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Impact of COVID-19 Infection on hospitalized Patients with Cardiovascular Diseases at the Regional Hospital Center of Saint-Louis, Senegal

Serigne Mor Beye[1*], Alassane Dieye[2], Mba El Hadji Bambo Diakhaby[3], Myriam Djedjelaife Aline Okoko[3], Moustapha Diedhiou[4,5], Ndiambé Sarr[4,5], Ibrahima Louis Martin Dieng[5], Seynabou Lo[3], Ndeye Mery Dia-Badiane[2]

[1]Cardiology Department, Regional Hospital Center Saint-Louis, University Gaston Berger, Saint-Louis, Senegal
[2]Infectious Diseases Department, Regional Hospital Center Saint-Louis, University Gaston Berger, Saint-Louis, Senegal
[3]Bacteriology and Virology Department, Regional Hospital Center Saint-Louis, University Gaston Berger, Saint-Louis, Senegal
[4]Anesthesiology and Intensive Care Department, Regional Hospital Center Saint-Louis, University Gaston Berger, Saint-Louis, Senegal
[5]Emergency Department, Regional Hospital Center Saint-Louis, University Gaston Berger, Saint-Louis, Senegal
Email: *serigne-mor.beye@ugb.edu.sn

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Abstract

Background: Patients with comorbidities cardiovascular diseases (CVD) present an increased risk of severe COVID-19 forms. This study aims to describe the characteristics and prognostic factors of cardiovascular patients hospitalized for COVID-19 in Saint Louis, Senegal. **Methods:** A retrospective single-center study was conducted at the Epidemic Treatment Center (ETC) of Saint-Louis Regional Hospital Center (RHC) from March 2020 to December 2021. All adult patients with positive PCR for SARS-CoV-2 and at least one cardiovascular pathology were included. Sociodemographic, clinical, biological, and evolutionary data were analyzed. **Results:** Among 450 hospitalized patients, 97 (21.6%) met inclusion criteria. Mean age was 59 years (±14.9) with male predominance (55.7%). Hypertension (39.2%) and diabetes (24.7%) were the most frequent comorbidities. Cough (48.5%) and dyspnea (46.4%) were predominant symptoms. Overall case fatality rate was 7.2%. In univariate analysis, advanced age ($p = 0.048$), severe COVID-19 form ($p = 0.009$), elevated CRP ($p < 0.001$), creatinine ($p = 0.002$), troponin ($p = 0.016$), and low HDL-cholesterol ($p = 0.012$) were significantly associated with death. **Conclusion:** This study confirms the significant burden of cardiovascular risk factors among patients hospitalized for COVID-19 in Senegal. Age and biological markers of inflammation, myocardial injury, and renal dysfunction are key prognostic determinants, emphasizing the need for particular vigilance in this

vulnerable population. Early intervention strategies should include systematic monitoring of CRP and troponin levels, close surveillance of renal function, and intensive management protocols for patients with cardiovascular comorbidities presenting with elevated inflammatory markers.

Keywords

COVID-19, Cardiovascular Diseases, Risk Factors, Senegal

1. Introduction

The COVID-19 pandemic, caused by the SARS-CoV-2 Coronavirus, has represented an unprecedented global health challenge. While infection can be asymptomatic or mild, it can also lead to severe pneumonia, acute respiratory distress syndrome (ARDS), and multi-organ failure, particularly in individuals with comorbidities [1] [2].

Among these comorbidities, cardiovascular diseases (CVD) and their risk factors (hypertension, diabetes, obesity) occupy a predominant position. International data indicate that patients with cardiovascular history are not only more susceptible to contracting severe forms of the disease but also present significantly higher mortality rates [3] [4]. This increased risk is explained by several mechanisms, including ACE2 receptor expression—the viral entry point on cardiomyocytes and endothelial cells—the pro-inflammatory and pro-thrombotic state induced by infection, and possible aggravation of underlying cardiovascular pathology [5] [6].

In Senegal, particularly in the Saint-Louis region, the prevalence of cardiovascular risk factors is high [7]. However, few local data describe the interaction between SARS-CoV-2 infection and CVD. This study aimed to:

Describe the sociodemographic, clinical, and biological profiles of cardiovascular patients with COVID-19;

Identify cardiovascular risk factors in this population;

Determine factors associated with in-hospital mortality.

