Original/Research Paper

Comparison of the characteristics of coronavirus disease 2019 (COVID-19) in dead and survived patients with heart failure: A retrospective study from northern Iran

Pooyan Ghorbani Vajargah [a] iD │ **Arsalan Salari** [b] iD │ **Zahra Ahmadnia** [b] iD │ **Samad Karkhah** [a] iD │ **Nazila Javadi-Pashaki** [b, c*] iD

a. Department of Medical-Surgical Nursing, School of Nursing and Midwifery, Guilan University of Medical Sciences, Rasht, Iran
b. Cardiovascular Diseases Research Center, Department of Cardiology, Heshmat Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran
c. Social Determinants of Health Research Center (SDHRC), Guilan University of Medical Sciences, Rasht, Iran

*****Corresponding author(s):** Nazila Javadi-Pashaki (PhD), Cardiovascular Diseases Research Center, Department of Cardiology, Heshmat Hospital, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran.
Email: n.javadip@gmail.com
https://doi.org/10.32598/JNRCP.23.100

Abstract

During coronavirus disease 2019 (COVID-19), one of the comorbidities that can cause more severe negative clinical consequences than other patients are heart failure (HF) disease. This study aimed to assess and compare characteristics of COVID-19 in dead or survived patients with HF. Using a retrospective study, 78 HF patients with COVID-19 referred to a heart center in northern Iran were included. Data gathering was performed via census sampling from August 2020 to 2021. The medical records of Hf patients with COVID-19 were assessed. Chi-square and t-tests were used to assess the relationship between study variables. Multiple logistic regression analysis was also applied to assess the relationships of clinical and demographic characteristics with in-hospital mortality. A total of 78 HF patients with COVID-19 were included in this study. The mean EF, duration of HF, and blood pressure of the patients were 25.83 (SD=12.31), 3.79 (SD=2.10) years, and 126.65 (SD=24.67) mmHg, respectively. Also, 74.36% and 30.77% of patients had hypertension/hypotension and angioplasty, respectively. Finally, 55.13% of HF patients with COVID-19 died. Most of the dead (65.12%) were females but most of the survivors (68.57%) were males (P=0.003). Mean blood pressure of dead patients was lower compared to survived patients (121.26 vs. 133.27 mmHg; P=0.032). Age and blood pressure were predictors of in-hospital mortality in HF patients with COVID-19. The odds of in-hospital mortality were higher in males compared with females (OR=35.717; 95% CI: 2.676 to 476.690; P=0.007). Also, the odds of in-hospital mortality increased with decreasing blood pressure (OR=0.945; 95% CI: 0.900 to 0.993; P=0.024). Therefore, health managers and policymakers should pay special attention to COVID-19 patients with HF.

Keywords: COVID-19, SARS-CoV-2, Heart Failure, Mortality, Cardiovascular Diseases.

1 │ Introduction

On December 2019, coronavirus disease 2019 (COVID-19) emerged in Wuhan, China. The rapid spread of this disease in the world led to a global health crisis [1-14]. The mortality rate of COVID-19 patients was more than six million people in the world until March 20, 2022 [15]. However, previous evidence has reported different clinical features and epidemiological risk factors. Hence, contradictory findings were reported in relation to variables such as gender [16-18], high blood pressure [16, 17], smoking [19, 20], and diabetes [16, 17, 21] with the mortality rate

of COVID-19 patients. Meanwhile, the presence of some comorbidities such as diabetes, blood pressure and heart diseases with COVID-19 was considered due to the possibility of negative clinical outcomes and higher mortality in these patients [22, 23]. During COVID-19, one of the comorbidities that can cause more severe negative clinical consequences than other patients is heart failure (HF) disease [22]. HF is a type of heart disease in which the functional capacity of the heart decreases. However, the association of HF with disease progression and mortality in COVID-19 patients has not yet been fully determined [24-26]. Based on

previous evidence, cardiac injuries such as thrombosis and ventricular dysfunction can lead to increased cardiovascular risk. On the other hand, SARS-CoV-2 enters the cell via the angiotensin-converting enzyme-2 (ACE-2) receptor, which may play a role in the regulation of renin-angiotensin. In addition, inconsistent activation of the renin-angiotensin system is common in HF patients [22]. Hence, a study in the USA [22] showed that COVID-19 patients with HF are at greater risk of complications and mortality. In addition, they showed that male gender, morbid obesity, and older age were associated with higher odds of mortality in COVID-19 patients with HF.

