DOI 10.26724/2079-8334-2024-1-87-166-171
UDC 616.002.1:616.12-008.46-008.313:612.397:616.988

O.S. Sychov, O.V. Stasyshena, T.V. Talaieva, T.I. Havrylenko, O.V. Sribna, T.V. Getman, O.Ya. Marchenko
State Institution "National scientific center "Institute of Cardiology, Clinical and Regenerative Medicine named after academician M.D. Strazhesko" of the National Academy of Medical Sciences of Ukraine" Kyiv

SYSTEMIC INFLAMMATION, IMMUNE SYSTEM, LIPID PROFILE, AND ELECTROLYTE STATUS IN PATIENTS WITH ATRIAL FIBRILLATION AFTER COVID-19

e-mail: oksana.stasushena1990@gmail.com

Atrial fibrillation is the most common form of arrhythmia. Associated with significant morbidity and mortality in patients after suffering from COVID-19. The main group was formed of 116 people (64.8 %) with atrial fibrillation who suffered from a coronavirus infection. Control group 1 – 49 patients with atrial fibrillation who had no history of COVID-19 infection. Control group 2 – 22 patients with extrasystole who underwent COVID-19 but did not develop AF. Systemic inflammation, which occurs as a result of CI, provokes the appearance of de novo atrial fibrillation and worsening of the course of an already existing arrhythmia. Accompanied by an increase in the level of the N-terminal fragment of the brain natriuretic peptide precursor. There was no significant difference between the studied groups in the indicators of the level of electrolytes and lipoptotheids.

Key words: arrhythmia, atrial fibrillation, coronavirus infection, inflammation, lipids, heart failure

О.С. Сичов, О.В. Стасишена, Т.В. Талаєва, Т.І. Гавриленко, Т.В. Гетьман, О.В. Срібна, О.Я. Марченко

СТАН СИСТЕМНОГО ЗАПАЛЕННЯ, ІМУННОЇ СИСТЕМИ, ЛІПІДНОГО ПРОФІЛЮ ТА ЕЛЕКТРОЛІТІВ У ПАЦІЄНТІВ ІЗ ФІБРИЛЯЦІЇ ПЕРЕДСЕРДЬ ПІСЛЯ COVID-19

Перенесена коронавірусна інфекція (COVID-19) пов'язана з появою, рецидивом, прогресуванням фібриляції передсердь та несприятливим прогнозом. Проте, дослідження їх взаємодії обмежені та потребують подальшого вивчення. Саме тому ми вирішили оцінити стан системного запалення , імунної системи, ліпідного профілю та електролітів крові у даної когорти пацієнтів. Основну групу склали 116 осіб із фібриляцією передсердь, які перенесли COVID – 19. Перша контрольна група – 49 пацієнтів з фібриляцією передсердь, які не мали в анамнезі коронавірусної інфекції. Друга контрольна група – 22 пацієнти з екстрасистолією, які перенесли COVID-19, але фібриляції передсердь не розвинулася. Системне запалення, яке виникає внаслідок COVID – 19, провокує появу фібриляції передсердь вперше та погіршує перебіг вже існуючої аритмії, супроводжується підвищенням рівня N-кінцевого фрагмента попередника мозкового натрійуретичного пептиду. Достовірної різниці між досліджуваними групами за показниками рівня електролітів та ліпопротеїдів не було.

Ключові слова: аритмія, фібриляція передсердь, коронавірусна інфекція, запалення, ліпіди, серцева недостатність

The study is a fragment of the research project "To study the influence of damaged infection andchronic stress due to martial law on the course of atrial fibrillation", state registration No. 0122U201827.

Coronavirus infection (CI) is a viral disease from the group of acute respiratory viral infections. For the first time, coronaviruses were described in the 60s of the 20th century, they were isolated from washings from the nasal cavity. An outbreak of the disease caused by the new coronavirus SARS-CoV-2 began in mid-December 2019 in Wuhan, Hubei Province, Central China. Corona virus disease 2019 (COVID-19) is a new, highly contagious and severe disease of the SARS-CoV-2 strain that has spread rapidly around the world, causing a global socio-economic collapse [1, 2, 7, 10].

