

(Lond). 2011;120(3):91–97. doi: 10.1042/CS20100377.

22. Renkema KY, Alexander RT, Bindels RJ, Hoenderop JG. Calcium and phosphate homeostasis: concerted interplay of new regulators. *Ann Med*. 2008; 40:82–91. doi:10.1080/07853890701689645.

23. Sidor P, Głowska D, Włodarek D, et al. Analysis of the dietary factors contributing to the future osteoporosis risk in young Polish women. *Roczniki Panstwowego Zakladu Higieny*. 2016; 67(3):279–285.

24. Sivtseva AI, Sivtseva EN, Shadrina SS, Melnikov VN, Boyakova SI, Dokhunaeva AM. Mi-

croelement composition of serum in Dolgans, indigenous inhabitants of the Russian Arctic, in the conditions of industrial development of territories. *Int J Circump Health*. 2020; 79(1):1764304. doi: 10.1080/22423982.2020.1764304.

25. Tonelli M, Sacks F, Pfeffer M, Gao Z, Curhan G. Relation between serum phosphate level and cardiovascular event rate in people with coronary disease. *Circulation*. 2005; 112(17):2627–2633. doi: 10.1161/Circulationaha.105.553198.

26. Vannucci L, Masi L, Gronchi G, Fossi C, Carossino AM, Brandi ML. Calcium intake, bone mineral density, and fragility fractures: evidence

from an Italian outpatient population. *Archives of Osteoporosis*. 2017; 12(1):40. doi: 10.1007/s11657-017-0333-4.

27. Wach S, Weigelt K, Michalke B, Lieb V, Stoehr R, Keck B, et al. Diagnostic potential of major and trace elements in the serum of bladder cancer patients. *J of trace elem in med and biol*. 2018;46:150–155. doi: 10.1016/j.jtemb.2017.12.010.

28. Zhang H, Yan Ch, Yang Zh, Zhang W, Niu Yi, Li X, et al. Alterations of serum trace elements in patients with type 2 diabetes. *J of trace elem in med and biol*. 2017;40:91–96. doi: 10.1016/j.jtemb.2016.12.017.

L.B. Kim, A.N. Putyatina

THE RELATIONSHIP OF LIPID PROFILE AND BLOOD PRESSURE IN MEN IN THE EUROPEAN NORTH OF RUSSIA

DOI 10.25789/YMJ.2023.81.24

УДК: 612.12-008.331/153.915-055.1(1-922)

The paper analyzes the relationship of traditional lipid indicators and lipid indices with the level of blood pressure in men living in the European North of Russia. In apparently healthy middle-aged men, normal high blood pressure, abdominal pre-obesity, and compliance of traditional lipid indicators with reference values were revealed. At the same time, a number of lipid indices (atherogenicity coefficient (AC), the ratio of total cholesterol (TC) to high-density lipoprotein cholesterol (HDL-C), atherogenic plasma index (AIP), triglyceride/HDL-C ratio and lipid accumulation index (LAP)) appeared to be elevated.

Correlation analysis revealed the linear relationship of systolic pressure in the brachial artery with the content of Apo A-1, Apo B, TC, low-density lipoprotein cholesterol (LDL-C) and cardiovascular risk (CVR); diastolic pressure with TC, CVR and the waist-hip circumference ratio; heart rate index with waist and hip circumferences and body mass index. More number and greater strength of significant correlations were found between indicators of central hemodynamics and lipid profile. The relationships between age and length of living in the North with peripheral and central hemodynamic parameters turned out to be obvious.

Thus, male northern residents with normal high blood pressure have abdominal pre-obesity, normolipidemia but elevated lipid indices. Apparently, lipid indices are of greater prognostic significance and may be more sensitive predictors of the risk of arterial hypertension at the normal level of traditional lipid profile indicators.

Keywords: blood lipids, lipid indices, peripheral and central pressure, men, Arctic.

Correlation analysis revealed the linear relationship of systolic pressure in the brachial artery with the content of Apo A-1, Apo B, TC, low-density lipoprotein cholesterol (LDL-C) and cardiovascular risk (CVR); diastolic pressure with TC, CVR and the waist-hip circumference ratio; heart rate index with waist and hip circumferences and body mass index.

More number and greater strength of significant correlations were found between indicators of central hemodynamics and lipid profile.

