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DOI 10.25789/YMJ.2023.84.24

УДК 612.015.39.396.397

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ASSESSMENT OF CARBOHYDRATE-LIPID BALANCE IN PEOPLE UNDERGONE COVID-19 AMONG THE RESIDENTS OF YAKUTSK

An assessment was made of the biological constant, consisting of the sum of glucose and total cholesterol levels in 161 residents of Yakutsk aged 20 to 72 years who had recovered from COVID-19.

The increase in this biological constant in the post-Covid period is most acutely expressed in individuals with morbid obesity. At the same time, there was a statistically significant tendency to increase the constant, as the disease worsened. Its significant increase to 12.25 mmol/l was noted in the post-ovoid period, in the group of patients with severe lung damage. The imbalance of harmony occurs due to an increase in glucose concentration, i.e. it is associated with a violation of carbohydrate metabolism. The results of our study indicate that patients who have suffered from SARS-CoV-2 coronavirus infection are at high risk of developing cardiovascular diseases in the postcovid period.

Keywords: coronavirus infection, glucose, total cholesterol, biological constant, body mass index, fatness.

Introduction. The rapid outbreak of coronavirus disease 2019 (COVID-19) has negatively impacted the quality of life of people around the world. According to WHO epidemiological data, up to December 2021, a total of 270,155,054 confirmed cases have been reported with a total of 5,305,991 deaths, with a mortality rate of 2.18% and hospital mortality of 15% to 20% [4].

During the pandemic, people's eating behavior has changed significantly. According to literature data, 5% of patients with COVID-19 who were treated in a hospital had a decrease in appetite, severe weight loss, a feeling of fullness, a change in taste, and a lack of smell [5, 8, 9]. Malnutrition compromises immunity and the inflammatory response, so a nutritional support system may be necessary to reduce complications caused by SARS-CoV-2, disease progression, and even death [3]. Decreased appetite and caloric intake have been reported to be associated with increased synthesis of pro-inflammatory interleukins, mainly TNF-alpha, leading to cachexia [7, 9].

Obesity is a major factor in the development of type 2 diabetes mellitus, and its global prevalence contributes to increased cardiovascular morbidity and mortality [2]. Body weight is regulated by the interaction of a number of processes, including homeostatic, environmental and behavioral factors [2, 6].

According to I.M. Rosly (2020), the total amount of cholesterol and glucose is equal to a rigid biological constant (10 mmol/l), which is necessary to assess the degree of changes in carbohydrate and lipid balance [1]. Disturbances in lipid metabolism caused by COVID-19 may persist in the post-Covid period, causing the development of cardiovascular diseases.

The purpose of the work was to study changes in glucose and total cholesterol levels in people who have had COVID-19, depending on body mass index and the severity of lung damage.

Material and methods. A survey was carried out on 161 people in Yakutsk, 60 men (37.1%) and 101 women (62.7%), who had recovered from COVID-19, with varying degrees of lung damage, aged from 20 to 72 years. The average age of the surveyed men was 50.5 [40.0; 61.7], women - 53.0 [42.0; 61.5] years. Patients with signs of ARVI at the time of the study were excluded from the group.

All examined patients, depending on their body mass index (BMI), were conditionally divided into 5 main groups according to the generally accepted WHO classification; the first group included persons with normal weight with a BMI of 18.5-24.9, the second group included those with a BMI of overweight - 25-29.9, the third person with class 1 obesity with BMI - 30-34.9, the fourth with class 2 obesity with BMI - 35-39.9 and the fifth person with class 3 obesity (morbid) with BMI above 40. Body mass index (BMI) or Quetelet II index was calculated using the formula:

BMI, kg/m2 = body weight, kg/height, m2.

To determine the frequency of lipid metabolism disorders, the Russian recommendations of the VII revision of the Russian Society of Cardiology 2020, compiled taking into account the European recommendations 2019, were used. Hypercholesterolemia (HCH) was defined as a total cholesterol level ≥ 5 mmol/l (190 mg/dl) taking into account the SCOR scale. Hyperglycemia was defined as glucose ≥ 5.6 mmol/L. The value of the hard biological constant was assessed by the level of total cholesterol and glucose, the values of which should not exceed 5 mmol/L and a total of 10 mmol/L.

