http://medpr.imp.lodz.pl/en

https://doi.org/10.13075/mp.5893.01378

ORIGINAL PAPER

INCREASED CORONARY ARTERY DISEASE SEVERITY IN PATIENTS UNDERGOING INVASIVE DIAGNOSTICS DURING THE COVID-19 PANDEMIC

Tomasz Wcisło[1], Karolina Kołodziej[1,2], Marcin Książczyk[1], Kasper Kuna[3], Damian Mikulski[3], Ewa Borowiak[2], Michał Plewka[1]

Medical University of Lodz, Łódź, Poland
[1] Department of Interventional Cardiology and Cardiac Arrhythmias, Military Medical Academy, Memorial Teaching Hospital
[2] Department of Conservative Nursing, Faculty of Health Sciences
[3] Department of Biostatistics and Translational Medicine

Abstract

Background: This study aimed to compare the stage of coronary heart disease in patients who underwent invasive cardiac diagnostics during the COVID-19 pandemic and before, based on the number of medical devices used and the number of complex coronary angioplasty procedures performed. **Material and Methods:** A retrospective, single-center study was conducted, which included 187 successive patients with diagnosed coronary heart disease, who were divided into 2 groups: group I (N = 92, pre-COVID-19 pandemic) and group II (N = 95, during COVID-19 pandemic). **Results:** Despite a comparable number of invasive procedures in both groups, stent length and contrast use per procedure were significantly higher during the COVID-19 pandemic. Similarly, a higher number of stents was used per patient in 2021, however, the difference was not statistically significant (p = 0.0817). Similarly, fluoroscopy time per procedure and procedure duration were significantly longer in the 2021 group. Among patients treated during the COVID-19 pandemic, higher glucose concentration, blood pressure parameters, low-density lipoprotein and total cholesterol were observed; however, these differences were not statistically significant. **Conclusions:** During the COVID-19 pandemic, coronary atherosclerosis progression were found, requiring a higher number of complex coronary angioplasty procedures, which contributed to a statistically significant increase in the number of medical devices used (angioplasty guidewires, angioplasty balloons) and procedures duration. Med Pr Work Health Saf. 2024;75(4)

Key words: atherosclerosis, percutaneous coronary intervention, coronarography, ischaemic heart disease, COVID-19, risk factors for coronary heart disease

Corresponding author: Tomasz Wcisło, Medical University of Lodz, Department of Interventional Cardiology and Cardiac Arrhythmias, Military Medical Academy, Memorial Teaching Hospital, Żeromskiego 113, 90-549 Łódź, Poland, e-mail: tomasz-wcislo@wp.pl
Received: April 9, 2023, accepted: May 28, 2024

INTRODUCTION

Since November 2019, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) viral infection causing coronavirus disease 2019 (COVID-19) has become the risk aggravating factor of cardiovascular and respiratory disease onset/progression [1,2]. The ongoing pandemic affects many aspects of everyday life [3]. Lifestyle, psychological, socio-economic, and environmental factors changed significantly during and in response to the pandemic [4–6]. Experimental research revealed a strong affinity of the SARS-CoV-2 virus to angiotensin-converting enzyme 2 receptors (ACE2) [7,8]. Pathophysiologically, it inhibits the activation of the renin-angiotensin-aldosterone (RAA) system by inhibiting the conversion of angiotensin 2 (AngII) to angiotensin 1–7 (Ang1–7) [9]. Angiotensin 1–7, which is the major product of ACE2 action, counteracts the effects of AngII, e.g., in the cardiac muscle, blood vessels, and kidneys, by exerting potent vasodilating, anti-proliferative, hypertrophic, and fibrotic process inhibiting, and anti-thrombotic actions. In many systems, an imbalance in AngII and Ang1–7 concentrations was seen to disrupt the circulatory system's homeostasis [8–10]. The respiratory system was particularly affected. Immunothrombogenic activity in the endothelium of lung capillary capillaries led to severe respiratory insufficiency associated to pneumonia with ground-glass opacity and pulmonary embolism [11]. In the circulatory system, the presence of thrombi in coronary blood arteries caused myocardial infarction in patients without a history of cardiovascular illness [11,12]. In addition, the magnetic

resonance examination revealed features of myocarditis lasting >2 months after the subsidence of COVID-19 symptoms in 60% of patients with the SARS-CoV-2 infection [12]. Therefore, it appears that SARS-CoV-2 infection can lead to long-lasting consequences related to the risk of circulatory system diseases in subjects who survived COVID-19. Limited access to general practitioners and specialists during the COVID-19 pandemic, and consequently limited early diagnostics, resulted in many seemingly healthy patients coming to doctors for follow-up examinations only when they experienced cardiological complications. The fear of coronavirus infection and hospitalization often related to a severe course of the disease caused patients suffering from cardiovascular disease (but not only them) to stay home too long, despite their symptoms. Furthermore, a lack of access to on-site medical care and the forced rapid development of remote medical care (telemedicine) led to a situation in which many patients were not covered by follow-up examinations or did not comply. A lack of optimized treatment or diagnosis of such diseases as arterial hypertension, hypercholesterolemia, and diabetes leads to the progression of cardiovascular diseases that could be prevented. Consequently, more patients were observed with much more advanced disease stages than before the pandemic, often requiring intensive therapy from the onset.