Due to the importance of this issue, this research aimed to assess and compare characteristics of COVID-19 in dead or survived patients with HF.

2 │ Methods

2.1 │ Study design and subjects

Using a retrospective study, 78 HF patients with COVID-19 referred to a heart center in northern Iran were included. Data gathering was performed via census sampling from August 2020 to 2021. The medical records of Hf patients with COVID-19 were assessed. Patients with HF over the age of 18 years with a duration of HF> 3 months were included in this study. Also, patients with incomplete medical records were excluded.

2.2 │ Ethical consideration

This study was confirmed by the Research Ethics Committee of Guilan University of Medical Sciences (IR.GUMS.REC.1399.023). After obtaining permission from the hospital administration, the researchers visited the hospital. Verbal informed consent was obtained from participants.

2.3 │ Data collection

Data gathering was performed using a researcher-made checklist including age, sex, active smoking, a history of hospitalization due to heart problems, and body mass index (BMI), ejection fraction (EF), duration of HF, blood pressure, symptoms, comorbidities, and pharmacological treatment, and in-hospital mortality.

2.4 │ Statistical analysis

SPSS version 16.0 (SPSS Inc., Chicago, IL, USA) was used for data analysis. Quantitative and qualitative variables were presented via mean (standard deviation) and number (percentage), respectively. The normal distribution of the data was assessed via the Kolmogorov-Smirnov test. Due to the abnormality of data distribution, Chi-square and t-tests were used to assess the

relationship between study variables. Multiple logistic regression analysis was also applied to assess the relationships of clinical and demographic characteristics with in-hospital mortality. The significance level was considered P <0.05.

3 │ Results

3.1 │ Participants' characteristics

A total of 78 HF patients with COVID-19 were included in this study. Participants' mean age and BMI were 66.02 (SD=12.05) years and 26.17 (SD=3.32) kg/m2, respectively. Of the participants, 50% were male, 26.92% were active smokers, and 12.82% had a history of hospitalization due to heart problems during the COVID-19 pandemic (Table 1). As presented in Table 2, the mean EF, duration of HF, and blood pressure of the patients were 25.83 (SD=12.31), 3.79 (SD=2.10) years, and 126.65 (SD=24.67) mmHg, respectively. Also, 74.36% and 30.77% of patients had hypertension/hypotension and angioplasty, respectively. Finally, 55.13% of HF patients with COVID-19 died.

3.2 │ Comparison of the characteristics of COVID-19 in dead and survived patients with HF

The mean age of dead patients was higher compared to survived patients (66.72 vs. 65.17 years; P=0.233). Most of the dead (65.12%) were females but most of the survivors (68.57%) were males (P=0.003). The mean EF of dead patients was higher compared to survived patients (26.98 vs. 24.43; P=0.145). Mean blood pressure of dead patients was lower compared to survived patients (121.26 vs. 133.27 mmHg; P=0.032). The most common symptom of COVID-19 in the dead (44.19%) and survived (62.86%) was cough (P=0.368). The most common comorbidities in the dead (69.77%) and survived (80.00%) were hypertension/hypotension (P=0.303).

3.3 │ Relationships of clinical and demographic characteristics of HF patients with COVID-19 with in-hospital mortality

As presented in Table 3, multiple logistic regression analyses were conducted to assess the clinical and demographic characteristics with in-hospital mortality. Age and blood pressure were predictors of in-hospital mortality in HF patients with COVID-19. The odds of in-hospital mortality were higher in males compared with females (OR=35.717; 95% CI: 2.676 to 476.690; P=0.007). Also, the odds of in-hospital mortality increased with decreasing blood pressure (OR=0.945; 95% CI: 0.900 to 0.993; P=0.024).

Table 1. Demographic characteristics of HF patients with COVID-19 by in-hospital mortality (n=78).

| | Total (n=78) | In-hospital mortality | | P-value |
		Dead (n=43)	Survived (n=35)	
Age (years)	66.02 (SD=12.05)	66.72 (SD=13.34)	65.17 (SD=10.40)	0.233*
Sex				
Male	39 (50.00)	15 (34.88)	24 (68.57)	0.003**
Female	39 (50.00)	28 (65.12)	11 (31.43)	
Active smoking				
Yes	21 (26.92)	9 (20.93)	12 (34.29)	0.186**
No	57 (73.08)	34 (79.07)	23 (65.71)	
History of hospitalization due to heart problems				
Yes	10 (12.82)	7 (16.28)	3 (8.57)	0.311**
No	68 (87.18)	36 (83.72)	32 (91.43)	
BMI (kg/m^2)	26.17 (SD=3.32)	26.29 (SD=3.14)	26.03 (SD=3.56)	0.236*

HF: Heart Failure; **SD:** Standard Deviation; **BMI:** Body Mass Index.