Depending on the degree of lung damage, all subjects were divided into four groups: the first group with CT 0 (no lesion), the second group with CT 1 (with mild damage), the third - CT 2 (with moderate-severe damage) and the fourth with CT 3 (severe damage), confirmed by the result of X-ray computed tomography (X-ray CT).

Biochemical indicators - the level of glucose, total cholesterol, triglycerides and lipoproteins, were determined on an automatic biochemical analyzer "Labio - 200" (Mindray, China), using Biocon reagents. Blood sampling was carried out in the morning, on an empty stomach, from the cubital vein. Laboratory studies were performed using blood serum.

The study was conducted with the informed consent of the subjects, approved by the decision of the ethical committee of the Federal State Budgetary Institution "Yakut Scientific Center for Complex Medical Problems".

The obtained data were processed using the statistical program SPSS Statistics 19. Data are presented as Me (median), Q1 and Q3 (25 and 75% quartiles). The significance of differences in mean values was assessed using Student's t-test and ANOVA, for independent samples with a normal distribution and the Mann-Whitney test with a non-normal distribution. Correlation analysis of data was carried out using the Pearson and Spearman method. The critical value of the level of statistical significance of differences (p) was taken equal to 5%.

Results and discussion. The results of our study revealed statistically significant changes in the biological constant in people sick with COVID-19, depending on the covid period (from the moment of admission to the hospital and discharge after treatment) and the post-covid period. The period from the moment of recovery ranged from 3 months to 1 year.

A significant increase was observed in patients infected with the SARS-CoV-2 virus in the post-Covid period, and amounted to 11.51±0.16 mmol/l. The equilibrium shift was shifted towards carbohydrate metabolism, since the levels of glucose and total cholesterol were above the norm of 5 mmol/l and amounted to 6.07±0.13 mmol/l and 5.44±0.08 mmol/l (Table 1). As a percentage, the excess of the concentration of total cholesterol from the norm was 8% and glucose - 7%, respectively.

Our analysis showed that upon admission to the hospital, the biological constant in patients with COVID-19 was 10.65±0.44 mmol/l. At discharge, this hard-biological constant was 10.78±0.72 mmol/l. The average total cholesterol value in patients with COVID-19 upon admission and discharge was within the physiological norm. At the same time, changes in the components of the biological constant were multidirectional: the glucose concentration in patients upon admission to the hospital was higher than at discharge, and the content of total cholesterol, on the contrary, at discharge was increased (Table 1).

In the post-Covid period, the content of total cholesterol in patients increased statistically significantly, compared with similar indicators in patients upon admission and upon discharge, and amounted to 5.44±0.08 mmol/l. The serum glucose level was characteristically high on admission to hospital compared with that on discharge and was 6.41±0.27 mmol/l (p=0.01). In the post-Covid period, this figure increased again (Table 1). The data presented indicate an imbalance and disruption of biological phenomena in patients upon admission to the hospital in general due to a decrease in glucose levels. The trend toward normalization of biological constants after treatment tends to occur in the post-Covid period.

Thus, the highest average value of the sum of glucose and total cholesterol was observed in the group of patients in the post-Covid period, exceeding the normal value by 15%, due to an increase in cholesterol levels by 9% and glucose by 8.4% from the normal level. An excess of

Table 1

The content of glucose and total cholesterol in the blood serum at different periods after infection with SARS-CoV-2.

Biochemical indicator	Upon admission 1	At discharge 2	The Postcovid period 3	p
Glucose, mmol/l	6.41±0.27** n=62	5.89±0.31 n=51	6.07±0.13 n=161	$p^{1.2}$=0.011 $p^{1.3}$=0.578 $p^{2.3}$=0.238
Total cholesterol, mmol/l	4.27±0.17** n=29	4.40±0.20** n=21	5.44±0.08** n=161	$p^{1.2}$=0.089 $p^{1.3}$=0.000 $p^{2.3}$=0.015
Biological constant, mmol/l	10.65±0.44 n=29	10.78±0.72 n=21	11.51±0.16 n=161	$p^{1.2}$=0.489 $p^{1.3}$=0.114 $p^{2.3}$=0.190

Note. In table 1 and 2 ** - differences are significant at p<0.05.

the constant by more than 10 mmol/l indicates the severity of metabolic disorders. Glucose plays a major role in metabolism, as it is the main source of energy.