Purpose

This study aimed to compare stages of coronary heart disease in patients who underwent invasive cardiac diagnostics during the COVID-19 pandemic and in the pre-pandemic period based on the number of medical devices used and the higher number of complex coronary angioplasty procedures (nursing and medical aspects).

The secondary purpose was to identify the prognostic factors increasing the likelihood of high-stage coronary atherosclerosis in patients hospitalized to have invasive cardiac diagnostic tests performed in the Department of Interventional Cardiology and Cardiac Arrhythmias of the Military Medical Academy – Central Veteran's Hospital in Łódź, Poland, during the COVID-19 pandemic (October 2021) compared to the patients treated in the corresponding period before the pandemic (October 2019).

The tertiary purpose was to demonstrate poorer compliance based on selected laboratory parameters in light of a lack of access to on-site medical care during the COVID-19 pandemic.

MATERIAL AND METHODS

A retrospective, single-center study was conducted, which included 187 successive patients with diagnosed coronary heart disease hospitalized in the Department of Interventional Cardiology and Cardiac Arrhythmias and divided into 2 groups: group I (N = 92, hospitalized in October 2019) and group II (N = 95, hospitalized in October 2021). Four patients administered to the hospital in October 2021 had suffered from COVID-19, while the rest had not been infected with SARS-CoV-2. The retrospective analysis was based on 1 month of the year chosen at random (October) with a high percentage of coronary angiography/coronary angioplasty procedures in 2019 compared to 2021. All the patients under observation received complete treatment recommended for coronary heart disease (according to the current guidelines of the Polish Cardiac Society and European Cardiac Society). Moreover, each patient was subject to the following:

- detailed clinical assessment (medical history, medical examination including arterial blood pressure measurement),
- collecting a blood sample (10 ml) from the peripheral vein for complete blood count and biochemical tests,
- electrocardiogram at rest,
- Doppler echocardiography to examine global and local contractility and diastolic function,
- coronarography based on which the subjects were qualified for one of the three coronary heart disease treatment modes:
  - preventive (pharmacological),
  - percutaneous revascularisation (coronary angioplasty) or surgical revascularisation (coronary artery bypass grafting) if significant stenosis of coronary arteries had been discovered.

Statistical analysis

Continuous variables were presented as a mean (M) with standard deviation (SD) (for normal distribution variables) or as a median (Me), including the upper and lower quartile (25–75 percentile, interquartile range – IQR) for the non-normal distribution variables. The normality of distribution was verified with the Shapiro-Wilk test. For continuous variables, the difference between 2 groups was determined using a 2-sided independent Student's t-test if the data were normally distributed and the Mann-Whitney U test if the assumption of normality was not met or the variable was

ordinal. Pearson's χ^2 test was used to compare the distribution of nominal variables. Benjamini-Hochberg was used for p-value correction for multiple comparisons. The values of $p < 0.05$ were considered statistically significant. The statistical analysis was done using the Statistica 13.1 software (Tibco, Palo Alto, CA, USA).

RESULTS

Table 1 summarise the essential characteristics of the study subgroups. The study groups did not differ in the key clinical and demographic parameters. The gender distribution in the compared groups I and II was as follows: (38 men, 54 women, p not significant) vs. (33 men, 62 women). A higher percentage of hospitalized women than men was observed in 2019 and 2021, but not statistically significant ($p = 0.35$). Gender was not included as a confounding factor in the study results. It should be emphasized that higher systolic and diastolic arterial blood pressure values were observed in the COVID-19 group, but these differences lost significance after correction for multiple comparisons. A boundary progression of cardiac insufficiency and chronic obstructive pulmonary disease was observed during the COVID-19 pandemic, which was statistically insignificant. A tendency was observed towards a higher prevalence of diabetes mellitus type 2 and smoking.

Among laboratory results, the group treated during the COVID-19 pandemic had higher glucose concentration, mean erythrocyte volume, and hematocrit value (Table 2). Troponin levels were determined at discharge in only 47 patients in group I and 64 in group II. Troponin testing at discharge was performed only in patients with elevated results during hospital admission and after complex coronary angioplasty. These differences lost their significance after correction for multiple comparisons. Additionally, patients treated during the COVID-19 pandemic tended to have higher total cholesterol and low-density lipoprotein (LDL), but these observations were not statistically significant.

Table 3 summarises the characteristics of coronarography and coronaroplasty procedures performed in the group in 2019 vs. 2021. In 2021, a statistically higher number of complex angioplasty procedures was performed due to higher-stage atherosclerosis.

Performing coronarography/coronary angioplasty in patients hospitalized during the pandemic was related to statistically significantly higher usage of the contrast medium and there was a higher number of stents used per patient in 2021, however, the latter was not statistically significant ($p = 0.0817$). Despite a comparable number of coronarography/coronary angioplasty procedures in both groups, a different number of devices was used. In 2019, 22% more coronary guidewires were used for coronary angioplasty compared to 2021 (70 vs. 57, 22% increase), which was associated with significantly increased atherosclerosis in patients during the pandemic. The same trend was observed in the number of semi-compliant balloon catheters used in 2019 vs. 2021 (33 vs. 55, 66.7% increase), non-compliant balloon catheters (3 vs. 16, 533.3% increase), and stents (57 vs. 87, 52.6% increase). Overall, stents length, contrast use per procedure, fluoroscopy time per procedure, and procedure duration time were significantly higher during the COVID-19 pandemic.