Values are given as number (percentage) for categorical variables and as mean (standard deviation) for continuous variables.

*P-value was obtained with t-test.

**P-value was obtained with Chi-square test.

Table 2. Clinical features of HF patients with COVID-19 by in-hospital mortality (n=78).

| | Total (n=78) | In-hospital mortality | | P-value |
		Dead (n=43)	Survived (n=35)	
Clinical features				
EF	25.83 (SD=12.31)	26.98 (SD=13.37)	24.43 (SD=10.90)	0.145*
Duration of HF (years)	3.79 (SD=2.10)	3.79 (SD=2.02)	3.80 (SD=2.23)	0.388*
Blood pressure (mmHg)	126.65 (SD=24.67)	121.26 (SD=25.58)	133.27 (SD=22.11)	0.032*
Symptoms				
Fever	26 (33.33)	13 (30.23)	13 (37.14)	
Tremor	33 (42.31)	17 (39.53)	16 (45.71)	
Cough	41 (52.56)	19 (44.19)	22 (62.86)	
Body pain	29 (37.18)	15 (34.88)	14 (40.00)	0.368**
Gastrointestinal problems	34 (43.59)	18 (41.86)	16 (45.71)	
Sore throat	27 (34.62)	18 (41.86)	9 (25.71)	
Loss of olfactory sense	31 (39.74)	13 (30.23)	18 (51.43)	
Loss of the sense of taste	26 (33.33)	15 (34.88)	11 (31.43)	
Headache	35 (44.87)	16 (37.21)	19 (54.29)	
Comorbidities				
Diabetes mellitus				
Yes	41 (52.56)	19 (44.19)	22 (62.86)	0.100**
No	37 (47.44)	24 (55.81)	13 (37.14)	
Myocardial infarction				
Yes	7 (8.97)	4 (9.30)	3 (8.57)	0.911**
No	71 (91.03)	39 (90.70)	32 (91.43)	
Angioplasty				
Yes	24 (30.77)	10 (23.26)	14 (40.00)	0.111**
No	54 (69.23)	33 (76.74)	21 (60.00)	
Valve diseases				
Yes	13 (16.67)	7 (16.28)	6 (17.14)	0.919**
No	65 (83.33)	36 (83.72)	29 (82.86)	
Hyperlipidemia				
Yes	20 (25.64)	11 (25.58)	9 (25.71)	0.989**
No	58 (74.36)	32 (74.42)	26 (74.29)	
Hypertension/Hypotension				
Yes	58 (74.36)	30 (69.77)	28 (80.00)	0.303**
No	20 (25.64)	13 (30.23)	7 (20.00)	
Pharmacological treatment				
Anti-platelets	77 (98.72)	42 (97.67)	35 (100.00)	
Nitrates	75 (96.15)	40 (93.02)	35 (100.00)	
Beta blockers	66 (84.61)	35 (81.39)	31 (88.57)	
Multivitamin	67 (85.90)	35 (81.39)	32 (91.43)	0.109**
Anti-lipids	73 (93.59)	38 (88.37)	35 (100.00)	
Angiotensin-converting-enzyme inhibitors	65 (83.33)	33 (76.74)	32 (91.43)	
Angiotensin receptor blockers	74 (94.87)	39 (90.70)	35 (100.00)	
Antidiabetics	49 (62.82)	25 (58.14)	24 (68.57)	
Diuretics	72 (92.31)	37 (86.05)	35 (100.00)	

| | Total (n=78) | In-hospital mortality | | P-value |
		Dead (n=43)	Survived (n=35)	
Antipsychotics	8 (10.26)	2 (4.65)	6 (17.14)	
Proton-pump inhibitors	68 (87.18)	35 (81.39)	33 (94.29)	
Calcium channel blockers	5 (6.41)	3 (6.98)	2 (5.71)	

HF: Heart Failure; **SD:** Standard Deviation; **EF:** Ejection fraction.

Values are given as number (percentage) for categorical variables and as mean (standard deviation) for continuous variables.