Although COVID-19 is mostly characterized by respiratory symptoms, cardiovascular disease and complications often accompany this infection, increasing patient morbidity and mortality. The prevalence of such a potentially dangerous arrhythmia as atrial fibrillation (AF) in the world is 2–4 % [3].

In Ukraine, according to 2022 data, there will be no less than 400,000 patients with AF, whose average age is 75 years, and the prevalence of this disease reaches 8–10 % at the age of over 80. But, taking into account the active hostilities in our country, the mass migration of the population both within and outside Ukraine, stress, problems with providing and receiving medical care, these indices can be much higher. Comorbidities such as hypertension, diabetes, obesity, chronic kidney disease, inflammatory diseases, and older age play a key role in the development of this rhythm disorder.

AF and COVID-19 are a common and potentially fatal combination. This rhythm disturbance is independently associated with an increase in mortality from all causes by 1.5-2 times. Almost 20 % of patients with CI have a history of AF, and the frequency of new AF is about 10 % in patients who have experienced COVID-19 infection. [4, 5, 11].

The pathophysiological changes in AF associated with COVID-19 are poorly understood, and putative mechanisms proposed include: direct viral damage to the endothelium, inflammatory cytokine storm, hyperactivation of the sympathoadrenal system, hypoxemia, and angiotensin-converting enzyme 2 receptor desensitization, interaction of CD147 and protein with sialic acid, increased inflammatory response, disturbance of electrolytes and acid-base balance in the acute phase of a severe disease [6, 14, 15].

Given that the incubation period of CI means five to six days, and in some cases up to 14 days, which is a relatively short period of time for fibrosis to form, it is likely that patients with COVID-19 and first-onset AF may have a pre-existing substrate for AF, and acute infection with COVID-19 is the trigger for the initiation of AF paroxysms, which is consistent with the temporal relationship between de novo AF and COVID-19 infection [5].

The purpose of the study was to determine the state of the immune system, the activity of the systemic inflammatory process, the lipid profile and the level of electrolytes in patients who have suffered a coronavirus infection, depending on the course of atrial fibrillation.

Materials and methods. The main group (OG) consisted of 116 patients hospitalized with AF aged 63.8 ± 0.6 years (men – 56, women – 60) who underwent CI from 1 to 12 months ago (on average 5.1±0.2 months) transferred CI. The first group (1st group) was formed by 36 people (31 %) with AF, which was registered for the first time after being infected with COVID-19. The period from the transferred CI to the deterioration of their condition was 2.01±0.19 months, and the period from the deterioration of the condition to the moment of hospitalization was 3.1±0.2 months.

The 2nd group (2nd group) included 25 patients (21.5 %) in whom there was a change in the course of AF after a CI, namely: the transformation of a paroxysmal form of AF into persistent AF or persistent AF into a permanent form of AF. The 3rd group (3rd group) included 55 (47.5 %) patients in whom the form of AF did not change. In the 3rd group, two subgroups were formed: 3A in the number of 35 patients in whom, although the form of AF did not change, but its course worsened – the frequency or duration of paroxysms increased, and 3B, which included 20 people without significant changes in the course of AF.

The first control group (C1) included 49 patients who had a history of AF but did not suffer from CI. The second control group (C2) included 22 patients with extrasystole who underwent HF but did not develop AF. Thus, as a result of transferred CI, AF “de novo” occurred in 31 % of the examined persons, and in 60 out of 80 patients (75 %), the course of this arrhythmia worsened.

All patients signed informed consent to participate in the study. The research protocol was approved by the local ethics commission in accordance with the main provisions of the Council of Europe Convention on Human Rights and Biomedicine, the World Medical Association Declaration of Helsinki on the ethical principles of conducting human medical research and current regulations of the Ministry of Health of Ukraine.

Blood parameters were studied: C-reactive protein (CRP), N-terminal fragment of brain natriuretic peptide precursor (NT-pro BNP), total cholesterol, triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low density lipoproteins cholesterol (LDL-C), very low-density lipoprotein cholesterol (VLDL-C), immunoglobulin M (Ig M) and immunoglobulin G (Ig), potassium (K), sodium (Na), D-dimer using devices "BioSystems", Finecare, Labsystems iEMS Reader MF.