The biological constant in patients infected with SARS-CoV-2 in the post-Covid period was higher than normal and depended on the severity of lung damage (Table 2).

At the same time, there was a statistically significant tendency towards an increase in the constant depending on the degree of lung damage. Its significant increase was noted in the group of patients with CT 3 and amounted to 12.26±0.41 mmol/l. Moreover, its increase is accompanied by a significant increase in glucose levels by 17%, compared with the group of patients with CT 0 (Table 2). In this group of patients, the constant was the smallest and equaled 10.97±0.32 mmol/l. It was observed that the concentration of glucose and the level of total cholesterol in the blood serum in patients who had recovered from COVID-19, regardless of the degree of lung damage, remained statistically significantly higher than the reference values (Table 2). In the group of patients with CT 2 and CT 3, this coefficient was 11.99±0.40 mmol/l and 12.26±0.41 mmol/l, respectively.

The results of our study revealed changes in glucose levels depending on BMI in the post-Covid period (Fig. 1). There was a statistically significant trend toward increased glucose levels in the more obese groups. The median glucose in patients with SARS-CoV-2 infection with normal body weight did not exceed the reference values and was equal to 5.40 [5.10; 5.80] mmol/l. In patients with excess body weight in the post-Covid period, the median was 5.71 [5.35; 6.15] mmol/l, when compared with patients with normal body weight (p=0.015). Meanwhile, in the group of patients with obesity of 1 and 2 degrees, the glucose level was 5.83 [5.50; 6.70] (p=0.001)

Table 2

Glucose and cholesterol levels depending on the severity of CT

Biochemical indicator	CT 0 n=27 1	CT 1 n=60 2	CT 2 n=42 3	CT 3 n=32 4	p
Glucose, mmol/l	5.62±0.12**	5.85±0.13**	6.29±0.36**	6.62±0.42**	$p^{1.3}$=0.076 $p^{2.4}$=0.036
Total cholesterol, mmol/l	5.34±0.26**	5.19±0.11**	5.70±0.14**	5.63±0.20**	$p^{1.4}$=0.043 $p^{2.3}$=0.007 $p^{3.1}$=0.049 $p^{3.2}$=0.007
Biological constant, mmol/l	10.97±0.32**	11.05±0.18**	11.99±0.40**	12.26±0.41**	$p^{1.3}$= 0.025. $p^{2.4}$=0.015 $p^{4.1}$=0.014 $p^{1.4}$=0.051

and 5.85 [5.46; 6.45] mmol/l, compared with patients with normal BMI (p=0.019). In two patients with a BMI over 40, the median glucose was 12.75 [5.40; 20.10] mmol/l, but due to the small number of subjects studied, the difference is not statistically significant.

According to our data, in the post-Covid period, the content of total cholesterol in the blood serum, regardless of BMI, was higher than the reference values (Fig. 2). The highest level of total cholesterol was observed in the group of patients with stage 2 obesity with a median of 5.47 mmol/l [4.64; 6.14]. In patients with morbid obesity, the median total cholesterol was 5.20 mmol/l [4.77; 5.78]. In the group of patients with normal and overweight, the concentration of total cholesterol was increased by 7-8% of the reference value.

Thus, the results of our study indicate that patients who had COVID-19 experienced an imbalance of the biological constant associated with impaired carbohydrate metabolism. In all study groups, the biological constant was higher than normal. At the same time, a tendency for the constant to increase with increasing body weight was revealed. Thus, in persons with normal body weight, this constant was increased by 8%, with overweight by 10.9%, with class 1 obesity by 12%, with class 2 obesity by 13% and with morbid obesity by 79%.

Correlation analysis showed that the sum of total cholesterol and glucose is positively correlated with the level of triglycerides, LDL cholesterol, VLDL cholesterol, Ka and has a positive relationship with BMI (Table 3). In turn, a high coefficient of atherogenicity is associated with excess body weight. Table 3 shows the relationship of body mass index with lipid metabolism fractions and glucose. An increase in body weight is accompanied by a significant increase in primarily TG, VLDL, Ka, and glucose. Among all the biochemical parameters associated with lipid metabolism, the antiatherogenic lipid fraction of HDL cholesterol, which negatively correlated with BMI, is of greater importance. The low level of antiatherogenic lipid fraction indicates that these patients are in the group with the highest risk of developing cardiovascular diseases.