*P-value was obtained with t-test.

**P-value was obtained with Chi-square test.

Table 3. Relationships of clinical and demographic characteristics of HF patients with COVID-19 with in-hospital mortality.

	B	SE	Wald	OR	95% CI	P-value
Age	0.063	0.043	2.120	1.065	0.978 to 1.159	0.145
Sex (Male vs. Female)	3.576	1.322	7.314	35.717	2.676 to 476.690	0.007
Active smoking (Yes vs. No)	-0.757	1.313	0.333	0.469	0.036 to 6.142	0.564
History of hospitalization due to heart problems (Yes vs. No)	2.047	2.350	0.759	7.742	0.077 to 774.717	0.384
BMI	0.006	0.223	0.001	1.006	0.650 to 1.555	0.980
EF	0.003	0.042	0.005	1.003	0.924 to 1.089	0.941
Duration of HF	-0.411	0.254	2.614	0.663	0.403 to 1.091	0.106
Blood pressure	-0.056	0.025	5.063	0.945	0.900 to 0.993	0.024
Symptoms						
Fever (Yes vs. No)	-0.331	1.278	0.067	0.718	0.059 to 8.787	0.795
Tremor (Yes vs. No)	-0.441	1.171	0.142	0.644	0.065 to 6.384	0.707
Cough (Yes vs. No)	-1.665	1.609	1.070	0.189	0.008 to 4.434	0.301
Body pain (Yes vs. No)	-1.057	1.057	1.000	0.347	0.044 to 2.757	0.317
Gastrointestinal problems (Yes vs. No)	-0.683	1.212	0.318	0.505	0.047 to 5.429	0.573
Sore throat (Yes vs. No)	1.480	1.300	1.296	4.393	0.344 to 56.167	0.255
Loss of olfactory sense (Yes vs. No)	0.069	1.341	0.003	1.071	0.077 to 14.850	0.959
Loss of the sense of taste (Yes vs. No)	1.675	1.098	2.325	5.338	0.620 to 45.959	0.127
Headache (Yes vs. No)	-0.584	0.979	0.356	0.558	0.082 to 3.801	0.551
Comorbidities						
Diabetes mellitus (Yes vs. No)	-3.404	1.875	3.296	0.033	0.001 to 1.311	0.069
Myocardial infarction (Yes vs. No)	3.728	3.287	1.287	41.616	0.066 to 26138.296	0.257
Angioplasty (Yes vs. No)	-1.864	1.176	2.510	0.155	0.015 to 1.556	0.113
Valve diseases (Yes vs. No)	-2.392	1.838	1.693	0.091	0.002 to 3.355	0.193
Hyperlipidemia (Yes vs. No)	-2.257	2.358	0.916	0.105	0.001 to 10.646	0.339
Hypertension/Hypotension (Yes vs. No)	-0.794	1.294	0.377	0.452	0.036 to 5.709	0.539
Pharmacological treatment						
Anti-platelets (Yes vs. No)	-5.192	62305.008	0	0.006	0	1.000
Nitrates (Yes vs. No)	17.285	68136.583	0	32129003.997	0	1.000
Beta blockers (Yes vs. No)	-1.100	2.164	0.258	0.333	0.005 to 23.156	0.611
Multivitamin (Yes vs. No)	-31.900	14315.682	0	0	0	0.998
Anti-lipids (Yes vs. No)	6.745	48745.372	0	849.625	0	1.000
Angiotensin-converting-enzyme inhibitors (Yes vs. No)	-3.789	3.392	1.247	0.023	0 to 17.460	0.264
Angiotensin receptor blockers (Yes vs. No)	6.156	56840.983	0	471.741	0	1.000
Antidiabetics (Yes vs. No)	-1.169	1.819	0.413	0.311	0.009 to 10.977	0.521
Diuretics (Yes vs. No)	17.539	40192.528	0	41394207.195	0	1.000
Antipsychotics (Yes vs. No)	6.256	3.244	3.718	520.941	0.902 to 300787.148	0.054
Proton-pump inhibitors (Yes vs. No)	31.296	14315.681	0	39067275368708.750	0	0.998
Calcium channel blockers (Yes vs. No)	-0.623	2.855	0.048	0.536	0.002 to 144.374	0.827

SE: Standard Error; **OR:** Odds Ratio; **CI:** Confidence Interval; **HF:** Heart Failure; **SD:** Standard Deviation; **EF:** Ejection fraction.