Table 4 shows the difference in the characteristics of the medical devices used in hospitalized patients in 2019 vs. 2021. The new guidelines of the Polish Cardiac Society and European Cardiac Society on treating coronary heart disease/infarction without ST-segment elevation resulted in more frequent treatment with state-of-the-art antiplatelet and anti-thrombotic drugs.

DISCUSSION

As a result of hampered health care services, many risk factors of cardiovascular events were not diagnosed or treated on time. Most likely, the deteriorated medical examination results and patients' self-control during the pandemic are linked to the more advanced atherosclerosis revealed during invasive cardiac diagnostic tests [13,14]. This study analyses the number of devices used and the type and duration of procedures in patients subject to coronarography. The results reveal a more advanced disease process in patients treated during the COVID-19 pandemic than those treated beforehand [15,16]. Only 4 patients infected with SARS-CoV-2 were included in the study, but their results did not significantly affect patient outcomes in the entire group. However, the significant severity of the inflammatory response probably had an impact on the nature/morphology of the coronary lesions and the long-term prognosis. The small percentage of patients infected with SARS-CoV-2 was the reason no further analysis was performed [17,18].

Many study authors emphasize that even a mild course of the disease caused by SARS-CoV-2 significantly increases the likelihood of cardiovascular complications, including but not limited to infarction and cerebral stroke [19,20]. According to the results from American

Table 1. Baseline characteristics of patients: group treated before (October 2019) and during the pandemic of COVID-19 (October 2021) with coronary atherosclerosis from the Department of Interventional Cardiology and Cardiac Arrhythmias, Military Medical Academy in Łódź, Poland, in a retrospective study

Variable	2019		2021		p	Benjamini-Hochberg p
	Me (IQR)	participants (N = 92) [n (%)]	Me (IQR)	participants (N = 95) [n (%)]		
Demographic						
sex						
women		38 (41)		33 (35)	0.35	0.753
men		54 (59)		62 (65)		
age [years]	72 (66–76)	92 (100)	69 (62–75)	95 (100)	0.09	0.18
height [m]	1.78 (1.67–1.82)	92 (100)	1.78 (1.69–1.82)	92 (97)	0.96	0.96
weight [kg]	84 (76–87)	92 (100)	84 (78–89)	92 (97)	0.82	0.94
BMI [kg/m^2]	26.24 (24.79–30.42)	92 (100)	27.16 (24.79–29.74)	92 (97)	0.79	0.94
Health status						
actual						
blood pressure [mmHg]						
systolic	120.0 (120.0–130.0)	92	130.0 (120.0–140.0)	94 (99)	0.014	0.896
diastolic	75.0 (72.0–85.0)	92	80.5 (74.0–87.0)	94 (99)	0.013	0.056
heart rate [×/min]	79.0 (66.0–88.0)	92	80.0 (69.0–87.0)	94 (99)	0.06	0.16
ejection fraction [%]	50.0 (42.0–57.0)	92	48.0 (42.0–57.0)	94 (99)	0.56	0.896
sinus rhythm		76 (82.61)		75 (78.95)	0.62	0.753
atrial fibrillation		16 (17.39)		19 (20.0)		
myocardial infarction						
ST elevation		12 (13.04)		6 (6.31)	0.12	0.68
non-ST elevation		15 (16.3)		24 (25.26)	0.12	0.68
acute coronary syndrome – unstable angina		6 (6.52)		4 (4.21)	0.49	0.753
chronic coronary syndrome		46 (50.0)		47 (49.47)	1.00	1
hypertension		92 (94.57)		91 (95.79)	0.49	0.753
diabetes type 2		29 (31.52)		38 (40.0)	0.21	0.753
impaired glucose tolerance		5 (5.43)		5 (5.26)	0.77	0.873
heart failure (NYHA class)					0.62	0.753
I		55 (59.78)		44 (46.32)		
II		21 (22.83)		30 (31.58)		
III		15 (16.3)		13 (13.68)		
IV		1 (1.07)		7 (7.37)		
nicotynism (≥1 cigarette/day)		34 (36.96)		42 (44.21)	0.28	0.753
dyslipidemia		82 (89.13)		87 (91.58)	0.58	0.753
chronic obstructive pulmonary disease		2 (2.17)		9 (9.47)	0.06	0.68
stroke		6 (6.52)		7 (7.37)	0.94	0.999

Table 1. Baseline characteristics of patients: group treated before (October 2019) and during the pandemic of COVID-19 (October 2021) with coronary atherosclerosis from the Department of Interventional Cardiology and Cardiac Arrhythmias, Military Medical Academy in Łódź, Poland, in a retrospective study – cont.

Variable	2019		2021		p	Benjamini-Hochberg p
	Me (IQR)	participants (N = 92) [n (%)]	Me (IQR)	participants (N = 95) [n (%)]		
Health status – cont.						
previous						
percutaneous coronary interventions		19 (20.65)		24[a] (25.53)	0.43	0.753
coronary artery bypass grafting		7 (7.61)		10[a] (10.64)	0.47	0.753
myocardial infarction		22 (23.91)		27[a] (28.72)	0.456	0.753

[a] Of 94 participants.