The interrelations between lipid parameters and pressure level were revealed: a) positive correlation of AC with peripheral systolic and diastolic pressure, systolic pressure in the aorta, diastolic and pulse pressure, b) TC-non-HDL with systolic and diastolic pressure in the aorta, c) negative correlation of LAP with peripheral pulse pressure.

These correlations indicate that in Arctic conditions, the presence of normolipidemia and pre-obesity may be a prerequisite for the formation of normal high pressure.

Keywords: blood lipids, lipid indices, peripheral and central pressure, men, Arctic.

Introduction. In the pathogenesis of cardiovascular diseases (CVD), an important role is assigned to lipid metabolism disorders, which are determined by the content of traditional lipid indicators in the blood, such as total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C). At the same time, LDL-C is considered as the

main predictor of an unfavorable prognosis of atherosclerosis and pathogenetically related CVD [14, 17], while an increased content of HDL-C in the blood is associated with a low degree of cardiovascular risk (CVR) [20]. However, it turned out that a significant increase in HDL-C is not always a protective factor [7]. It is suggested that the functional activity of HDL-C is more determined by the concentration of HC in individual HDL-C subfractions than the level of HC contained in HDL-C.

To more accurately clarify the role of lipid metabolism in the development of atherosclerosis and related diseases, their derivatives, the so-called lipid indices or combined lipid parameters (in the English literature), have increasing-

ly been used along with traditional indicators of lipid metabolism. Most of the known indices reflect the ratio of the main classes of lipids in blood plasma, the relationship within lipid metabolism, the ratio of pro- and anti-atherogenic potential of blood [4]. It is believed that lipid indices represent the greatest strength in predicting CVD, while LDL-C may show a weak connection with the pulse wave velocity or not at all [10, 13, 18, 22].

In atherosclerosis, lipid accumulation in the intima of the arteries modulates vascular stiffness. There are isolated data on the relationship of lipids with vascular stiffness in residents of the North. In particular, it was shown that in young men, residents of Finland, the elasticity of the aorta was not associated with stan-

KIM Lena B. – MD, chief researcher, head of the Connective tissue biochemistry group, Federal Research Center of Fundamental and Translational Medicine (FRC FTM); **PUTYATINA Anna N.** – PhD of Medical Sciences, researcher of the Connective tissue biochemistry group, Federal Research Center of Fundamental and Translational Medicine (FRC FTM)

dard lipid parameters [16]. At the same time, the ratio of HDL-C/TC did not reveal an association with aortic elasticity, but showed a decrease in the extensibility of the carotid artery in individuals with a low ratio of HDL-C/TC. In another study in patients with arterial hypertension (AH), residents of Nadym, risk factors such as hypercholesterolemia, body mass index (BMI) and smoking did not affect the viscoelastic properties of the common carotid artery wall [3].

Despite the fact that arterial stiffness is a common indicator of AH [19, 21], there is no convincing data on the relationship of lipid parameters and indices with AH.

The results of studies of the lipid profile in residents of the Arctic regions and the facts of early and frequent development of CVD [1, 2, 8], dictate the need to study lipid indices and assess their relationship with the level of blood pressure in Northerners.

Objective: to study the relationship of traditional lipid indicators and lipid indices with arterial hypertension in men in the European North of Russia.

Materials and methods. The study was conducted in the Murmansk region (67° N) in the autumn-winter period. Men working at a mining and processing plant were examined (n=31). The average calendar age was 42.68±2.44 years, the northern experience was 19.69±2.40 years, the total work experience was 22.38±2.63 years.

Inclusion criteria: no complaints at the time of the study, average age, written consent to participate in the examination and blood donation for biochemical tests.

Exclusion criteria: exacerbation of chronic diseases, presence of familial hypercholesterolemia, oncological, infectious diseases, diabetes mellitus, chronic heart failure, aortic aneurysm, heart and aortic valve diseases, myocardial infarction and stroke in the anamnesis.

Blood sampling was carried out in the BD Vacutainer from the ulnar vein in the morning hours after a night of fasting. After blood centrifugation (3000 rpm, 10 min), plasma was transferred to Eppendorf tubes, frozen and stored at a temperature of -70°C.

Biochemical research. After a single plasma defrosting, the content of TC and TG was determined using Thermo Fisher Scientific kits (USA). To determine LDL-C, HDL-C, apolipoprotein A1 (Apo A1) and B (Apo B) kits from DiaSys (Germany) were used. The lipid content was measured using an AU 480 Beckman Coulter automatic biochemical analyzer (USA).