In the post-Covid period, an increase in the biological constant occurs due to a metabolic disorder in carbohydrate metabolism. Perhaps the increase in blood glucose levels is due to poor carbohy-

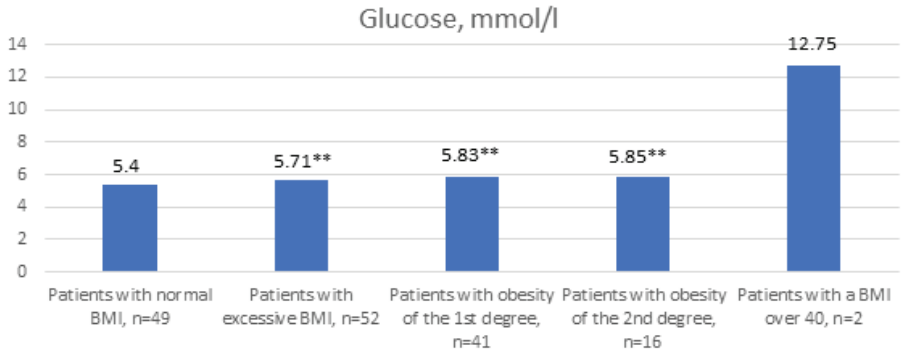

Fig. 1. Median serum glucose in patients with COVID-19 in the postcovid period, where, ** is the level of statistical significance p≤0.05

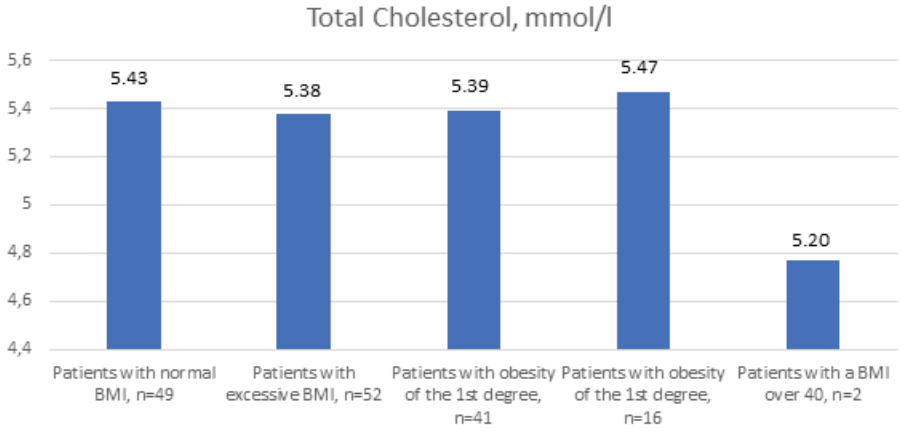

Fig. 2. Median total serum cholesterol in patients with COVID-19 in the postcovid period, where ** is the level of statistical significance p≤0.05

Table 3

Correlation of BMI of lipids and glucose in the blood serum of the subjects in the postcovid period

	TG	TCH	HDLP	LDLP	VLDLP	C_a	Glucose	TCH+ Glucose
BMI	0.378** 0.000		-0.241** 0.000		0.366** 0.000	0.232** 0.000	0.233** 0.000	0.155** 0.01
TG		0.255** 0.000	-0.290** 0.000	0.166** 0.002	0.983** 0.000	0.436** 0.000	0.275** 0.000	0.365** 0.000
TCH			0.153** 0.004	0.758** 0.000	0.255** 0.000	0.209** 0.000		0.585** 0.000
HDLP	-0.290** 0.000	0.153** 0.004			-0.280** 0.000	-0.640** 0.000	-0.152** 0.005	
LDLP		0.758** 0.000			0.160** 0.003	0.297** 0.000		0.524** 0.000
VLDLP						0.425** 0.000	0.266** 0.000	0.358** 0.000
C_a		0.209** 0.000					0.198** 0.000	0.267** 0.000
Glucose						0.198** 0.000		0.522** 0.000

Note: ** - correlation is significant at 0.01 (two-way).

drate-dominant nutrition: an addiction to sweets and a deficiency of complete proteins.