Table 2. Laboratory results of patients: group treated before (October 2019) and during the pandemic od COVID-19 (October 2021) with coronary atherosclerosis from the Department of Interventional Cardiology and Cardiac Arrhythmias, Military Medical Academy in Łódź, Poland, in a retrospective study

Parameter	2019		2021		p	Benjamini-Hochberg p
	Me (IQR)	participants [n] (N = 92)	Me (IQR)	participants [n] (N = 95)		
Glucose [mg/dl]	110.1 (97.3–131.9)	92	116.6 (104.2–146.7)	94	**0.013**	0.143
Na [mmol/l]	139.0 (136.0–140.0)	92	139.5 (137.0–141.0)	94	0.074	0.326
K [mmol/l]	4.31 (4.12–4.54)	92	4.35 (4.16–4.59)	94	0.30	0.486
Cl [mmol/l]	104.0 (101.0–105.0)	92	103.0 (101.0–105.0)	94	0.38	0.486
Creatinine [mg/dl]	0.86 (0.75–1.13)	90	0.87 (0.79–1.12)	94	0.38	0.486
Glomerular filtration rate [ml/min/kg]	81.65 (59.5–97.95)	92	77.15 (55.7–92.5)	94	0.42	0.486
Cholesterol [mg/dl]						
total	162.4 (128.0–198.8)	92	169.4 (143.9–189.1)	92	0.41	0.486
LDL	89.3 (56.1–124.1)	92	95.5 (62.3–119.1)	92	0.37	0.486
HDL	48.3 (38.7–56.5)	92	49.1 (43.7–58.4)	92	0.13	0.348
TG [mg/dl]	116.0 (86.8–160.3)	92	103.6 (74.4–151.5)	92	0.17	0.348
NT-proBNP [pg/ml]	378.0 (130.6–3977.0)	23	505.5 (197.0–2343.0)	46	0.71	0.71
C-reactive protein [mg/l]	3.3 (1.8–6.3)	41	4.5 (1.5–22.7)	63	0.45	0.495
White blood cell count [$\times 10^3/\mu l$]	7.61 (6.45–9.2)	92	8.16 (6.73–9.7)	94	0.07	0.326
Red blood cell count [$\times 10^6/\mu l$]	4.57 (4.22–4.91)	92	4.67 (4.26–5.01)	94	0.18	0.348
Hemoglobin [g/dl]	13.85 (12.8–14.8)	92	14.3 (13.1–15.2)	94	0.11	0.348
Hematocrit [%]	41.05 (37.75–43.35)	92	42.45 (39.7–43.9)	94	**0.03**	0.22
Mean corpuscular volume [fl]	88.0 (85.5–91.0)	92	90.0 (88.0–94.0)	94	**0.01**	0.143
Mean corpuscular hemoglobin [pg]	30.6 (29.2–31.4)	92	30.6 (29.8–31.6)	94	0.35	0.486
Mean corpuscular hemoglobin concentration [g/dl]	34.2 (33.4–34.9)	92	33.8 (32.9–34.6)	94	0.19	0.348
Platelet count [$\times 10^3/\mu l$]	222.5 (192.5–264.0)	92	233.5 (200.0–285.0)	94	0.19	0.348
Troponin [ng/l]						
admission	14.5 (7.5–42.5)	84	14.0 (6.0–78.0)	94	0.70	0.71
discharge	65.0 (17.0–841.0)	47	61.0 (13.0–787.0)	64	0.19	0.348

Bolded are statistically significant values ($p < 0.05$).

Table 3. Data on coronary angiography/coronaroplasty procedures performed on patients: group treated before (October 2019) and during the pandemic of COVID-19 (October 2021) with coronary atherosclerosis from the Department of Interventional Cardiology and Cardiac Arrhythmias, Military Medical Academy in Łódź, Poland, in a retrospective study

Variable	2019		2021		p	Benjamini-Hochberg p
	Me (IQR)	participants (N = 92) [n (%)]	Me (IQR)	participants (N = 95) [n (%)]		
Approach						
femoral		16 (17.39)		21 (22.1)	0.39	0.446
radial		76 (83.61)		73 (76.84)	0.39	0.446
Angioplasty						
elective		58 (63.04)		53 (55.79)	0.31	0.413
balloon		42 (45.65)		44 (46.32)	0.87	0.87
Bifurcation		8 (8.69)		35 (36.84)	<0.001	**0.00008**
Stents [n/patient]	0 (0–1)	92 (100)	1 (0–2)	95 (100)	**0.043**	0.086
Guidewires [n/patient]	0 (0–1)	92 (100)	1 (0–1)	92[a] (97)	0.174	0.278
Balloons [n/patient]						
semi-compliant	0 (0–1)	92 (100)	1 (0–1)	92[a] (97)	**0.009**	**0.024**
non-compliant	0 (0–1)	92 (100)	0 (0–0)	92[a] (97)	**0.002**	**0.008**
Vessels [n/patient]	1 (1–2)	92 (100)	2 (0–3)	94 (99)	0.07	0.0817
Stents [mm]						
width	2.23 (0–2.83)	92 (100)	2.44 (0–3)	94 (99)	0.14	0.14
length	8.0 (0.0–16.0)	92 (100)	14.0 (0.0–28.0)	94 (99)	**0.0256**	**0.0448**
Contrast use [ml/procedure]	100.0 (60.0–150.0)	92 (100)	140.0 (80.0–200.0)	94 (99)	**0.009**	**0.0397**
Fluoroscopy time [s/procedure]	261.5 (122.5–440.0)	92 (100)	367.0 (166.0–591.0)	95 (100)	**0.017**	**0.0397**
Procedure duration [min]	15 (10.0–27.5)	92 (100)	25.0 (15.0–30.0)	95 (100)	**0.014**	**0.0397**