2. Methods

2.1. Study Setting and Design

A retrospective, descriptive, and analytical study was conducted at the Epidemic Treatment Center (ETC) of Saint-Louis CHR over 21 months (March 2020 to December 2021).

2.2. Study Population and Inclusion Criteria

The population consisted of all patients hospitalized at the ETC with a positive PCR test for SARS-CoV-2 and having at least one pre-existing cardiovascular pathology. Pre-existing cardiovascular pathology was defined as having documented

cardiovascular risk factors (hypertension defined as systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg or current antihypertensive treatment; diabetes mellitus defined as fasting glucose ≥ 1.26 g/L or HbA1c ≥ 6.5% or current antidiabetic treatment; obesity defined as BMI ≥ 30 kg/m^2) or established cardiovascular disease (documented coronary artery disease, heart failure, valvular heart disease, arrhythmias, or peripheral arterial disease).

2.3. Exclusion Criteria

Incomplete medical records or those without cardiovascular evaluation were excluded. From the initial pool of 450 hospitalized COVID-19 patients, 353 were excluded: 97 patients met the inclusion criteria of having documented cardiovascular pathology with complete medical records and cardiovascular evaluation.

2.4. Data Collection

Data were collected from ETC and laboratory registers using a pre-established form. Variables collected included:

Sociodemographic: age, sex, origin.

Clinical: cardiovascular risk factor, functional signs at admission, clinical form of COVID-19 (asymptomatic, moderate, severe according to WHO COVID-19 Clinical Management: Living Guidance, version dated 25 January 2021).

Biological: glycemia, creatininemia, CRP, lipid profile (total cholesterol, HDL, LDL, triglycerides), troponin.

Evolution: hospitalization duration, outcome (recovery or death).

2.5. Statistical Analysis

Data were analyzed using SPSS version 25. Qualitative variables are expressed as frequencies and percentages, and quantitative variables as means ± standard deviation. Chi-square (or Fisher's exact) tests and Student's t-test were used for comparisons. A p-value < 0.05 was considered significant.

2.6. Ethical Considerations

Data anonymity and confidentiality were strictly respected. The study was approved by the Saint-Louis CHR administration.

3. Results

3.1. Population Characteristics

Among 450 patients hospitalized for COVID-19, 97 (21.6%) presented cardiovascular pathology. Table 1 presents their sociodemographic and clinical characteristics.

The most frequently reported symptoms at admission were cough (48.5%), dyspnea (46.4%), fatigue (43.3%), and fever (39.2%).

3.2. Biological Data

In terms of laboratory findings, nearly 40% of patients had hyperglycemia and

renal function was impaired in 24% of cases. Table 2 summarizes measured biological parameters and prevalence of abnormalities among patients.

Table 1. Sociodemographic, clinical characteristics and comorbidities of the studied population (N = 97).

Variables	Effectif (n)	Percentage (%)
Age years, mean ± SD 59 ± 14.9		
Age groups (years)		
30 - 39	12	12.4
40 - 49	9	9.3
50 - 59	22	22.7
60 - 69	27	27.8
70 - 79	17	17.5
≥80	10	10.3
Male sex	**54**	**55.7**
Cardiovascular risk factors		
At least one risk factor	62	63.9
Hypertension	38	39.2
Diabetes	24	24.7
Obesity	8	8.2
Heart disease	6	6.2
Active smoking	5	5.2
Asymptomatic	8	8.2
Moderate	46	47.5
Severe	43	44.3

Table 2. Biological parameters and prevalence of abnormalities in the cohort (N = 97).

Biological parameters	Testing rate (%)	Mean value (±SD)	Prevalence of abnormality (%)
Fasting hyperglycemia (≥1.10 g/L)	93.8	1.20 g/L (±0.62)	39.6
Elevated CRP (>6 mg/L)	49.5	27.2 mg/L (±48.9)	47.9
Elevated creatininemia	94.8	11.9 mg/L (±7.2)	23.9
Total hypercholesterolemia (≥2 g/L)	93.8	1.9 g/L (±0.5)	37.4
Hypo-HDL-cholesterolemia (<0.4 g/L)	93.8	0.5 g/L (±1.8)	29.7
Hyper-LDL-cholesterolemia (≥1.6 g/L)	92.8	1.2 g/L (±0.5)	17.8
Hypertriglyceridemia (≥1.5 g/L)	93.8	1.2 g/L (±0.7)	22.0
Elevated troponin (≥14 ng/L)	100	25 ng/L (±87.3)	30.9

3.3. Factors Associated with Mortality

Among the 97 patients, 7 died, representing a fatality rate of 7.2%. This fatality is associated with factors such as advanced age, severity of clinical condition and elevated CRP, among others. Table 3 presents factors significantly associated with death in univariate analysis.

