, increased activity of liver enzymes), it is advisable to refrain from their use in the acute period of COVID-19.
Hypertension treatment should be consistent with current guidelines in the context of the COVID-19* pandemic. *According to the ESC experts, no data has been found on the adverse effects of ACE inhibitors and angiotensin receptor blockers on the course of COVID-19 and it is recommended to continue taking them. Four classes of drugs - beta-blockers, calcium antagonists, ACE inhibitors, and angiotensin receptor blockers - can be used to treat hypertension in COVID-19 patients.
When prescribing antiviral therapy: • (lopinavir/ritonavir) conduct an ECG, with an assessment of the P-Q interval, taking into account the possibility of its lengthening. Lopinavir/ritonavir is not recommended in patients with AV block. • Hydroxychloroquine, ECG monitoring is recommended to assess the Q-T interval, especially in cases of administration with azithromycin. In the case of Q-T lengthening by more than 60 ms from the initial one, resolve the issue of drug withdrawal.
With the development of tachyarrhythmias (atrial fibrillation/flutter): beta-blockers in the absence of heart failure (HF) and / or shock. In the presence of HF or borderline / low blood pressure, amiodarone is the drug of choice.

According to these algorithms, patients were examined with a confirmed diagnosis of COVID-19 with pneumonia, hospitalized in the intensive care unit of the Zangiota №2 specialized clinic for the treatment of patients with coronavirus infection. The EchoCG study was conducted in 54 patients diagnosed with COVID-19 who were admitted to intensive care units consecutively, 2 patients were excluded from the study due to poor visualization of the heart during EchoCG. 46 patients were on non-invasive ventilation (NVL) and 6 on invasive ventilation. Clinical characteristics of patients, taking into account laboratory and ECG parameters, are shown in Table 3. Concomitant diseases occurred in 92% of patients, the most frequent comorbid background was arterial hypertension (AH) in 75%, coronary heart disease (IHD) 46%, diabetes mellitus (DM) 37%, obesity 37%, etc.

Table 3

Clinical characteristics of the patients

Parameters	Number of patients (n=52)
Average age	46,3±12,4
Number of men, n (%)	32 (62%)
Number of women, n (%)	20 (38%)
Arterial Hypertension, n (%)	39 (75%)
Cardiac Ischemia, n (%)	24 (46%)
Diabetes, n (%)	19 (37%)
Obesity, n (%)	19 (37%)
Chronic kidney disease, n (%)	6 (11%)

Chronic obstructive pulmonary disease, n (%)	4 (7%)
Oncology, n (%)	1 (2%)
C-reactive protein, mg/dL	50,7±4,4
D-dimer, ng/mL	1376,3±206,3
Ferritin, ng/mL	275,5±28,4
Interleukin-6, pg/mL	39,4±6,7
Albumin, g/L	33,5±0,7
Heartrate, average.	85±18
Sinus rhythm, n (%)	48 (92%)
Atrial fibrillation, n (%)	4 (8%)
Right bundle branch block, n (%)	9 (17%)
Left bundle branch block, n (%)	2 (4%)
Elevation of the S-T segment, n (%)	2 (4%)
S-T segment depression, n (%)	14 (27%)
T wave inversion, n (%)	27 (52%)
Q-Tc, мs	417,2±48,1

Treatment and respiratory support of patients was carried out according to the temporary guidelines for the management of patients infected with coronavirus infection [1]. During echocardiography, the averaged indicators of three cardiac cycles were calculated. All data measured and calculated by formulas were divided into groups characterizing the structure, systolic and diastolic functions of the left and right ventricles (RV). RV indicators were assessed in the apical 4-chamber position: end-systolic and diastolic dimensions, movement of the tricuspid ring. The flow in the outflow tract of the pancreas and in the pulmonary artery (PA) was assessed in the parasternal position along the short axis at the level of the PA trunk. The time of flow acceleration (AT) in the pulmonary artery and the ejection time (ET) were estimated, and the mean pressure in the PA was determined by the AT/ET ratio.

Echocardiographic results. Left ventricular diastolic dysfunction (LVDD) in patients with concomitant coronary artery disease and preserved ejection fraction (EF) (n=16) was assessed using the algorithm for diagnosing normal diastolic function and diastolic dysfunction.Analysis using this algorithm revealed the presence ofLVDD in 14 of 16 patients with coronary artery disease.All 16 patients had a ratio E/e′>14 and an increase in the speed of tricuspid regurgitation of more than 2.8 m/s. An increase in the left atrial (LA) volume index>34 ml/m^2 was noted in 12 patients. Analysis of LVDD in patients with coronary artery disease with reduced EF (n=8) showed an increase in pressure in the LA and LVDD of II and III degrees in 6 patients, in 2 patients, due to insufficient criteria, the degree of LVDD could not be determined.

RV size was enlarged in 22 patients (42%). Assessment of pulmonary blood flow showed a decrease in AT in all patients.

In patients with a severe course of the disease, including those on mechanical ventilation, a significant decrease in AT was observed, which indicated an increase in the afterload on the RV. Clinical worsening of the disease was observed in 23% of patients, and repeated echocardiography showed a further deterioration of the RV parameters, probably associated with an increase in PA pressure.

The severity of RV diastolic dysfunction in patients with COVID-19 was associated with an increased level of D-dimer, C reactive protein (CRP), and Interleukin-6 (Table 4).

Table 4

Indicators of RV diastolic function, pulmonary flow and correlation between D-dimer, CRP in patients with COVID-19

Index	D-dimer, r	CRP, r	IL-6
E′/A′,average	0,69	0,53	0,614
DT,ms	0,24	0,16	0,312
AT, ms	0,576	0,49	0,542
Mean pulmonary artery pressure	0,613	0,54	0,718
RV EDD	0,21	0,26	0,47
RV ESD	0,15	0,51	0,62

Note: E′/A′ - the ratio of the speed of early and late diastolic movement of the tricuspid valve annulus; DT -deceleration time of the rate of early filling of the right ventricular; AT - acceleration time of pulmonary flow; RV EDD - end-diastolic diameter of the right ventricular; RV ESD - end-systolic diameter of the right ventricular

Conclusion

In contrast to the functional parameters of the LV, all parameters of the RV hemodynamics were worse in patients with COVID-19, especially with an increased level of IL-6 and D-dimer, against the background of a worsening of the clinical course of the disease. Echocardiography with the determination of right ventricular function and indicators of pulmonary hypertension will make it possible to effectively carry out dynamic monitoring of the course of the disease and can be of decisive importance in determining timely treatment. The key to successful cardiac rehabilitation in conditions of coronavirus infection is the timely diagnosis of CVD and targeted therapeutic rehabilitation based on taking into account the compatibility of drugs and their side effects. An important component is the differential diagnosis of infectious myocardial injury and worsening of the existing CVD / respiratory failure. The use of the above algorithms will significantly reduce the frequency of cardiac manifestations, which also contributes to a reduction in hospital stay and treatment costs.

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