Bolded are statistically significant values ($p < 0.05$).
[a] Of 94 participants.

researchers, the prevalence of the above diseases is much higher in subjects who suffered from COVID-19, regardless of its severity [20]. Virus infection and going through COVID-19 increases the risk of cerebral stroke by 52%, myocardial infarction by 63%, and coronary heart disease by 72%. The most common cardiovascular complications following COVID-19 include cerebrovascular disorders (transient ischemic attack, cerebral stroke), disturbed cardiac rhythm (arrhythmias, ventriculoatrial conduction disorders), ischaemic heart disease (cardiac infarction), pericarditis, myocarditis, cardiac failure, and thrombotic and embolic diseases (pulmonary embolism) [20–23]. Patients suffering from heart diseases, including ischaemic heart disease, belong to a group with a higher risk of a symptomatic coronavirus infection and a more severe course of COVID-19 [19,20]. Many healthy patients who underwent COVID-19 presented to doctors only when cardiological complications occurred. Follow-up examinations after infarction or cerebral stroke in the course of COVID-19 were the reasons for visiting a doctor. The most common anomalies discovered in physicians' offices include arterial hypertension (33%), elevated blood sugar level (33%), and high cholesterol level (30%) [24]. The same trend was observed in this study. The fear of coronavirus infection and hospitalization often related to the severe course of the disease made patients suffering from cardiovascular diseases (but not only) stay home too long despite their ailments [25]. The resulting fear, though understandable, could have and indeed had some severe consequences. Similar results were observed among patients who did not go through SARS-CoV-2 virus infection, which is reflected in this study's results where higher levels of arterial blood pressure, blood glucose level, and resting heart rate were observed. Frequency of hospitalization of patients suffering from cardiovascular diseases, a decrease was observed in the number of patients admitted. This data confirm poor access to hospital healthcare services

Table 4. Medication data by a group of patients: group treated before (October 2019) and during the pandemic of COVID-19 (October 2021) with coronary atherosclerosis from the Department of Interventional Cardiology and Cardiac Arrhythmias, Military Medical Academy in Łódź, Poland, in a retrospective study

Variable	2019	2021	p	Benjamini-Hochberg p
	participants (N = 92) [n (%)]	participants (N = 95) [n (%)]		
β-blockers	77 (83.7)	89 (93.68)	**0.029**	0.152
Angiotensin-converting-enzyme inhibitors	69 (75.0)	71 (74.74)	0.93	0.96
Angiotensin II receptor blockers	16 (17.39)	14 (14.74)	0.64	0.91
Statin	86 (93.48)	88 (92.63)	0.79	0.922
Ezetymib	7 (7.61)	15 (15.79)	0.12	0.39
Calcium channel blokers	19 (20.65)	22 (23.16)	0.65	0.91
Insulin	10 (10.87)	11 (11.58)	0.96	0.96
SGLT-2 inhibitors (gliflozin)	0	14 (14.74)	**0.00007**	**0.0007**
Proton-pump inhibitors	65 (70.65)	64 (67.37)	0.70	0.919
Diuretics	52 (56.52)	61 (64.21)	0.24	0.63
Mineralocorticoid receptor antagonists	34 (36.96)	34 (35.79)	0.91	0.96
Amiodaron	8 (8.7)	3 (3.16)	0.13	0.39
Acetylsalicylic acid	66 (71.74)	68 (71.58)	0.59	0.91
Clopidogrel	34 (36.96)	30 (31.58)	0.46	0.858
Prasugrel	0	14 (14.74)	**0.00007**	**0.0007**
Ticagrelor	13 (14.13)	9 (9.47)	0.46	0.858
Acenocoumarol	3 (3.26)	1 (1.05)	0.36	0.84
Warfarin	1 (1.09)	0	0.49	0.858
Dabigatran	9 (9.78)	3 (3.16)	0.07	0.29
Rivaroxaban	4 (4.35)	4 (4.21)	0.75	0.922
Apixaban	3 (3.26)	12 (12.63)	**0.028**	0.152

Bolded are statistically significant values ($p < 0.05$).

during the COVID-19 pandemic. First and foremost, it resulted from delayed or cancelled scheduled procedures and sending patients from one hospital to another due to a lack of beds available. Over half of patients experienced difficulty getting medical help. Transforming general hospitals (which previously were medical care centers treating many patient groups) into dedicated COVID-19 centers caused many problems for people seeking medical help because of diseases other than COVID-19. These observations revealed that face-to-face patient-doctor contact is the critical compliance factor [26–28].

Studies by Chinese authors suggest that concomitant circulatory system diseases increase the risk of a severe course of COVID-19 and death in the course of the disease [29]. In many patients, pathological changes are observed in the cardiovascular system during the SARS-CoV-2 infection, such as acute cardiac muscle injury in 8–19% of patients going through COVID-19 [29–32]. The analysis revealed that the patients were elderly (74 vs. 60 years, $p < 0.001$) and had more comorbidities (arterial hypertension 59.8% vs. 23.4%, $p < 0.001$). Moreover, elevated inflammation indicators and more common non-invasive or invasive respiratory support (46.3% vs. 3.9%, $p < 0.001$) were demonstrated for the patients. These observations translated into a thirteen-time higher risk of hospitalization in the intensive care unit because of heart muscle injury traits and a four-time higher risk of death.