P-value was obtained with Multiple Logistic Regression test.

Note. B: regression coefficient.

4 | Discussion

The findings of the present study showed that 55.13% of HF patients with COVID-19 died. Most of the dead (65.12%) were females but most of the survivors (68.57%) were males. Mean blood pressure of dead patients was lower compared to survived patients. Age and blood pressure were predictors of in-hospital

mortality in HF patients with COVID-19. The odds of in-hospital mortality were higher in males compared with females. Also, the odds of in-hospital mortality increased with decreasing blood pressure.

The findings of the present study showed that 55.13% of HF patients with COVID-19 died. Most of the dead (65.12%) were females but most of the survivors (68.57%) were males. The odds of in-hospital mortality were higher in males compared with females. Also, the odds of in-hospital mortality increased with decreasing blood pressure. Consistent with the findings of the present study, a study in the USA [27] showed that the mortality rate was higher in COVID-19 patients with HF compared to COVID-19 patients without HF (40% vs. 24.9%). Also, they showed that a history of HF was associated with more than threefold and almost twofold risk for mechanical ventilation connection and higher mortality in patients with COVID-19, respectively [27]. However, the findings of the present study were inconsistent with a study in the USA [22]. They showed that the mortality rate in COVID-19 patients with HF was 2.6%. Also, they showed that the mortality rate was higher in men than in women (66% vs. 34%) [22]. These differences can be due to differences in the type of studies, the studied samples, the research community and the study methodology [16, 18, 19, 26, 27]. The systemic effects of COVID-19 on the cardiovascular system are known [28, 29]. Hence, SARS-COV-2 has been found in epithelial cells, pericytes, and macrophages, leading to widespread inflammation and increased microvascular and macrovascular thrombosis that can be associated with myocardial damage [29, 30]. This damage is characterized by troponin concentration, which will ultimately lead to an increased risk of mortality in HF patients [31]. Therefore, it is recommended to design more valid and population-based studies in this field. Although HF has been identified as a risk factor for worse clinical outcomes in COVID-19, however, previous evidence regarding the clinical profile and prognosis of COVID-19 patients with HF is limited [22, 27].

Mean blood pressure of dead patients was lower compared to survived patients. Age and blood pressure were predictors of in-hospital mortality in HF patients with COVID-19. In fact, age and blood pressure were predictors of mortality in COVID-19 patients with HF. Previous evidence has shown that unstable diastolic and systolic blood pressure control in patients with COVID-19 is associated with adverse clinical outcomes including intensive care unit admission and mortality, especially when combined with other comorbidities such as HF [27, 32-34]. However, previous evidence in this area is limited. Therefore, it is suggested that researchers pay special attention to COVID-19 patients with HF in future studies.

4.1 │ Limitations

The current research had some limitations. The use of electronic health records to collect data could lead to bias in the validity of the findings. Hence, many COVID-19 patients with HF were not included due to deficiencies in medical records. On the other hand, readmission of COVID-19 patients with HF to other hospitals was not investigated.

5 │ Conclusions

Overall, this research showed that 55.13% of HF patients with COVID-19 died. Most of the dead (65.12%) were females but most of the survivors (68.57%) were males. Mean blood pressure of dead patients was lower compared to survived patients. Age and blood pressure were predictors of in-hospital mortality in HF patients with COVID-19. The odds of in-hospital mortality were higher in males compared with females. Also, the odds of in-hospital mortality increased with decreasing blood pressure. Therefore, health managers and policymakers should pay special attention to COVID-19 patients with HF.

Ethics approval and consent to participate

The Research Ethics Committee of Guilan University of Medical Sciences confirmed this research (IR.GUMS.REC.1399.023). After obtaining permission from the hospital administration, the researchers visited the hospital. Verbal informed consent was obtained from participants.

Ghorbani Vajargah *et al.*

References

1. Dorjee K, Kim H, Bonomo E, Dolma R. Prevalence and predictors of death and severe disease in patients hospitalized due to COVID-19: A comprehensive systematic review and meta-analysis of 77 studies and 38,000 patients. *PLoS One*. 2020;15(12):e0243191.

2. Ghazanfari MJ, Mazloum SMH, Rahimzadeh N, Arasteh M, Ghorbani Vajargah P, Mollaei A, et al. Burns and pregnancy during the COVID-19 pandemic. *Burns*. 2022;48(8):2015-2017.