Table 3. Factors associated with in-hospital mortality in univariate analysis.

Factor	Survivors (n = 90)	Deceased (n = 7)	p-value
Mean age (years)	58.2	69.7	0.048
Severe clinical form	37.8%	100%	0.009
Mean CRP (mg/L)	20	192	$p < 0.001$
Mean creatininemia (mg/L)	11.4	19.2	0.002
Elevated troponin	27.8%	71.4%	0.016
Hypo-HDL-cholesterolemia	24.4%	71.4%	0.012

The multivariate analysis was not performed due to the limited sample size in the death group (n = 7), which provides insufficient statistical power for a stable multivariable regression model. A minimum of 10 events per predictor variable is generally recommended to avoid overfitting and ensure reliable coefficient estimates.

4. Discussion

This study provides valuable insight into COVID-19's impact on cardiovascular patients in a West African context. The high prevalence of cardiovascular risk factors (63.9%) among patients hospitalized for COVID-19 in Saint-Louis reflects the ongoing epidemiological transition in Senegal and is consistent with regional data [7]. The predominance of hypertension and diabetes as main comorbidities is a classic result, widely documented in international cohorts [3] [4] [8].

The 7.2% case fatality rate in our at-risk cohort is lower than those reported in some initial European and Chinese studies, which could exceed 20% for CVD patients [3] [9]. This difference could be explained by the younger age structure of the Senegalese population, early protocoled management at the ETC, or possible underestimation due to sample size. Nevertheless, it remains significant and underscores infection severity in this group.

4.1. Age as a Major Risk Factor

The advanced age, confirmed as a major mortality risk factor, is consistent across COVID-19 literature [10] [11]. Recent meta-analyses have demonstrated that each decade increase in age is associated with a 2-3-fold increase in mortality risk [12]. This reflects physiological frailty, immunosenescence, and higher comorbidity burden. In sub-Saharan Africa, where the median age is lower than developed countries, the relatively younger cardiovascular population may partially explain

our lower mortality rates compared to Western studies [13].

4.2. Inflammatory Markers and Cytokine Storm

The marked CRP elevation in deceased patients is the most significant marker in our analysis. This result corroborates numerous studies indicating that cytokine storm and hyper-inflammatory state are major drivers of COVID-19 severity and mortality [14] [15]. Recent research has established specific CRP thresholds (>100 mg/L) as strong predictors of severe outcomes and mortality [16] [17]. The extreme CRP elevation (192 mg/L) in our deceased patients aligns with this evidence. Furthermore, longitudinal studies have shown that persistent CRP elevation rather than peak values may be more predictive of adverse outcomes [18].

4.3. Myocardial Injury and Cardiac Biomarkers

The troponin elevation, a marker of myocardial injury, was strongly associated with death. This can be explained by several mechanisms: direct viral myocardial lesion via ACE2 receptor, aggravation of underlying ischemic heart disease by hypoxia and stress, or inflammatory myocarditis [5] [6] [19]. Recent studies have demonstrated that cardiac injury occurs in 20% - 30% of COVID-19 patients and is associated with 3-5-fold increased mortality risk [20] [21]. The SARS-CoV-2 virus directly infects cardiomyocytes through ACE2 receptors, leading to myocarditis, arrhythmias, and heart failure [22]. Additionally, the hypercoagulable state induced by COVID-19 increases myocardial infarction risk through coronary thrombosis [23].

4.4. Renal Dysfunction

Renal function impairment (elevated creatinine) is another well-established poor prognostic factor. It may result from dehydration, pre-existing nephropathy, drug nephrotoxicity, or virus-related glomerulonephritis [24]. Recent data suggest that acute kidney injury occurs in 5% - 15% of hospitalized COVID-19 patients and is associated with significantly higher mortality [25] [26]. The kidney expresses high levels of ACE2 receptors, making it vulnerable to direct viral injury. Additionally, systemic inflammation, hypoxia, and hypercoagulability contribute to acute kidney injury in COVID-19 [27].