Mathematical processing of the material was performed on a personal computer using the standard statistical programs Statistics 10 for Windows (StatSoftInc., Oklahoma, USA) and IBM SPSS Statistics 20. For quantitative indicators, the primary statistical processing included the calculation (M±m, where M – arithmetic mean, m – standard deviation of the mean) or absolute and relative values.

Results of the study and their discussion. The latest studies indicate a connection between inflammatory processes and the development of AF, so we evaluated a number of indices, which are shown in Table 1.

CRP which is a protein of the acute phase and participates in the formation of nonspecific immunity. Under conditions of inflammation, the synthesis of CRP in the liver increases several times, and the increase in its concentration in plasma/serum is detected 6 or more hours after the onset of an inflammatory disease or tissue damage. Patients (MG), those who had AF and underwent CI, had a significantly higher CRP index than the first control group (C1), which included patients with AF who did not suffer from CI. A statistically significant high level of CRP, 1.5 times higher, was also found in the 2nd group of patients, in whom AF transformation into a more severe form occurred after CI, in comparison with the 3rd group of people, in whom the form of AF did not change, but in comparison with the control group, C1 is probably 1.7 times higher. It should also be added that the average level of SRP was higher than the norm in the 1st and 2nd groups, that is, in patients in whom the transferred CI caused the appearance of AF or a significant worsening of its course.

The systemic inflammation that occurs as a result of CI provokes the appearance of de novo AF and the worsening of an already existing arrhythmia, which is evidenced by significantly higher CRP indicators in patients who have undergone a COVID-19 infection.

Table 1

CRP, NT-pro BN and D-dimer in patients of the examined groups and subgroups

Comparison groups and subgroups	CRP (mg/L)	NPproBN (pg/mL)	D-dimer (mgFEU/mL)
MG (1st & 2nd & 3rd)	4.92±0.36	592.03±139.10	0.32±0.027
1st ((AF-)(CI+))	5.42±0.43	415.52±144.44	0.29±0.024
2nd& 3rd ((AF+)(CI+))	4.83±0.45	705.9±124.56	0.33±0.015
2nd	6.12±0.82	1099.6±137.71	0.34±0.045
3rd	4.21±0.29	444.3±71.33	0.32±0.047
3A subgroups	4.31±0.41	519.9±87.79	0.27±0.015
3B subgroups	3.99±0.29	437.2±153.07	0.36±0.085
C1	3.58±0.21	363.9±176.09	0.26+0.024
C2	3.74±0.18	87.2±14.85	0.27±0.023
Normal values	<5.0	0–125	0–0.55
MG and C1	p<0.005	not reliable	not reliable
1st and C2	p<0.002	p<0.05	not reliable
2nd & 3rd and C1	p<0.02	no data	p<0.02
2nd and C1	p<0.02	p<0.005	not reliable
3rd and C1	not reliable	not reliable	not reliable
2nd and 3rd	p<0.02	not reliable	not reliable
3A and 3B	not reliable	not reliable	not reliable
3A and C1	not reliable	not reliable	not reliable
3B and C1	not reliable	not reliable	not reliable

Another marker of the severity of cardiovascular disease is brain natriuretic peptide (BNP), which is secreted as a result of ventricular wall stress, which is usually caused by volume or pressure overload. In patients with COVID-19, numerous studies have also found a significant relationship between (NT-pro) BNP concentrations at hospitalization and subsequent clinical outcomes. Thus, according to data from a representative single-center study conducted in Spain with the inclusion of 396 patients with COVID-19 who presented to the emergency department of a medical care center during the first wave of the COVID-19 pandemic, approximately half of the patients had NT-pro BNP levels above the recommended cut-off values for the identification of heart failure (n = 192), but only 47 patients met the clinical criteria for heart failure. After multivariable Cox regression analysis, the authors reported a significant association between NT-pro BNP and mortality.

Data from meta-analyses further highlighted the prognostic value of both BNP and NT-pro BNP for mortality and disease severity in patients with COVID-19.