The atherogenicity coefficient (AC) =

$(TC - HDL-C)/HDL-C$ and other lipid indices were calculated using the formulas: Apo B/Apo A-1 ratio; atherogenic plasma index (AIP) = $(\log TG/HDL-C)$; atherogenic index (ATH) = $((TC - HDL-C) \times Apo B)/(HDL-C \times Apo A1)$; TC-non-HDL (non-HDL) = $TC - HDL-C$; Castelli index 1 = $TC / HDL-C$; Castelli index 2 = $LDL-C/HDL-C$ [4]; TG/HDL-C; accumulation index lipids (LAP) = $(\text{waist circumference} - 65) \times TG$ [5].

The assessment of the total risk of fatal events from CVD, cardiovascular risk (CVR) over the next 10 years was carried out on the SCORE scale (ARSSC, 2011).

Physiological studies. After resting for 15 min in a sitting position, systolic, diastolic and pulse pressure on the brachial artery (bSBP, bDBP, bPP) were measured twice with an interval of 2 min using an automatic cuff oscilloscope device (MT-4, MediTech, USA), heart rate (HR). The parameters of central (aortic) hemodynamics (aSBP, aDBP, aPP) were determined by applanation tonometry using the SphygmoCor apparatus (Atcor Medical, Australia) according to the description [11].

Anthropometric studies. Height (m) and body weight (kg), waist circumference (WC, cm) and hips (HC, cm) were measured by well-known methods, body mass index (BMI) was calculated.

This study approved by the Bioethical committee of FRC FTM was performed in accordance with the requirements of "Ethical principles for medical research involving human subjects" (the Helsinki

Declaration of the World Medical Association 1964, as amended in 2013) and "Rules for clinical practice in the Russian Federation" (Order of the Ministry of Health of the Russian Federation № 266 of 19.06.2003).

Statistical processing was carried out using the Statistica v. 10 application software package (Stat Soft Inc., USA). Depending on the normality of the distribution of features in the sample, calculated by the Kolmogorov-Smirnov method, nonparametric analysis methods were used to determine the median (Me), lower, upper quartile (Q25; Q75) and arithmetic mean (M), mean error (m). Correlation analysis was performed by Spearman (r , p).

Results and discussion. Men had an excess BMI (27.47 (24.45; 29.94) kg/m²), which indicates the presence of excess body weight. The measurement results WC (95.00 (89.00; 102.00) cm), HC (103.00 (99.00; 108.00) cm) and their ratio (0.91 (0.87; 0.97)) indicate an android type of adipose tissue distribution, which suggests the presence of an abdominal form of pre-obesity. At the same time, the content of individual lipids (TG – 1.14 (0.82; 2.23) mmol/L; HC – 4.96 (3.98; 5.44) mmol/L; HDL – 1.04 (0.75; 1.35) mmol/L; LDL – 2.63 (2.10; 2.98) mmol/L) and apolipoproteins (Apo A1 – 140.08 (124.52; 160.36) mg/dl; Apo B – 45.16 (36.04; 52.06) mg/dl) corresponded to reference values, indicating normolipidemia. Nevertheless, the results of anthropometry suggest an increased risk of

Relationship of peripheral and central hemodynamic parameters with lipid profile, anthropometric indicators and cardiovascular risk of men, residents of the European North of Russia (r ; p)

Parameter	TC	HDL-C	LDL-C	Apo A-1	Apo B	WC	HC	WC/HC	BMI	CVR
bSBP	-	0.43; 0.030	0.40; 0.043	0.43; 0.030	0.42; 0.031	-	-	-	-	0.57; 0.003
bDBP	0.46; 0.019	-	-	-	-	-	-	0.45; 0.017	-	0.52; 0.008
HR	-	-	-	-	-	0.48; 0.007	0.48; 0.007	-	0.43; 0.015	-
aSBP	0.67; 0.0001	-	0.53; 0.003	0.53; 0.003	0.58; 0.001	-	-	-	-	0.74; 0.0001
aDBP	0.59; 0.001	-	0.51; 0.006	0.41; 0.031	0.51; 0.006	0.46; 0.010	-	0.60; 0.001	-	0.65; 0.0003
aPP	0.44; 0.016	0.45; 0.015	0.37; 0.050	0.44; 0.018	0.39; 0.039	-	-	-	-	0.58; 0.001