4.5. Lipid Metabolism and HDL-Cholesterol

The association between low HDL-cholesterol levels and mortality is particularly intriguing. HDL possesses anti-inflammatory and antioxidant properties. Its decrease during acute inflammatory syndrome is well-known and could contribute to worsening SARS-CoV-2-induced endotheliopathy and vascular dysfunction [28]. Recent research has revealed that COVID-19 significantly alters lipid metabolism, with marked decreases in HDL-cholesterol levels correlating with disease severity [29] [30]. This phenomenon is linked to impaired reverse cholesterol transport, which may contribute to endothelial dysfunction and thrombosis risk

in COVID-19 patients [31].

4.6. Cardiovascular Disease Mechanisms in COVID-19

The increased vulnerability of cardiovascular patients to severe COVID-19 involves multiple pathophysiological mechanisms beyond those identified in our study. The renin-angiotensin-aldosterone system (RAAS) plays a central role, as ACE2 downregulation by SARS-CoV-2 leads to unopposed angiotensin II activity, promoting inflammation, vasoconstriction, and thrombosis [32] [33]. Endothelial dysfunction, a hallmark of cardiovascular disease, is exacerbated by COVID-19 through direct viral invasion and inflammatory mediators, leading to increased vascular permeability, coagulopathy, and organ dysfunction [34] [35].

4.7. Global Perspective and Sub-Saharan Africa Context

Our findings contribute to the growing body of evidence from sub-Saharan Africa, where COVID-19 outcomes in cardiovascular patients may differ from high-income countries due to younger population demographics, different genetic factors, and varying healthcare systems [36] [37]. Recent systematic reviews have shown that while cardiovascular comorbidities remain significant risk factors across all populations, case fatality rates in sub-Saharan Africa are generally lower than reported in Europe and North America [38] [39].

4.8. Clinical Implications and Risk Stratification

The identified prognostic factors: age, inflammatory state (CRP), myocardial injury (troponin), renal dysfunction, and lipid profile disturbances are accessible indicators that should alert clinicians and guide intensive, multidisciplinary management. Recent clinical practice guidelines recommend systematic cardiac biomarker monitoring in COVID-19 patients with cardiovascular comorbidities [40] [41]. Risk stratification tools incorporating these parameters have been developed and validated for predicting severe outcomes in COVID-19 patients with cardiovascular disease [42] [43].

4.9. Study Limitations

This study has several limitations, including its retrospective and single-center design, small sample size in the death group limiting multivariate analysis power, and absence of data on certain examinations (chest CT, systematic ECG). Additionally, we lacked data on specific cardiovascular medications (ACE inhibitors, ARBs, statins) that may influence COVID-19 outcomes. The study period (March 2020-December 2021) also spans different pandemic phases with varying dominant viral variants, which could influence outcomes.

5. Conclusions

This study conducted at Saint-Louis RCH confirms that patients with cardiovascular pathologies constitute a vulnerable population facing COVID-19. The iden-

tified prognostic factors: age, inflammatory state (CRP), myocardial injury (troponin), renal function impairment, and lipid profile disturbances are accessible indicators that should alert clinicians and guide intensive, multidisciplinary management.

Early intervention strategies should include:

- Systematic monitoring of CRP levels at admission and during hospitalization with escalation of care when CRP exceeds 100 mg/L;
- Serial troponin measurements in patients with cardiovascular comorbidities to detect myocardial injury early;
- Close surveillance of renal function with prompt management of acute kidney injury;
- Lipid profile assessment to identify patients at higher risk;
- Implementation of intensive management protocols, including anticoagulation, anti-inflammatory therapies, and cardiovascular support for high-risk patients.

Strengthening primary prevention of cardiovascular risk factors in the general population remains a public health priority to mitigate the impact of future pandemics. These findings support the need for enhanced surveillance, early intervention strategies, and targeted vaccination programs for cardiovascular patients in sub-Saharan African settings.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., *et al.* (2020) Clinical Features of Patients Infected with 2019 Novel Coronavirus in Wuhan, China. *The Lancet*, **395**, 497-506. https://doi.org/10.1016/s0140-6736(20)30183-5

[2] Zhou, F., Yu, T., Du, R., Fan, G., Liu, Y., Liu, Z., *et al.* (2020) Clinical Course and Risk Factors for Mortality of Adult Inpatients with COVID-19 in Wuhan, China: A Retrospective Cohort Study. *The Lancet*, **395**, 1054-1062. https://doi.org/10.1016/s0140-6736(20)30566-3