In addition, its concentration also increases in AF, which indicates overstretching of the atria.

The average level of NT-pro BNR was increased in all the groups examined by us, except for the control group (C2), which included patients without the development of AF after undergoing CI. As for the role of CI in the increased levels of this indicator under investigation, its value was probably greater in the 1st group, which included patients in whom COVID-19 caused the initiation of AF (by 8.1 times) compared to the control group C2 , in which CI did not provoke this type of arrhythmia.

Among all groups, the level of NT-pro BNR was the highest in the 2nd group, which included patients who underwent a transformation of the AF form to a more unfavorable one (3.0 times), compared to the control group (C1), which included patients with AF without a history of COVID-19 infection. This is quite logical, since the level of NT-pro BNR is a marker of HF, and in the 1st and 2nd groups the class of HF was greater, and more patients with HF IIA stage were also found.

According to the obtained results of the study, it can be concluded that as a result of transferred CI there is an increase in the level of NT-pro BNR, as a marker of HF, which is especially pronounced in patients in whom this infection caused the initiation of AF de novo or provoked its transformation. That is why determination of NT-pro BNP level may improve early prognostic stratification in patients with AF after suffering from COVID-19.

Another pathophysiological mechanism that occurs with COVID-19 is a hypercoagulable state. It is well known that a hypercoagulable state is demonstrated by high levels of CRP and D-dimer . An increase in the level of D-dimer indicates hyperactivation of secondary fibrinolysis, which means a tendency to intravascular thrombosis. D-dimer is a breakdown product of cross-linked fibrin, and it is a circulating marker of thrombus formation. Elevated D-dimer levels may reflect atrial thrombus formation and a higher

risk of embolism in patients with AF D-dimer is universally considered the gold standard test for coagulation activation.

The impact of D-dimer levels in patients who had recovered from COVID-19 within the past 6 months was evaluated in a meta-analysis of a prospective study conducted at the Medical University of Vienna, the Hitzing Hospital and the Otto-Wagner Hospital. It was found that 15 % of patients who recovered from COVID-19 had persistent elevation of D-dimer, on average, 3 months after COVID-19.

In the patients examined by us, the mean indices of D-dimer were within the normal range. Although the mean values in the groups of patients with AF who underwent CI were 7-27 % higher than in the control groups C1 and C2. However, a statistical difference was obtained between the groups of patients with AF undergoing CI (groups 2nd &3rd) and the control group (C1), which included individuals with AF but no history of COVID-19. This fact certainly confirms the presence of a more pronounced systemic inflammation in patients with AF who underwent CI caused by COVID-19 (1st group) and especially in patients with AF and in patients of the 2nd group, in whom AF transformation took place (2nd group).

The next stage of the study was the study of immune status, namely IgM and IgG. As we know, the presence of IgM allows establishing a recent infection with the SARS-CoV-2 coronavirus and confirming the acute phase of the infection. IgM antibodies are detected from the 7th day after the onset of the disease. The level of IgM was evaluated at a value of <0.9 g/l as negative, between 0.9 and 1.1 g/l as doubtful, and in the case of > 1.1 g/l as positive.

The presence of IgG makes it possible to assess the level of antibodies to the SARS-CoV-2 coronavirus, as a result of the transferred coronavirus disease COVID-19 and/or after vaccination against COVID-19. It is advisable to detect IgG antibodies from the 14th day after the onset of the disease or the administration of the first dose of the vaccine. The result of the analysis was interpreted as negative at a value of 0-10 BAU/ml, at values in the range of 11-79 BAU/ml as a low neutralizing effect, and in the case of > 80 BAU/ml as a persistent effect.