Note: bSBP, bDBP – systolic, diastolic blood pressure on the brachial artery; HR – heart rate; aSBP, aDBP, aPP – systolic, diastolic, pulse aortic pressure; TC – total cholesterol; HDL-C – high-density lipoprotein cholesterol; LDL-C – low-density lipoprotein cholesterol; WC – waist circumference; HC – hip circumference; BMI – body mass index; CVR – cardiovascular risk

CVD, and the CVR on the SCORE scale (3.36 ± 0.84) predicts a moderate risk. According to the Recommendations of the ARSSC (2008), the indicators of bSBP (134.5 (122.25 ; 140.00) and bDBP (88.00 (81.25 ; 90.00) mmHg. art. in the Northerners correspond to high normal pressure. The bPP value was 47.50 (40.00 ; 50.00) mmHg, HR – 77.00 (69.00 ; 83.00) beats/min.

9 lipid indices were evaluated, derivatives of traditional lipid indicators reflecting the ratio of atherogenic and anti-atherogenic lipid profile in Northerners. 5 of them were elevated: AC (3.70 (2.45 ; 5.25)) above 3.0 , Castelli index 1 (4.68 (3.43 ; 6.26)) above 4.0 ; AIP (0.17 (-0.19 ; 0.36)) above 0.1 ; TG/HDL-C ratio (1.49 (0.66 ; 2.29)) above 0.9 and LAP (36.34 (24.59 ; 61.02)) is greater than 21.2 relative to the data of other authors [4, 5, 12] obtained in healthy individuals. Other indexes: Apo B/Apo A-1 ratio (0.32 (0.26 ; 0.40)), ATH (1.16 (0.59 ; 2.10)), non-HDL (3.77 (3.03 ; 4.44)) and the Castelli index 2 (2.57 (1.78 ; 3.29)) did not differ from the data of other authors [4, 9, 15].

There is evidence that in healthy men, residents of Arkhangelsk aged 20 to 59 years, the LAP was 17.8 (9.1 ; 30.5), in the age group of 40–49 years, the indicator increased to 21.2 (12.3 ; 33.2) [5], nevertheless, this is significantly lower than in the group of Northerners surveyed by us. The lower values of the LAP index in Archangelgorodians can be explained by lower anthropometric indicators: WC 81.0 (75.0 ; 87.0) cm, BMI 24.4 (22.1 ; 26.3) kg/m². In Japanese men ($n=1720$, ages 25 and 55, WC 81.8 cm, BMI 23 kg/m²), LAP did not exceed 21.2 , the TG/HDL-C index – 0.9 [12].

Thus, in Northerners with normolipidemia, the revealed high lipid indices may be associated with an increased risk of atherosclerosis and CVD. Since AC reflects the ratio of atherogenic lipoproteins to anti-atherogenic cholesterol, whereas the TC/HDL-C index is the ratio of TC to anti-atherogenic lipoproteins, AC can more accurately predict the risk of developing CVD. Moreover, it has already been shown that the progression of AH and changes in the geometric parameters of the left ventricle were more closely associated with AC than with individual lipids [6].

Indicators of peripheral hemodynamics correlated with indicators of lipid profile and anthropometry. A positive correlation of average strength was noted: bSBP with Apo A-1, Apo B, TC, LDL-C and CVR; bDBP – with TC, CVR and the ratio of WC/HC; HR – with OT, OB and BMI, which reflects the relationship

of the pressure level with lipid metabolism, while HR – with anthropometry data (table). These connections are aimed at the possibility of regulating hemodynamics in Northerners by controlling lipid metabolism and abdominal pre-obesity.

A significantly greater number of correlations and greater strength were found between the indicators of central hemodynamics (aSBP 118.00 (106.00 ; 129.00), aDBP (88.00 (81.00 ; 92.00), aPP (30.00 (24.00 ; 34.00) mmHg) and lipid profile. Positive associations were noted: aSBP with Apo A-1, Apo B, TC, LDL-C, CVR; aDBP – with Apo A-1, Apo B, TC, LDL-C, CVR, WC; WC/HC; aPP – with Apo A-1, Apo B, TC, HDL-C, LDL-C, CVR.