3. Ghazanfari M J, Chaghian Arani R, Mollaei A, Mollaei A, Falakdami A, Takasi P, et al. Death Anxiety and Related Factors in Nurses during the COVID-19 Pandemic: A systematic Review. *Jorjani Biomed J*. 2022;10(3):35-42.

4. Ghazanfari MJ, Esmaeili S, Emami Zeydi A, Karkhah S. Moral distress among nurses during COVID-19 pandemic: Challenges and coping strategies. *Nurs Open*. 2022;9(4):2227-2228.

5. Ghazanfari MJ, Karkhah S, Taghadosi M. Potential Interactions between Cardiovascular and Covid-19 Medication Regimens among Patients with Heart Failure. *Pak Heart J*. 2022;55(1):92-93.

6. Ghorbani Vajargah P, Miri S, Ghazanfari MJ, Farhadi Farouji A, Falakdami A, Mollaei A, et al. Effects of Corona Virus-2019 (COVID-19) Pandemic on Older People. *Gerontol Geriatr Med*. 2022;8:23337214221109822.

7. Javadi-Pashaki N, Ghazanfari MJ, Karkhah S. COVID-19 pandemic: An opportunity to promote e-learning in the nursing profession. *J Clin Nurs*. 2023;32(11-12):2943-2944.

8. Javadi-Pashaki N, Ghazanfari MJ, Miri S, Karkhah S. Decreased Life Expectancy among Older People during the COVID-19 Pandemic: A Public Health Issue. *Jorjani Biomed J*. 2021;9(4):62-64.

9. Monfared A, Moghadamnia MT, Karkhah S, Maroufizadeh S, Asadian Rad M, Kheirkhah J, et al. A Survey for Predictors of Mortality among COVID-19 Patients: A Retrospective Study from Iran. *Jorjani Biomed J*. 2021;9(4):13-21.

10. Karkhah S, Ghazanfari MJ, Shamshirian A, Panahi L, Molai M, Zeydi AE. Clinical Features of Patients with Probable 2019 Novel Coronavirus Infected Pneumonia in Rasht, Iran: A Retrospective Case Series. *Open Access Maced J Med Sci*. 2020;8(T1):16-22.

11. Karkhah S, Maroufizadeh S, Hakimi E, Ghazanfari MJ, Osuji J, Javadi-Pashaki N. Information Seeking Behavior on COVID-19 Among Older Adults: A Cross-Sectional Study in Northern Iran. *Gerontol Geriatr Med*. 2022;8:23337214221120746.

12. Miri S, Karkhah S, Ghorbani Vajargah P, Mollaei A, Falakdami A, Takasi P, et al. Ethical Challenges and Coping Strategies about Issues Related to The Healthcare System and Social Issues During the COVID-19 Pandemic: A Narrative Review. *Jorjani Biomed J*. 2022;10(1):84-95.

13. Mobayen M, Ghazanfari MJ, Feizkhah A, Mobayen M, Emami Zeydi A, Karkhah S. Effects of COVID-19 pandemic on burns care. *Burns*. 2022;48(4):1020-1021.

14. Emami Zeydi A, Ghazanfari MJ, Sanandaj FS, Panahi R, Mortazavi H, Karimifar K, et al. Coronavirus Disease 2019 (COVID-19): A Literature Review from a Nursing Perspective. *Biomedicine (Taipei)*. 2021;11(3):5-14.

15. World Health Organization. WHO Coronavirus (COVID-19) Dashboard. WHO; 2022. [March 20, 2022]. Available from: https://covid19.who.int/.

16. Cummings MJ, Baldwin MR, Abrams D, Jacobson SD, Meyer BJ, Balough EM, et al. Epidemiology, clinical course, and outcomes of critically ill adults with COVID-19 in New York City: a prospective cohort study. *Lancet*. 2020;395(10239):1763-1770.

17. Palaiodimos L, Kokkinidis DG, Li W, Karamanis D, Ognibene J, Arora S, et al. Severe obesity, increasing age and male sex are independently associated with worse in-hospital outcomes, and higher in-hospital mortality, in a cohort of patients with COVID-19 in the Bronx, New York. *Metabolism*. 2020;108:154262.

18. Du RH, Liang LR, Yang CQ, Wang W, Cao TZ, Li M, et al. Predictors of mortality for patients with COVID-19 pneumonia caused by SARS-CoV-2: a prospective cohort study. *Eur Respir J*. 2020;55(5):2000524.