It is worth noting that at the time of our examination of the patients, vaccination was not carried out, which reduces its effect on the results in the studied groups of patients. These research results are presented in Fig. 1

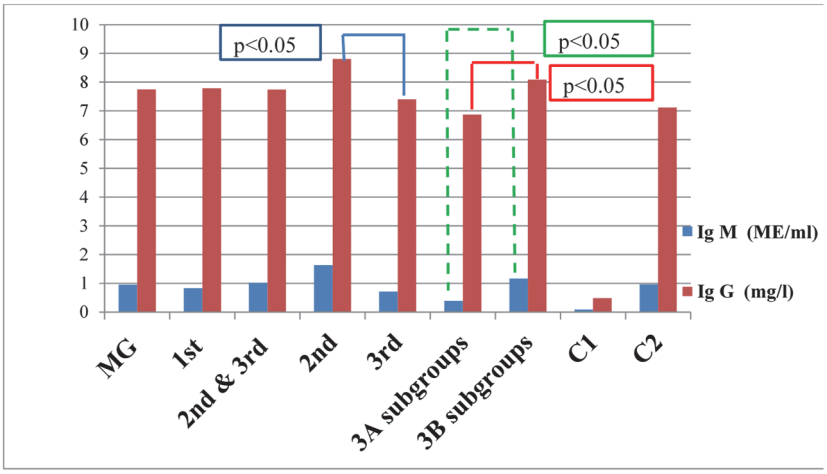

Fig. 1. Levels of IgM and IgG in the examined groups and subgroups

According to the obtained data, the level of IgM in all main studied groups of patients with AF who underwent CI was statistically significantly higher than in the control group K1, which included patients with AF without a history of CI, and did not differ in comparison with the comparison group C2, that included patients with a history of COVID-19 without subsequent AF development. At the same time, the highest level of IgM was in patients of the 2nd group, in which the transformation of the form of FP took place and in subgroup 3B.

The same pattern was characteristic for the IgG index. As can be seen from Table 2, its level in all main studied groups of patients with AF who underwent CI was probably significantly higher than in the control group C1, which included patients with AF without a history of CI, and did not differ in comparison with the comparison group C2 (patients with a history of COVID-19 and without AF). Based on the above, it can be concluded that the most pronounced reaction on the part of the immune system was in patients in whom the transferred CI led to the transformation of the AF form.

Taking into account the importance of electrolyte homeostasis in the genesis of any arrhythmia, including AF, an analysis of K and Na levels was performed in patients of the examined groups and subgroups. These data are shown in Fig. 1. It should be noted that the mean values of these indices in all studied groups and subgroups were within the normal range and there was no statistically significant difference between the examined patients regarding the level of K and Na.

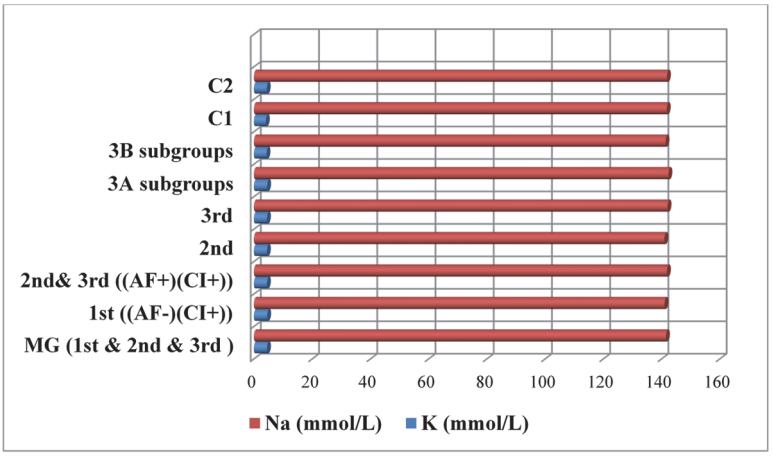

Fig. 2. Levels of K+ and Na+ in the examined groups and subgroups

An analysis of the level of lipids in the examined groups and subgroups of patients was also carried out. In general, dyslipidemias in COVID-19 can probably be caused by a cytokine storm, a violation of immune function due to a viral infection. Since dyslipidemia can lead to cardiovascular diseases, in particular, the development of hypertension. Increased attention should be paid to changes in the lipid profile in patients with COVID-19.

In this connection, the levels of HC, TG, LDL, LDL, and HDL were analyzed (Table 2).