[3] Clerkin, K.J., Fried, J.A., Raikhelkar, J., Sayer, G., Griffin, J.M., Masoumi, A., *et al.* (2020) COVID-19 and Cardiovascular Disease. *Circulation*, **141**, 1648-1655. https://doi.org/10.1161/circulationaha.120.046941

[4] Guo, T., Fan, Y., Chen, M., Wu, X., Zhang, L., He, T., *et al.* (2020) Cardiovascular Implications of Fatal Outcomes of Patients with Coronavirus Disease 2019 (COVID-19). *JAMA Cardiology*, **5**, 811-818. https://doi.org/10.1001/jamacardio.2020.1017

[5] Zheng, Y., Ma, Y., Zhang, J. and Xie, X. (2020) COVID-19 and the Cardiovascular System. *Nature Reviews Cardiology*, **17**, 259-260. https://doi.org/10.1038/s41569-020-0360-5

[6] Bonow, R.O., Fonarow, G.C., O'Gara, P.T. and Yancy, C.W. (2020) Association of Coronavirus Disease 2019 (COVID-19) with Myocardial Injury and Mortality. *JAMA Cardiology*, **5**, 751-753. https://doi.org/10.1001/jamacardio.2020.1105

[7] Pessinaba, S., Mbaye, A., Yabéta, G.A.D., Harouna, H., Sib, A.E., Kane, A.D., *et al.* (2013) Enquête de prévalence des facteurs de risque cardiovasculaire en population

générale à Saint-Louis (Sénégal). *Annales de Cardiologie et d'Angéiologie*, **62**, 253-258. https://doi.org/10.1016/j.ancard.2013.02.005

[8] Richardson, S., Hirsch, J.S., Narasimhan, M., Crawford, J.M., McGinn, T., Davidson, K.W., *et al.* (2020) Presenting Characteristics, Comorbidities, and Outcomes among 5700 Patients Hospitalized with COVID-19 in the New York City Area. *JAMA*, **323**, 2052-2059. https://doi.org/10.1001/jama.2020.6775

[9] Shi, S., Qin, M., Shen, B., Cai, Y., Liu, T., Yang, F., *et al.* (2020) Association of Cardiac Injury with Mortality in Hospitalized Patients with COVID-19 in Wuhan, China. *JAMA Cardiology*, **5**, 802-810. https://doi.org/10.1001/jamacardio.2020.0950

[10] Onder, G., Rezza, G. and Brusaferro, S. (2020) Case-Fatality Rate and Characteristics of Patients Dying in Relation to COVID-19 in Italy. *JAMA*, **323**, 1775-1776. https://doi.org/10.1001/jama.2020.4683

[11] Bonanad, C., García-Blas, S., Tarazona-Santabalbina, F., Sanchis, J., Bertomeu-González, V., Fácila, L., *et al.* (2020) The Effect of Age on Mortality in Patients with COVID-19: A Meta-Analysis with 611,583 Subjects. *Journal of the American Medical Directors Association*, **21**, 915-918. https://doi.org/10.1016/j.jamda.2020.05.045

[12] Romero Starke, K., Petereit-Haack, G., Schubert, M., Kämpf, D., Schliebner, A., Hegewald, J., *et al.* (2020) The Age-Related Risk of Severe Outcomes Due to COVID-19 Infection: A Rapid Review, Meta-Analysis, and Meta-Regression. *International Journal of Environmental Research and Public Health*, **17**, Article No. 5974. https://doi.org/10.3390/ijerph17165974

[13] Nachtigall, I., Lenga, P., Jóźwiak, K., Thürmann, P., Meier-Hellmann, A., Kuhlen, R., *et al.* (2020) Clinical Course and Factors Associated with Outcomes among 1904 Patients Hospitalized with COVID-19 in Germany: An Observational Study. *Clinical Microbiology and Infection*, **26**, 1663-1669. https://doi.org/10.1016/j.cmi.2020.08.011

[14] Del Valle, D.M., Kim-Schulze, S., Huang, H., Beckmann, N.D., Nirenberg, S., Wang, B., *et al.* (2020) An Inflammatory Cytokine Signature Predicts COVID-19 Severity and Survival. *Nature Medicine*, **26**, 1636-1643. https://doi.org/10.1038/s41591-020-1051-9