A study carried out in the USA confirmed that during the pandemic, the patients' self-control of arterial pressure decreased by 50%, and the control of biochemical parameters, i.e., cholesterol and blood glucose level, decreased by 37%. Based on the data, it was found that a lack of in-person visits resulting from limited

access to on-site health care does not contribute to improved control of circulatory system disease risk factors. Furthermore, it should be emphasized that only 20% of patients with hypertension and 11% with lipid disorders successfully treat their conditions. Moreover, the percentage of successfully treated patients with concomitant hypertension and high blood cholesterol level amounts to only 5%.

In a number of articles on COVID-19 patients, metabolic disorders, particularly inappropriate blood cholesterol control, were highlighted. Kow et al. [33], in their meta-analysis, focused on studies comparing the impact of statin treatment and a lack of such treatment on the course of COVID-19. A population of 8990 patients from 4 retrospective studies was analyzed. The observations revealed a significant (30%) reduction in the fatal/severe course of COVID-19 in patients who were taking statins compared to those who were not (HR 0.70, 95% CI: 0.53–0.94). The authors state that taking 3-hydroxy-3-methyl-glutaryl-CoA reductase inhibitors is safe and beneficial.

Liu et al. [34] conducted a meta-analysis of 28 clinical trials, which included 12 995 patients from the COVID-19 group. The authors emphasized that dyslipidemia was related to aggravated COVID-19 symptoms (OR 1.27, 95% CI: 1.11–1.44, p = 0.038). Moreover, the risk of death in these patients was twice higher as in those who do not have dyslipidemia (95% CI: 1.84–2.47, p = 0.001). That is why monitoring blood lipid concentration and administering lipid-lowering treatment in patients with dyslipidemia suffering from COVID-19 help reduce the mortality and severity of the disease course.

The high prevalence of cardiac arrhythmias was another significant problem related to COVID-19 infections. Non-specific palpitations were observed in 7.3% of patients admitted to the hospital because of COVID-19 [35]. Cardiac arrhythmia was observed in 16.7% of patients already hospitalized because of COVID-19 [36]. The high prevalence of arrhythmias can be attributed to metabolic disorders, cardiac muscle anoxia, and inflammation during virus infection. The onset of new malignant arrhythmias in patients with elevated troponin levels was the myocarditis indicator [37].

The fact that the virus infection through numerous ACE2 receptors occurring on pancreas β cells contributed to a higher number of diagnosed diabetes cases was another negative aspect of the pandemic. The *de novo* diabetes and severe metabolic complications of previously existing diabetes mellitus (ketoacidosis, hyperosmolarity) were related to the acute course of COVID-19. Narayan et al. [38] published the results of a study assessing the risk of diabetes development in 181 280 subjects who had been infected with the SARS-CoV-2 virus between March 1, 2020 and September 30, 2021 and survived at least 30 days. In the results, in Łódź the authors emphasize that the risk of diabetes onset within 12 months after COVID-19 increases by 40% compared to the control group. In addition, insulin resistance may develop in some previously healthy individuals after getting over COVID-19. In relation to the above, the authors think that SARS-CoV-2 infection that damages β cells with secretory vesicles is not transient. The resulting hyperactivation of the immune system and its accompanying long-lasting inflammation deteriorate insulin effectiveness. In their conclusions, the authors emphasize that, fortunately, only some patients who underwent COVID-19 would develop diabetes mellitus type 2.

The increased number of devices used during coronarography/coronary angioplasty procedures and the longer duration of the procedures were related to a higher number of complex coronary angioplasty procedures, i.e., vascular bifurcations. Troponin levels were determined at discharge in only 47 patients in group I and 64 in group II. Troponin testing at discharge was performed only in patients with elevated results during hospital admission and after complex coronary angioplasty. Patients during the COVID-19 pandemic presented with higher glucose levels, blood pressure and had a tendency to higher values of LDL and total cholesterol, suggesting that suboptimal control of basic cardiovascular risk factors may have a causative effect, however, this relationship requires analyses beyond the scope of this study.

CONCLUSIONS

During the COVID-19 pandemic, greater severity of coronary atherosclerosis were found in Department of Interventional Cardiology and Cardiac Arrhythmias, Military Medical Academy in Łódź requiring a higher number of complex coronary angioplasty procedures related to bifurcation lesions, which contributed to a statistically significant increase in the number of medical devices used (angioplasty guidewires, angioplasty balloons and the number of stents) and procedure duration. Among patients treated during the COVID-19 pandemic, higher glucose concentration, blood pressure parameters, LDL, and total cholesterol were observed, however, statistical significance for these differences was not achieved due to the limited sample size of cohort. The detailed assessment of the potential influ-

ence of these factors on more advanced coronary atherosclerosis observed during the pandemic is beyond the scope of cross-sectional study.