Table 2

Lipidogram indices in the examined groups and subgroups

Comparison groups and subgroups	Total Cholesterol (mmmol/L)	TG (mmmol/L)	VLDL-C (mmmol/L)	LDL-C (mmmol/L)	HDL-C (mmmol/L)
MG (1st & 2nd & 3rd)	5.31±0.11	1.37±0.08	0.62±0.04	3.28±0.11	1.40±0.04
1st	5.35±0.19	1.52±0.18	0.59±0.05	3.16±0.21	1.46±0.08
2nd& 3rd	5.28±0.13	1.30±0.06	0.64±0.05	3.33±0.12	1.37±0.03
2nd	5.31±0.11	1.24±0.06	0.57±0.02	3.12±0.22	1.41±0.05
3rd	5.33±0.17	1.33±0.07	0.67±0.07	3.43±0.15	1.40±0.04
3A subgroups	5.26±0.13	1.36±0.07	0.63±0.02	3.38±0.16	1.32±0.04
3B subgroups	5.46±0.36	1.28± 0.15	0.72±0.13	3.50±0.29	1.42±0.04
C1	5.48±0.19	1.52±0.10	0.72±0.05	3.29±0.20	1.42±0.06
C2	5.60±0.25	1.05±0.11	0.52±0.12	3.60±0.25	1.51±0.11
Normal values	2.8±5.2	0.2±1.7	0.1-0.57	0-4.12	0.91-1.56

It was noted that there was no statistically significant difference between the indices of the examined groups. However, in all examined groups and subgroups, the mean values of HC and VLDL were higher than normal. This is logical, given that the majority of patients suffered from coronary heart disease. But as for the average values of TG, LDL, and HDL, as can be seen, they were within the normal range in all groups and subgroups.

The obtained data are confirmed with the analyzed results of literary sources. Thus, in a study that included 673 patients with SARS-CoV-2 infection, the level of CRP was significantly higher in patients with first-onset paroxysms of AF compared to those who did not. The scientists concluded that the increase in systemic inflammatory activity in these patients is a predictor of the development of "de novo" AF [8, 9, 12, 13]. In addition, a multicenter study that was conducted in the Netherlands and included 3064 patients with COVID-19 demonstrated that first-ever verified AF is a marker of disease severity and correlates with an increase in pro-inflammatory protein [14].

A retrospective cohort study involving 416 patients with COVID-19 in Wuhan Tongji Hospital should be mentioned. Its interest was that electrocardiogram (ECG), D-dimer levels and in-hospital mortality were recorded for all patients. ECG changes, namely AF registration of about 10 % and elevated D-dimer levels, were found to be associated with a higher risk of critical illness and death in patients hospitalized for COVID-19. Thus, ECG screening and elevated D-dimer levels can be used to predict the risks of COVID-19 in patients with AF [2].

Conclusions

1. Systemic inflammation, which occurs as a result of CI, provokes the appearance of de novo atrial fibrillation and the deterioration of the course of an already existing arrhythmia, as evidenced by significantly higher rates of SRP in patients who have undergone a COVID-19 infection.

2. As a result of infection with COVID-19, there is an increase in the level of the N-terminal fragment of the brain natriuretic peptide precursor, as a marker of retinal insufficiency, which is especially

evident in patients in whom the transferred corona virus disease contributed to the emergence of atrial fibrillation or its transformation.

3. The most pronounced reaction on the part of the immune system was in patients in whom the transferred CI led to the transformation of the AF form.

4. There was no significant difference between the studied groups in indices of the level of electrolytes and lipoproteins.

References

1. Ali SA, Baloch M, Ahmed N, Ali AA, Iqbal A. The outbreak of Coronavirus Disease 2019 (COVID-19) –An emerging global health threat. J Infect Pub Health. 2020; 13(1) :644–646. doi: 10.1016/j.jiph.2020.02.033.

2. Changaripour S, Sarvazad H, Barghi M, Sajadi E, Sadeghian MH, Roozbahani NE. Lipid profile changes in patients with COVID-19 referred to medical centers in Kermanshah, Iran; a case-control study. J Int Med Res. 2022; 50(2) :30–99. doi: 10.1177/03000605221078699.

3. Chen J, Wang Y, Wang J, Chen L, Luo Q, Wang B, et.al. Coronavirus disease 2019 death prediction by electrocardiographic abnormalities and elevated D-dimer levels. Front Cardiovasc Med. 2022; 9(1): 83–94. doi: 10.3389/fcvm.2022.948347.