Significant positive associations of the age of Northerners with bSBP ($r=0.54$; $p=0.003$), bDBP ($r=0.48$; $p=0.010$), aSBP ($r=0.71$; $p=0.0001$), aDBP ($r=0.57$; $p=0.001$), aPP ($r=0.60$; $p=0.0003$) and polar experience with bSBP ($r=0.51$; $p=0.006$), bDBP ($r=0.45$; $p=0.017$), aSBP ($r=0.69$; $p=0.0002$), aDBP ($r=0.56$; $p=0.001$), aPP ($r=0.59$; $p=0.001$).

Correlations between lipid indices and the level of pressure in men deserve attention. In particular, a) positive correlation of AC with indicators of bSBP (0.44 ; 0.025), bDBP (0.44 ; 0.023), aSBP (0.62 ; 0.0003), aDBP (0.56 ; 0.002), aPP (0.42 ; 0.022); b) non-HDL with aSBP ($r=0.49$; $p=0.007$), aDBP ($r=0.48$; $p=0.010$) and c) negative correlation of LAP with aPP ($r=-0.51$; $p=0.015$). These correlations indicate that in Arctic conditions, the presence of normolipidemia and pre-obesity may be a prerequisite for the formation of normal high pressure, which, in turn, is realized by the interaction of lipid indices with peripheral and central hemodynamics.

Conclusion. The results of this study showed that in men, residents of the European North of Russia, who have normal high blood pressure, abdominal pre-obesity with normolipidemia, moderate CVR on the SCORE scale, elevated lipid indices – AC, Castelli index 1, AIP, TG/HDL-C ratio and, especially, LAP were found relative to similar indicators of other researchers. Traditional lipid parameters are more closely related to the parameters of central hemodynamics than peripheral, which should be taken into account when developing diagnostic and preventive measures. The determination of lipid indices can increase the detection of latent lipid metabolism disorders even at the normal level of traditional lipid profile indicators in the blood, i.e., lipid indices may be more sensitive predictors of AH risk. The results obtained by us dictate the need for additional stud-

ies involving a larger number of subjects among residents of the Arctic region to determine the reference values of lipid indices.

The study was carried out with the partial support of the Presidium of the Russian Academy of Sciences under the basic research Program "Exploratory fundamental scientific research in the interests of the development of the Arctic zone of the Russian Federation".

We used the equipment of Core Facility "Modern Optical Systems" FRC FTM.

Reference

1. Averyanova I.V., Lugovaya E.A. Vozrastnye izmeneniya funktsional'nykh rezervov organizma muzhchin-evropeoidov urozhenchev Severa [Age-related readjustments of caucasian men's functional reserves in the North]. Uspekhi gerontol [Adv. Gerontol. 2021; 34 (6): 814–22 (In Russ.)] DOI: 10.34922/AE.2021.34.6.001
2. Bichkaeva F.A., Tipisova E.V., Volkova N.I. Sootnoshenie soderzhaniya insulina, polovykh gormonov, steroidov i glikotsidov s β -globulinom, parametrov lipidnogo obmena i glikotsidov u muzhskogo naseleniya Arktiki [The ratio of insulin, sex hormones, sex hormone-binding β -globulin, parameters of lipid metabolism and glucose in the male population of the Arctic]. Problemy reprodukcii [Russian Journal of Human Reproduction. 2016; 22(2): 99–110 (In Russ.)] DOI: 10.17116/repro201622299-110
3. Erdakova T.K., Salamatina L.V., Buganov A.A. Strukturno-funktsional'nye izmeneniya sosudistoy stenki u bol'nykh arterial'noy gipertoniej na Krajnem Severe [Structural-functional changes of vascular wall in hypertensive patients of the far North]. Ros. med.-biol. vestn. im. akad. I.P. Pavlova [I.P. Pavlov Russian Medical Biological Herald. 2009; 17(2): 89–93 (In Russ.)]
4. Kaneva A.M., Boiko E.R. Indeksy lipidnogo obmena: informativnost' i klinicheskoe znachenie pri ocenke aterogennosti lipidnogo profilya krovi [Lipid metabolism index: information capacity and clinical significance in the course of valuation of atherogenicity of lipid profile]. Medicinskij akademicheskij zhurnal [Medical Academic Journal. 2017; 17(1): 41–50 (In Russ.)]
5. Kaneva A.M., Potolitsyna N.N., Boiko E.R. Diapazon var'irovaniya znachenij indeksa nakopleniya lipidov (lipid accumulation product, LAP) u zdorovykh zhitelej evropejskogo Severa Rossii [Range of values for lipid accumulation product (LAP) in healthy residents of the European North of Russia]. Ozhirenie i metabolism [Obesity and metabolism. 2020; 17 (2): 179–86 (In Russ.)] DOI: 10.14341/omet11278
6. Makoveeva E.A. Indeks aterogennosti kak integral'nyj pokazatel' porazheniya organa mishechnykh (serdca) pri gipertonicheskoj bolezni [The index of atherogenicity as an integral indicator of organ target (heart) for arterial hypertension]. Universum: Medicina i farmakologiya: elektron. nauchn. zhurn [Universum: Medicine and Pharmacology: electron. scientific. journal. 2013; 1(1) (In Russ.)] URL: <http://7universum.com/ru/med/archive/item/322>
7. Metelskaya V.A. Funktsional'naya mnogoraznost' lipoproteinov vysokoj plotnosti: poisk zolotoj serediny [Functional diversity of high-density lipoproteins: finding the golden mean]. Ateroskleroz [Atherosclerosis. 2021; 17 (2): 61–71 (In