[15] Zeng, F., Dai, C., Cai, P., Wang, J., Xu, L., Li, J., *et al.* (2020) A Comparison Study of SARS-CoV-2 IGG Antibody between Male and Female COVID-19 Patients: A Possible Reason Underlying Different Outcome between Sex. *Journal of Medical Virology*, **92**, 2050-2054. https://doi.org/10.1002/jmv.25989

[16] Smilowitz, N.R., Kunichoff, D., Garshick, M., Shah, B., Pillinger, M., Hochman, J.S., *et al.* (2021) C-Reactive Protein and Clinical Outcomes in Patients with COVID-19. *European Heart Journal*, **42**, 2270-2279. https://doi.org/10.1093/eurheartj/ehaa1103

[17] Wang, G., Wu, C., Zhang, Q., Wu, F., Yu, B., Lv, J., *et al.* (2020) C-Reactive Protein Level May Predict the Risk of COVID-19 Aggravation. *Open Forum Infectious Diseases*, **7**, ofaa153. https://doi.org/10.1093/ofid/ofaa153

[18] Sharifpour, M., Rangaraju, S., Liu, M., Alabyad, D., Nahab, F.B., Creel-Bulos, C.M., *et al.* (2020) C-Reactive Protein as a Prognostic Indicator in Hospitalized Patients with COVID-19. *PLOS ONE*, **15**, e0242400. https://doi.org/10.1371/journal.pone.0242400

[19] Lala, A., Johnson, K.W., Januzzi, J.L., Russak, A.J., Paranjpe, I., Richter, F., *et al.* (2020) Prevalence and Impact of Myocardial Injury in Patients Hospitalized with COVID-19 Infection. *Journal of the American College of Cardiology*, **76**, 533-546. https://doi.org/10.1016/j.jacc.2020.06.007

[20] Shi, S., *et al.* (2020) Cardiac Manifestations of a Patient with Coronavirus Disease

2019 (COVID-19). *JACC Cardiovasc Imaging*, **13**, 969-970.

[21] Sandoval, Y., Januzzi, J.L. and Jaffe, A.S. (2020) Cardiac Troponin for Assessment of Myocardial Injury in COVID-19: JACC Review Topic of the Week. *Journal of the American College of Cardiology*, **76**, 1244-1258. https://doi.org/10.1016/j.jacc.2020.06.068

[22] Lindner, D., Fitzek, A., Bräuninger, H., Aleshcheva, G., Edler, C., Meissner, K., *et al.* (2020) Association of Cardiac Infection with SARS-CoV-2 in Confirmed COVID-19 Autopsy Cases. *JAMA Cardiology*, **5**, 1281-1285. https://doi.org/10.1001/jamacardio.2020.3551

[23] Bangalore, S., Sharma, A., Slotwiner, A., Yatskar, L., Harari, R., Shah, B., *et al.* (2020) ST-Segment Elevation in Patients with COVID-19—A Case Series. *New England Journal of Medicine*, **382**, 2478-2480. https://doi.org/10.1056/nejmc2009020

[24] Nadim, M.K., Forni, L.G., Mehta, R.L., Connor, M.J., Liu, K.D., Ostermann, M., *et al.* (2020) COVID-19-Associated Acute Kidney Injury: Consensus Report of the 25th Acute Disease Quality Initiative (ADQI) Workgroup. *Nature Reviews Nephrology*, **16**, 747-764. https://doi.org/10.1038/s41581-020-00356-5

[25] Hirsch, J.S., Ng, J.H., Ross, D.W., Sharma, P., Shah, H.H., Barnett, R.L., *et al.* (2020) Acute Kidney Injury in Patients Hospitalized with COVID-19. *Kidney International*, **98**, 209-218. https://doi.org/10.1016/j.kint.2020.05.006

[26] Cheng, Y., Luo, R., Wang, K., Zhang, M., Wang, Z., Dong, L., *et al.* (2020) Kidney Disease Is Associated with In-Hospital Death of Patients with COVID-19. *Kidney International*, **97**, 829-838. https://doi.org/10.1016/j.kint.2020.03.005

[27] Batlle, D., Soler, M.J., Sparks, M.A., Hiremath, S., South, A.M., Welling, P.A., *et al.* (2020) Acute Kidney Injury in COVID-19: Emerging Evidence of a Distinct Pathophysiology. *Journal of the American Society of Nephrology*, **31**, 1380-1383. https://doi.org/10.1681/asn.2020040419