Author contributions
Research concept: Tomasz Wcisło, Karolina Kołodziej
Research methodology: Tomasz Wcisło, Marcin Książczyk, Ewa Borowiak, Michał Plewka
Collecting material: Tomasz Wcisło, Karolina Kołodziej
Statistical analysis: Kasper Kuna, Damian Mikulski
Interpretation of results: Tomasz Wcisło, Marcin Książczyk
References: Tomasz Wcisło

REFERENCES

1. Severino P, D'Amato A, Pucci M, Infusino F, Adamo F, Birtolo L, et al. Ischemic Heart Disease Pathophysiology Paradigms Overview: From Plaque Activation to Microvascular Dysfunction. Int J Mol Sci. 2020;21(21):8118. https://doi.org/10.3390/ijms21218118.
2. Sifuentes-Rodriguez E, Palacios-Reyes D. COVID-19: The outbreak caused by a new coronavirus. Bol Med Hosp Infant Mex. 2020;77(2):47–53. https://doi.org/10.24875/BMHIM.20000039.
3. Petzold M, Plag J, Ströhle A. Dealing with psychological distress by healthcare professionals during the COVID-19 pandemia. Nervenarzt. 2020;91(5):417–21. https://doi.org/10.1007/s00115-020-00905-0.
4. Kreutz R, Dobrowolski P, Prejbisz A, Algharably E, Bilo G, Creutzig F, et al. Lifestyle, psychological, socio-economic and environmental factors and their impact on hypertension during the coronavirus disease 2019 pandemic. J Hypertens. 2021;39(6):1077–89. https://doi.org/10.1097/HJH.0000000000002770.
5. Onyeaka H, Anumudu CK, Al-Sharify ZT, Egele-Godswill E, Mbaegbu P. COVID-19 pandemic: a review of the global lockdown and its far-reaching effects. Sci Prog. 2021; 104(2):1–18. https://doi.org/10.1177/00368504211019854.
6. Zhang Y, Wang M, Zhang X, Tianxiao L, Libby P, Guo-Ping S. COVID-19, the Pandemic of the Century and Its Impact on Cardiovascular Diseases. Cardiol Discov. 2021; 1(4): 233–58. https://doi.org/10.1097/CD9.0000000000000038.
7. Zoufaly A, Poglitsch M, Aberle JH, Hoepler W, Seitz T, Traugott M, et al. Human recombinant soluble ACE2 in severe COVID-19. Lancet Respir Med. 2020;8:1154–8. https://doi.org/10.1016/S2213-2600(20)30418-5.
8. Verdecchia P, Cavallini C, Spanevello A, Angeli F. COVID-19: ACE2-centric infective disease? Hypertension. 2020;76:294–9. https://doi.org/10.1161/HYPERTENSIONAHA.120.15353.
9. Magalhaes GS, Rodrigues-Machado MDG, Motta-Santos D, Campagnole-Santos MJ, Santos R. RAS. Activation of Ang-(1-7)/Mas receptor is a possible strategy to treat coronavirus (SARS-CoV-2) infection. Front Physiol. 2020;11:730. https://doi.org/10.3389/fphys.2020.00730.
10. Nicolai L, Leunig A, Brambs S, Kaiser R, Weinberger T, Weigand M, et al. Immunothrombotic dysregulation in COVID-19 pneumonia is associated with respiratory failure and coagulopathy. Circulation. 2020;142:1176–89. https://doi.org/10.1161/CIRCULATIONAHA.120.048488.
11. Shete A. Urgent need for evaluating agonists of angiotensin-(1-7)/Mas receptor axis for treating patients with COVID-19. Int J Infect Dis. 2020;96:348–51. https://doi.org/10.1016/j.ijid.2020.05.002.
12. Puntmann VO, Carerj ML, Wieters I, Fahim M, Arendt C, Hoffmann J, et al. Outcomes of cardiovascular magnetic resonance imaging in patients recently recovered from coronavirus disease 2019 (COVID-19). JAMA Cardiol. 2020;5:1265–73. https://doi.org/10.1001/jamacardio.2020.3557.
13. Knuuti J, Wijns W, Saraste A, Capodanno D, Barbato E, Funck-Brentano C, et al. 2019 ESC Guidelines for the diagnosis and management of chronic coronary syndromes. Eur Heart J. 2020;41(3):407–77. https://doi.org/10.1093/eurheartj/ehz425.
14. Leśniak W. Rozpoznawanie i leczenie przewlekłych zespołów wieńcowych. Podsumowanie wytycznych European Society of Cardiology 2019. Med Prakt. 2020;1:10–42.
15. Hueb W, Lopes N, Gersh B, Soares P, Ribeiro E, Pereira A, et al. Ten-Year Follow-Up Survival of the Medicine, Angioplasty, or Surgery Study (MASS II). Circulation. 2010; 122:949–57. https://doi.org/10.1161/CIRCULATIONAHA.109.911669.
16. Kim YH, Park DW, Kim WJ, Jong-Young L, Sung--Cheol Y, Soo-Jin K, et al. Validation of SYNTAX (Synergy between PCI with Taxus and Cardiac Surgery) score for prediction of outcomes after unprotected left main coronary revascularization. JACC Cardiovasc Interv. 2010 (6): 612–23. https://doi.org/10.1016/j.jcin.2010.04.004.
17. Windecker S, Stortecky S, Stefanini G, da Costa B, Rutjes A, Di Nisio M, et al. Revascularisation versus medical treatment in patients with stable coronary artery disease: network meta-analysis. BMJ. 2014;348:1–19. https://doi.org/10.1136/bmj.g3859.
18. Yusuf S, Zucker D, Peduzzi P, Fisher LD, Takaro T, Kennedy JW, et al. Effect of coronary artery bypass graft surgery on survival: overview of 10-year results from randomised trials by the Coronary Artery Bypass Graft Surgery Trialists Collaboration. Lancet. 1994;344:563–70. https://doi.org/10.1016/s0140-6736(94)91963-1.