4. Donniacuo M, De Angelis A, Rafaniello C, Cianflone E, Paolisso P, Torella D, et.al. COVID-19 and atrial fibrillation: Intercepting lines. Front Cardiovasc Med. 2023; 10(1): 1093053. doi: 10.3389/fcvm.2023.1093053.

5. Gawałko M, Kapłon-Cieślicka A, Hohl M, Dobrev D, Linz D. COVID-19 associated atrial fibrillation: Incidence, putative mechanisms and potential clinical implications. Int J Cardiol Heart Vasc. 2020; 30:100631. doi: 10.1016/j.ijcha.2020.100631.

6. Hindricks G, Potpara T, Dagres N, Arbelo E, Bax JJ, Blomström-Lundqvist C, et. al. 2020 ESC Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS): The Task Force for the diagnosis and management of atrial fibrillation of the European Society of Cardiology (ESC) Developed with the special contribution of the European Heart Rhythm Association (EHRA) of the ESC. European Heart Journal. 2021; 42(5):373–498. doi.org/10.1093/eurheartj/ehaa612.

7. Kaufmann CC, Ahmed A, Burger AL, Muthspiel M, Jäger B, Wojta J, et. al. Biomarkers Associated with Cardiovascular Disease in COVID-19. Cells. 2022; 11(6) :922. doi: 10.3390/cells11060922.

8. Lehmann A, Prosch H, Zehetmayer S, Gysan MR, Bernitzky D, Vonbank K, et. al. Impact of persistent D-dimer elevation following recovery from COVID-19. PLoS One. 2021; 16(10) :0258351. doi: 10.1371/journal.pone.0258351. (18).

9. McDonagh TA, Metra M, Adamo M, Gardner RS, Baumbach A, Böhm M et. al. ESC Scientific Document Group. 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure. Eur Heart J. 2021;42(36):3599–3726. doi: 10.1093/eurheartj/ehab368.

10. Pranata R, Huang I, Lukito AA, Raharjo SB. Elevated N-terminal pro-brain natriuretic peptide is associated with increased mortality in patients with COVID-19: systematic review and meta-analysis. Postgrad Med J. 2020; 96(1137) :387–391. doi: 10.1136/postgradmedj-2020-137884.

11. Plaut S. “Long COVID-19” and viral “fibromyalgianess”: Suggesting a mechanistic role for fascial myofibroblasts (Nineveh, the shadow is in the fascia). Front Med (Lausanne). 2023; 10:952278. doi: 10.3389/fmed.2023.952278.

12. Sano T, Matsumoto S, Ikeda T, Kuroda S, Kitai T, Yonetsu T. New-Onset Atrial Fibrillation in Patients with Coronavirus Disease 2019 (COVID-19) and Cardiovascular Disease – Insights From the CLAVIS-COVID Registry. Circulation Journal. 2022; 86 (8):1237–1244. doi.org/10.1253/circj.CJ-21-0911(8)

13. Serafino Fazio. Risks of deep vein thrombosis, pulmonary embolism, and bleeding after covid-19: nationwide self-controlled cases series and matched cohort study. BMJ 2022; 377:069590 doi: https://doi.org/10.1136/bmj-2021-069590 (17)

14. Sychov OS, Stasyshena OV, Mikhalieva TV, Torbas OO, Husarchuk AG. Influence og the transmitted infection of COVID-19 on the prevalence and course of atrial fibrillation in hospitalized patients. World of Medicine and Biology. 2023; 3(85) :171–174. doi:10.26724/2079-8334-2023-3-85-171-174

15. Yarmola TI, Gutsalenko OO, Tkachenko LA, Katerenchuk IP, Kostrikova UA, Pustovoyt HL, Talash VV, Tsyganenko IV. Microscopic Polyangiitis is a “Masquerade Ball” in Modern Realities: A Literature Review. J Urol Nephrol. 2023; 8 (4): 000248. doi: 10.23880/oajun-16000248

Стаття надійшла 19.02.2023 р.