[28] Cho, K. (2022) The Current Status of Research on High-Density Lipoproteins (HDL): A Paradigm Shift from HDL Quantity to HDL Quality and HDL Functionality. *International Journal of Molecular Sciences*, **23**, Article No. 3967. https://doi.org/10.3390/ijms23073967

[29] Wang, G., Zhang, Q., Zhao, X., Dong, H., Wu, C., Wu, F., *et al.* (2020) Low High-Density Lipoprotein Level Is Correlated with the Severity of COVID-19 Patients: An Observational Study. *Lipids in Health and Disease*, **19**, Article No. 204. https://doi.org/10.1186/s12944-020-01382-9

[30] Wei, X., Zeng, W., Su, J., Wan, H., Yu, X., Cao, X., *et al.* (2020) Hypolipidemia Is Associated with the Severity of COVID-19. *Journal of Clinical Lipidology*, **14**, 297-304. https://doi.org/10.1016/j.jacl.2020.04.008

[31] Marfella, R., Paolisso, P., Sardu, C., Bergamaschi, L., D'Angelo, E.C., Barbieri, M., *et al.* (2020) Negative Impact of Hyperglycaemia on Tocilizumab Therapy in COVID-19 Patients. *Diabetes & Metabolism*, **46**, 403-405. https://doi.org/10.1016/j.diabet.2020.05.005

[32] Gheblawi, M., Wang, K., Viveiros, A., Nguyen, Q., Zhong, J., Turner, A.J., *et al.* (2020) Angiotensin-Converting Enzyme 2: SARS-CoV-2 Receptor and Regulator of the Renin-Angiotensin System: Celebrating the 20th Anniversary of the Discovery of ACE2. *Circulation Research*, **126**, 1456-1474. https://doi.org/10.1161/circresaha.120.317015

[33] South, A.M., Tomlinson, L., Edmonston, D., Hiremath, S. and Sparks, M.A. (2020) Controversies of Renin-Angiotensin System Inhibition during the COVID-19 Pandemic. *Nature Reviews Nephrology*, **16**, 305-307. https://doi.org/10.1038/s41581-020-0279-4

[34] Varga, Z., Flammer, A.J., Steiger, P., Haberecker, M., Andermatt, R., Zinkernagel, A.S., *et al.* (2020) Endothelial Cell Infection and Endotheliitis in COVID-19. *The Lancet*, **395**, 1417-1418. https://doi.org/10.1016/s0140-6736(20)30937-5

[35] Libby, P. and Lüscher, T. (2020) COVID-19 Is, in the End, an Endothelial Disease. *European Heart Journal*, **41**, 3038-3044. https://doi.org/10.1093/eurheartj/ehaa623

[36] Dryden-Peterson, S., *et al.* (2020) COVID-19 in Botswana: Leveraging Lessons Learned from the Country's HIV/AIDS Response. *AIDS Research and Human Retroviruses*, **36**, 589-593.

[37] Diop, B.Z., Ngom, M., Pougué Biyong, C. and Pougué Biyong, J.N. (2020) The Relatively Young and Rural Population May Limit the Spread and Severity of COVID-19 in Africa: A Modelling Study. *BMJ Global Health*, **5**, e002699. https://doi.org/10.1136/bmjgh-2020-002699

[38] Mwananyanda, L., Gill, C.J., MacLeod, W., Kwenda, G., Pieciak, R., Mupila, Z., *et al.* (2021) COVID-19 Deaths in Africa: Prospective Systematic Postmortem Surveillance Study. *BMJ*, **372**, n334. https://doi.org/10.1136/bmj.n334

[39] Maeda, T. and Obata, R. (2021) Clinical Characteristics and Risk Factors for COVID-19 in Africa: A Systematic Review. *QJM*, **114**, 1-11.

[40] European Society of Cardiology (2020) ESC Guidance for the Diagnosis and Management of CV Disease during the COVID-19 Pandemic.

[41] American College of Cardiology (2020) COVID-19 Clinical Guidance for the Cardiovascular Care Team.

[42] Knight, S.R., *et al.* (2020) Risk Stratification of Patients Admitted to Hospital with COVID-19 Using the ISARIC WHO Clinical Characterisation Protocol: Development and Validation of the 4C Mortality Score. *BMJ*, **370**, m3339.

[43] Wynants, L., *et al.* (2020) Prediction Models for Diagnosis and Prognosis of COVID-19 Infection: Systematic Review and Critical Appraisal. *BMJ*, **369**, m1328.