Russ.).] DOI: 10.52727/2078-256X-2021-17-2-61-71

8. Gapon L.I. [et al.] Rezultaty dupleksnogo skanirvaniya brachiocefal'nyh arterij i ocenki lipidnogo spektra pri ishemicheskoy bolezni serdca i arterial'noj gipertenzii u koren'nogo i prishlogo naseleniya Yamalo-Nenetskogo avtonomnogo okruga [Results of duplex scanning of brachiocephalic arteries and estimation of the lipid spectrum in coronary heart disease and arterial hypertension in indigenous and alien population of Yamalo-Nenetsky autonomous okrug]. Klinicheskaya medicina [Clinical Medicine. 2013; 1:46–49 (In Russ.).]

9. Vallée A., et al. Association between different lipid parameters and aortic stiffness: clinical and therapeutic implication perspectives. J. Hypertens. 2019; 37: 2240–46. DOI: 10.1097/HJH.0000000000002161

10. Zhan B., et al. Association between lipid profiles and arterial stiffness in Chinese patients with hypertension: insights from the CSPPT. Angiology. 2019; 70(6): 515–22. DOI: 10.1177/0003319718823341

11. Melnikov VN., et al. Association of circulating extracellular matrix components with cen-

tral hemodynamics and arterial distensibility of peripheral arteries. J. Vasc. Res. 2021; 58(6): 370–78. DOI: 10.1159/000516841

12. Nakagomi A., et al. Central blood pressure and pulse wave velocity in young and middle-aged Japanese adults with isolated systolic hypertension. Hypertens Res. 2020; 43: 207–12. DOI: 10.1038/s41440-019-0364-x

13. Chi C., et al. Comparison of various lipid parameters in association of target organ damage: a cohort study. Lipids Health. Dis. 2018; 17(1): 199. DOI: 10.1186/s12944-018-0800-y

14. Catapano AL., et al. 2016 ESC/EAS Guidelines for the management of dyslipidaemias. Eur. Heart J. 2016; 37(39): 2999–3058. DOI: 10.1093/eurheartj/ehw272

15. Kaneva AM, Potolitsyna NN, Bojko ER. Variability of values for the atherogenic index (ATH Index) in healthy men. Iran. J. Public. Health. 2021; 50(6): 1282–84. DOI: 10.18502/ijph.v50i6.6431

16. Toikka JO., et al. Large-artery elastic properties in young men: relationships to serum lipoproteins and oxidized low-density lipoproteins. Arterioscler. Thromb. Vasc. Biol. 1999; 19(2): 436–41. DOI: 10.1161/01.atv.19.2.436

17. Alique M., et al. LDL biochemical modifications: a link between atherosclerosis and aging. Food Nutr. Res. 2015; 59: 29240. DOI: 10.3402/fnr.v59.29240

18. Wen J., et al. Lipoprotein ratios are better than conventional lipid parameters in predicting arterial stiffness in young men. J. Clin. Hypertens (Greenwich). 2017; 19(8): 771–76. DOI: 10.1111/jch.13038

19. Mancia G. Blood pressure reduction and cardiovascular outcomes: past, present, and future. Am. J. Cardiol. 2007; 100(3A): 3J–9J. DOI: 10.1016/j.amjcard.2007.05.008

20. Hoefer IE., et al. Novel methodologies for biomarker discovery in atherosclerosis. Eur. Heart J. 2015; 36(39): 2635–42. DOI: 10.1093/eurheartj/ehv236

21. Masugata H., et al. Relationship between arterial stiffness and variability in systolic blood pressure during a single clinic visit in patients with hypertension. J. Int. Med. Res. 2013; 41(2): 325–33. DOI: 10.1177/0300060513476590

22. Wen JH., et al. Triglyceride to HDL-C ratio and increased arterial stiffness in apparently healthy individuals. Int. J. Clin. Exp. Med. 2015; 8(3): 4342–48.