Under conditions of severe energy deficiency, the conjugation of these two components is triggered: an increase in glucose levels leads to a decrease in cholesterol levels and vice versa. Exceeding the constant (10 mmol/l) indicates the severity of metabolic disorders. At the same time, the detected increase in glucose and cholesterol levels can be considered as an indicator of the risk of cardiovascular diseases, atherosclerosis and liver diseases.

The data we obtained are consistent with the literature data of other researchers, overwhelmingly foreign ones, and reflect the general trend: the greater the weight, the more aggravated the disease [5, 6, 10].

Conclusion. The features of changes in glucose and total cholesterol levels in individuals during the post-Covid period identified in our study depend on the degree of obesity and lung damage. Hypercholesterolemia and hyperglycemia were expressed in all study groups, regardless of the severity of the disease and body weight. The peak incidence of hyperglycemia is up to 56% in patients with SARS-CoV-2 infection with morbid obesity and up to 15% in people with severe lung damage (50-75%) compared to patients without lung damage. In all groups of patients in the post-Covid period, the value of the constant remained high, due to a significant increase in the concentration of glucose in the blood on an empty stomach, which indicates liver dysfunction, or complete depletion of the internal substrate-energy reserves of the body, which indicates inhibition of the mechanisms of lipid breakdown and dominance in general bioenergetics carbohydrate metabolism. An increase in glucose activity and a decrease in cholesterol indicates a gradual transition from the use of predominantly fat to the use of glucose. Thus, all patients who have had COVID-19 in terms of the sum of total cholesterol and glucose have an increased biological constant of ten, and are at risk of developing cardiovascular diseases, so these patients need further observation, treatment and rehabilitation.

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ARCTIC MEDICINE

K.O. Pashinskaya, A.V. Samodova, L.K. Dobrodeeva

THE RELATIONSHIP OF THE CONTENT OF BLOOD TRANSPORT PROTEINS WITH THE STATE OF THE IMMUNE SYSTEM IN PRACTICALLY HEALTHY INHABITANTS OF THE SVALBARD ARCHIPELAGO DURING THE POLAR DAY

DOI 10.25789/YMJ.2023.84.25

УДК 612.114: [612.017.1+612.017.2]

The article presents data on the content of transport proteins of the blood system in relation to the state of the immune system in people living in extremely unfavorable conditions of the Svalbard archipelago. It has been established that the inhabitants of Spitsbergen have an activation of cell migration into tissues in case of insufficient oxygenation of tissues. A decrease in the level of lymphocytes in the circulation causes a violation of the regulation of immune reactions with the accumulation in the blood of extracellular forms of receptors, circulating immune complexes. People living in Svalbard have an increased need for transport components of the blood system: haptoglobin, transferrin and IgM.

Keywords: neutropenia, lymphopenia, free forms of cell receptors, immune complexes, haptoglobin, transferrin, immunoglobulins, Svalbard archipelago.

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Introduction. Physiological, biochemical and immunological reactions in the human body, as a rule, occur against the background of quantitative changes in the content of transport components of the blood system, including albumins, lipoproteins, haptoglobin, transferrin, a2-macroglobulin and immunoglobulins. The influence of the complex of unfavorable factors of the North and the Arctic is manifested in changes in the internal environment of the human body, including changes in the content of transport proteins and parameters of the blood system. Northern tissue hypoxia, low air temperature, lack of illumination, ionomagnetic disturbance voltage have an ambiguous effect on adaptive adjustments and can lead to depletion of the body's reserve capabilities [2,3,4]. The change in the content of components of blood transport systems is associated with the functional state of the human body and is aimed at maintaining homeostasis with participation in the regulation of the immune system.

Conducting research in the Svalbard archipelago is difficult and few, which leads to insufficient data on the risks to human health.

Purpose of the work – to establish the state of the transport components of the blood system and the immune system in people living and working in extremely unfavorable conditions of the Svalbard archipelago.

Material and methods. The paper presents the results of studying the immunological parameters of 75 residents of the Barentsburg settlement of the Svalbard archipelago, 46 of them women and 29 men and 79 residents of the Arkhangelsk region 58 of them women and 21 men aged 20 to 60 years, practically healthy of the survey, at the during the polar day (July-August 2017). All research was conducted with the consenot of the volunteers and in accordance with the requirements of the World Medical Association's Declaration of Helsinki (2013). The work was approved and approved by the Commission on Biomedical Ethics at the N. Laverov Federal Center for Integrated Arctic Research of the