19. Alqahtani JS, Oyelade T, Aldhahir AM, Alghamdi SM, Almehmadi M, Alqahtani AS, et al. Prevalence, Severity and Mortality associated with COPD and Smoking in patients with COVID-19: A Rapid Systematic Review and Meta-Analysis. *PLoS One*. 2020;15(5):e0233147.

20. Lippi G, Henry BM. Active smoking is not associated with severity of coronavirus disease 2019 (COVID-19). *Eur J Intern Med*. 2020;75:107-108.

21. Wu C, Chen X, Cai Y, Xia J, Zhou X, Xu S, et al. Risk Factors Associated With Acute Respiratory Distress Syndrome and Death in Patients With Coronavirus Disease 2019 Pneumonia in Wuhan, China. *JAMA Intern Med*. 2020;180(7):934-943.

22. Bhatt AS, Jering KS, Vaduganathan M, Claggett BL, Cunningham JW, Rosenthal N, et al. Clinical Outcomes in Patients With Heart Failure Hospitalized With COVID-19. *JACC Heart Fail*. 2021;9(1):65-73.

23. Caraballo C, McCullough M, Fuery MA, Chouairi F, Keating C, Ravindra NG, et al. COVID-19 infections and outcomes in a live registry of heart failure patients across an integrated health care system. *PLoS One*. 2020;15(9):e0238829.

24. Akhmerov A, Marbán E. COVID-19 and the Heart. *Circ Res*. 2020;126(10):1443-1455.

25. Li X, Guan B, Su T, Liu W, Chen M, Bin Waleed K, et al. Impact of cardiovascular disease and cardiac injury on in-hospital mortality in patients with COVID-19: a systematic review and meta-analysis. *Heart*. 2020;106(15):1142-1147.

26. Zheng YY, Ma YT, Zhang JY, Xie X. COVID-19 and the cardio-vascular system. *Nat Rev Cardiol*. 2020;17(5):259-260.

27. Alvarez-Garcia J, Lee S, Gupta A, Cagliostro M, Joshi AA, Rivas-Lasarte M, et al. Prognostic Impact of Prior Heart Failure in Patients Hospitalized With COVID-19. *J Am Coll Cardiol*. 2020;76(20):2334-2348.

28. Hoffmann M, Kleine-Weber H, Schroeder S, Krüger N, Herrler T, Erichsen S, et al. SARS-CoV-2 Cell Entry Depends on ACE2 and TMPRSS2 and Is Blocked by a Clinically Proven Protease Inhibi-tor. *Cell*. 2020;181(2):271-280.e8.

29. Chen L, Li X, Chen M, Feng Y, Xiong C. The ACE2 expression in human heart indicates new potential mechanism of heart injury among patients infected with SARS-CoV-2. *Cardiovasc Res*. 2020;116(6):1097-1100.

30. Atri D, Siddiqi HK, Lang JP, Nauffal V, Morrow DA, Bohula EA. COVID-19 for the Cardiologist: Basic Virology, Epidemiology, Cardiac Manifestations, and Potential Therapeutic Strategies. *JACC Basic Transl Sci*. 2020;5(5):518-536.

31. Lala A, Johnson KW, Januzzi JL, Russak AJ, Paranjpe I, Richter F, et al. Prevalence and Impact of Myocardial Injury in Patients Hos-pitalized With COVID-19 Infection. *J Am Coll Cardiol*. 2020;76(5):533-546.

32. Ran J, Song Y, Zhuang Z, Han L, Zhao S, Cao P, et al. Blood pres-sure control and adverse outcomes of COVID-19 infection in pa-tients with concomitant hypertension in Wuhan, China. *Hypertens Res*. 2020;43(11):1267-1276.

33. Tomasoni D, Italia L, Adamo M, Inciardi RM, Lombardi CM, Sol-omon SD, et al. COVID-19 and heart failure: from infection to in-flammation and angiotensin II stimulation. Searching for evidence from a new disease. *Eur J Heart Fail*. 2020;22(6):957-966.

34. Zhang Y, Coats AJS, Zheng Z, Adamo M, Ambrosio G, Anker SD, et al. Management of heart failure patients with COVID-19: a joint position paper of the Chinese Heart Failure Association & Na-tional Heart Failure Committee and the Heart Failure Association of the European Society of Cardiology. *Eur J Heart Fail*. 2020;22(6):941-956.