SCIENTIFIC REVIEWS AND LECTURES

R.N. Mustafin, A.V. Kazantseva, E.K. Khusnutdinova

THE ROLE OF COVID-19 IN MODIFIED COGNITIVE FUNCTIONING

DOI 10.25789/YMJ.2023.81.25

УДК 616.517:577.12(048)

SARS-CoV-2 virus impairs cognitive functions during illness and in long-term periods: from 3 months (in 44% of patients) to one year (in 16.2% – 63% of patients) after recovery. Cognitive deficits are more common in patients with severe COVID-19, especially those treated in the intensive care unit, and with infection duration of more than 28 days. Such consequences are associated with direct impact of SARS-CoV-2 on the functioning of brain neurons and changes mediated by endothelial dysfunction due to impaired blood supply to the cerebral cortex. The long-term results of the viral effect on brain neurons are due to immune responses to the virus multiplying in cells and to changes in the epigenetic regulation of gene expression. The immune response leads to inflammation, which is expressed in the form of encephalitis, encephalopathy, anosmia, hypogeusia and is reflected in the development of cognitive deficit. Epigenetic changes are mediated by virus-induced activation of retroelements that have cis- and trans-effects on genes involved in neurogenesis. SARS-CoV-2 promotes the expression of miRNAs that silence the expression of many genes, thus impairing cognitive functioning. The mechanism of these changes is associated with the effect of the virus on retroelements, which are the sources of miRNAs. Reverse transcriptase and endonuclease of retroelements may be involved in the integration of SARS-CoV-2 into the human genome, which may also affect the change in the expression of genes necessary for cognitive development.

Keywords: cognitive functions; microRNA; retroelements; COVID-19.

Introduction. The COVID-19 pandemic remains an urgent problem for all mankind both due to a high mortality rate and due to the consequences, which are developed after recovery. Since individual cognitive functions (CF) inherently de-

termine the ability of complete functioning, professional skills and self-care, the question on the impact of COVID-19 on cognitive functioning remains relevant. Indeed, it is impossible to imagine individual's life without CF [24, 35], that can be adversely affected by the virus. Back in 2020, the analysis of 214 hospitalized patients with COVID-19 in Wuhan, China, showed the development of neurological impairments in 41.1% of patients [34]. Modified cognitive functioning in patients after recovery remains highly relevant [47]. COVID-19 also accelerates neurodegenerative processes in the elderly [2].

The most pronounced cognitive impairments are detected in severe patients who require intensive care (IT) during hospitalization [21]. Thus, the study of 92 COVID-19 patients, who re-

quired IT therapy, were characterized by pathological cognitive changes in 44% of cases 3 months after recovery [47]. The duration of infection plays an important role. In the study of 3,762 patients from 56 countries with a confirmed diagnosis of COVID-19, which duration was more than 28 days, cognitive dysfunction and memory problems were identified in all age groups in 88% of patients [11]. Nevertheless, another study of 81,337 patients after COVID-19 recovery demonstrated that cognitive deficit developed even in individuals with asymptomatic course of the disease compared with the control group [19].

Indicators of the frequency of cognitive impairments observed after COVID-19 recovery differ in the studies from various countries. However, significantly en-

MUSTAFIN Rustam Nailevich – PhD, associate professor, Bashkir State Medical University, ruji79@mail.ru; **KAZANTSEVA Anastasiya Valerievna** – PhD in Biology, senior researcher, Institute of Biochemistry and Genetics, Subdivision of the Ufa Federal Research Centre of the Russian Academy of Sciences, ORCID: 0000-0002-3744-8058; **KHUSNUTDINOVA Elza Kamilevna** – Doctor in Biology, Professor, corresponding member, Director of the Institute of Biochemistry and Genetics UFRS RAS, head of the department UUST, ORCID ID: 0000-0003-2987-3334.