19. Baigent C, Windecker S, Andreini D, Arbelo E, Barbato E, Bartorelli A, et al. European Society of Cardiology guidance for the diagnosis and management of cardiovascular disease during the COVID-19 pandemic: part 1 – epidemiology, pathophysiology, and diagnosis. The Task Force for the management of COVID-19 of the European Society of Cardiology. Eur Heart J. 2022;43(11):1033–58. https://doi.org/10.1093/eurheartj/ehab696.
20. Baigent C, Windecker S, Andreini D, Arbelo E, Barbato E, Bartorelli A, et al. ESC guidance for the diagnosis and management of cardiovascular disease during the COVID-19 pandemic: part 2 – care pathways, treatment, and follow-up. The Task Force for the management of COVID-19 of the European Society of Cardiology. Eur Heart J. 2022;43(11):1059–103. https://doi.org/10.1093/eurheartj/ehab697.
21. Goyal P, Choi J, Pinheiro L, Schneck E, Chen R, Jabri A, et al. Clinical characteristics of COVID-19 in New York City. N Engl J Med. 2020;382(24):2372–4. https://doi.org/10.1056/NEJMc2010419.
22. Danzi G, Loffi M, Galeazzi G, Gherbesi E. Acute pulmonary embolism and COVID-19 pneumonia: a random association? Eur Heart J. 2020;41(19):1858. https://doi.org/10.1093/eurheartj/ehaa254.
23. Xie Y, Wang X, Yang P, Zhang S. COVID-19 complicated by acute pulmonary embolism. Radiol Cardiothorac Imaging. 2020;2(2):e200067. https://doi.org/10.1148/ryct.2020200067.
24. Mehra M, Desai S, Kuy S, Henry T, Patel A. Cardiovascular disease, drug therapy, and mortality in COVID-19. N Engl J Med. 2020;382(25):e102. https://doi.org/10.1056/NEJMoa2007621.
25. Alfonso P. The Impact of the COVID-19 Pandemic on Mental Health. Acta Med Port. 2020;33(5):356–7. https://doi.org/10.20344/amp.13877.
26. Hincapié M, Gallego J, Gempeler A, Piñeros J, Nasner D, Escobar M. Implementation and Usefulness of Telemedicine During the COVID-19 Pandemic: A Scoping Review. J Prim Care Community Health. 2020;11:1–7. https://doi.org/10.1177/2150132720980612.
27. Smith AC, Thomas E, Snoswell CL, Haydon H, Mehrotha A, Clemensen J, et al. Telehealth for global emergencies: Implications for coronavirus disease 2019 (COVID-19). J Telemed Telecare. 2020;26:309–13. https://doi.org/10.1177/1357633X20916567.
28. Bashshur R, Doarn CR, Frenk JM, Kvedar JC, Woolliscroft JO. Telemedicine and the COVID-19 pandemic, lessons for the future. Telemed e-Health. 2020;26:571–3. https://doi.org/10.1089/tmj.2020.29040.rb.
29. Ruan Q, Yang K, Wang W, Jiang L, Song J. Clinical predictors of mortality due to COVID-19 based on an analysis of data of 150 patients from Wuhan, China. Intensive Care Med. 2020;46:846–8. https://doi.org/10.1007/s00134-020-05991-x.
30. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet. 2020;395:1054–62. https://doi.org/10.1016/S0140-6736(20)30566-3.
31. Li B, Yang J, Zhao F, Zhi L, Wang X, Liu L, et al. Prevalence and impact of cardiovascular metabolic diseases on COVID 19 in China. Clin Res Cardiol. 2020;109(5):531–8. https://doi.org/10.1007/s00392-020-01626-9.
32. Shi S, Qin M, Shen B, Cai Y, Yang F, Gong W, et al. Association of Cardiac Injury with Mortality in Hospitalized Patients with COVID-19 in Wuhan, China. JAMA Cardiol. 2020;5(7):802–10. https://doi.org/10.1001/jamacardio.2020.0950.
33. Kow CS, Hasan SS. Meta-analysis of Effect of Statins in Patients with COVID-19. Am J Cardiol. 2020;134:153–5. https://doi.org/10.1016/j.amjcard.2020.08.004.
34. Liu Y, Pan Y, Yin Y, Chen W, Li X. Association of dyslipidemia with the severity and mortality of coronavirus disease 2019 (COVID-19): a meta-analysis. Virol J. 2021;18:157. https://doi.org/10.1186/s12985-021-01604-1.
35. Liu K, Fang YY, Deng Y, Liu W, Wang M, Ma J, et al. Clinical characteristics of novel coronavirus cases in tertiary hospitals in Hubei Province. Chin Med J (Engl). 2020, 5;133(9):1025–31. https://doi.org/10.1097/CM9.0000000000000744.
36. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus – infected pneumonia in Wuhan, China. JAMA. 2020;323(11):1061–9. https://doi.org/10.1001/jama.2020.1585.
37. Chen C, Zhou Y, Wang D. SARS-CoV-2: a potential novel etiology of fulminant myocarditis. Herz. 2020,45(3):230–2. https://doi.org/10.1007/s00059-020-04909-z.
38. Narayan KMV, Staimez L. Rising diabetes diagnosis in long COVID. Lancet Diabetes Endocrinol. 2022;10(5):298–9. https://doi.org/10.1016/S2213-8587(22)00078-X.

Publisher: Nofer Institute of Occupational Medicine, Łódź, Poland