Cardiovascular Profile of Patients With COVID-19 Infection Admitted in a Tertiary Care Hospital in Manila, Philippines: A 2-Year Single-Center Retrospective Study

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Abstract

INTRODUCTION: Respiratory symptoms are the most commonly observed clinical manifestations in patients with COVID-19 infection; however, some patients may present with cardiovascular complications. Patients with underlying cardiovascular diseases are associated with increased mortality risk. This study aimed to provide local data on the clinical profile and cardiovascular outcomes and to determine predictors of in-hospital mortality among COVID-19 patients admitted to a tertiary care hospital in the Philippines.

METHODS: This single-center retrospective study included hospitalized patients diagnosed with COVID-19 between March 2020 and May 2022. Clinical parameters were subjected to univariate and multivariate regression analyses, with in-hospital mortality as the dependent variable.

RESULTS: A total of 1341 patients were admitted with a mean age of 50 years, half of whom were males. Hypertension is the most common comorbidity (728 [54.3%]), followed by diabetes mellitus (393 [29.3%]) and heart disease (136 [10.1%]). Patients admitted to the intensive care unit had significantly higher systolic blood pressure than non–intensive care unit patients (127 ± 19 vs 139 ± 26 mm Hg; $P < 0.001$), as well as higher plasma erythrocyte sedimentation rate, C-reactive protein, D-dimer, troponin, ferritin, and lactate dehydrogenase. The most common cardiac complications observed were heart failure (39%), acute cardiac injury (30%), and arrhythmia (30%). During hospitalization, 100 patients (7.4%) died; almost half were admitted to the critical care unit, and 84 had cardiac complications, with heart failure (21%) being the most common. Sinus tachycardia was the most common electrocardiographic abnormality (436 [32%]). Univariate analysis showed diabetes (odds ratio [OR], 2.7; $P = 0.029$) and hypertension (OR, 3.4; $P = 0.11$). Multivariate analysis revealed that age (OR, 1.095; $P < 0.05$) and admission duration (OR, 0.906; $P < 0.05$) were significantly associated with mortality.

CONCLUSION: This study highlights the clinical characteristics of patients contracted with COVID-19 who may experience several cardiac conditions. Therefore, particular attention should be given to the role of preexisting cardiovascular diseases and cardiac complications that may contribute to long-term outcomes.

KEYWORDS: cardiac complications, COVID-19, cardiovascular outcomes

INTRODUCTION

Background of the Study

In December 2019, a novel coronavirus disease of 2019 (COVID-19) was discovered in Wuhan, Hubei Province, China, which caused an outbreak that spread rapidly throughout China. This disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was declared a pandemic by the World Health Organization (WHO) in March 2020.[1]

The first case of COVID-19 was reported in the Philippines in January 2020, and local transmission occurred in March 2020. Patients with COVID-19 infection manifest primarily with nonspecific flulike symptoms and develop complications related to pneumonia and acute respiratory distress syndrome (ARDS). Although the most commonly observed clinical manifestations are respiratory symptoms, COVID-19 complications are associated with cardiovascular symptoms such as arrhythmias, myocardial infarction, embolisms, and heart failure.[2-19]

This study reports the clinical and laboratory characteristics, including the outcomes of patients confirmed with COVID-19 infection admitted to our institution, and compares the clinical features between the intensive care unit (ICU) and non-ICU.

METHODS

Study Population and Design

The study is a cross-sectional analytical retrospective research design involving 1341 hospitalized adult patients with laboratory-confirmed COVID-19 infection confirmed by direct detection of SARS-CoV-2 RNA by reverse transcription–polymerase chain reaction (RT-PCR) assay for nasopharyngeal, oropharyngeal, or endotracheal swab specimens. Patients involved in the study were admitted from March 1, 2020, to May 31, 2022. The institutional review boards approved the study under the waiver of consent.

Study Participants

A. Inclusion Criteria

- Patients 18 years and older admitted in a tertiary care hospital from March 2020 to May 2022
- Confirmed diagnosed case of COVID-19 (via RT-PCR)
- COVID-19 patients with moderate to severe risk classification
- COVID-19 patients either given standard of care or antibiotics or mechanically ventilated

B. Exclusion Criteria

- Medical records were unavailable during the time of the study period.

Operational Definitions

1. COVID-19 patients: patients with COVID-19 infection confirmed via laboratory diagnosis (RT-PCR)
2. Moderate risk classification: COVID-19 patients with the following criteria: stable comorbid illness and with pneumonia; stable vital signs (respiratory rate <30 breaths per minute, heart rate <125 beats per minute, or SpO_2 >93% on room air). COVID-19 patients classified as moderate risk are admitted to a non-ICU ward (regular or progressive care unit)
3. Severe risk classification: COVID-19 patients with fever (T_{max} ≥37.8°C) or severe acute respiratory infection: respiratory rate >30 breaths per minute, severe respiratory distress, or SpO_2 <93% on room air. Sepsis presented as follows: altered mental status, difficulty breathing or decreased oxygen saturation, decreased urine output, increased heart rate, weak pulse, cold extremities or decreased blood pressure, or laboratory evidence of coagulopathy, thrombocytopenia, acidosis, high lactate, or hyperbilirubinemia. COVID-19 patients classified as severe risk are admitted at an ICU unit.
4. ICU: patients admitted who are in shock (hypovolemic, septic, anaphylactic shocks); acute organ failure; cardiac cases such as myocardial infarction (suspected or confirmed), life-threatening arrhythmias, digitalis intoxication, and electrical pacemaker problems; respiratory failure requiring ventilatory support; any life-threatening medical condition requiring close monitoring care and ICU support
5. Non-ICU: patients admitted who are conscious and hemodynamically stable, have no signs of sepsis, are stable renal function, and have no cardiac dysrhythmias, no bleeding problems, and stable neurologic status
6. Arrhythmia: abnormal change in the regular heartbeat of the heart and may include irregular heartbeats, skipped beats, and conduction blocks
7. Myocardial injury: defined as the elevated blood level of cardiac biomarker greater than the 99th percentile upper reference limit, regardless of new abnormalities in electrocardiography and echocardiography.
8. Heart failure: defined as a clinical syndrome with symptoms and/or signs caused by a structural or functional cardiac abnormality as evidenced by echocardiographic findings and corroborated by changes in natriuretic peptide levels
9. Inflammatory markers: also known as acute phase reactants, which signify the presence of acute inflammation. Commonly used inflammatory markers are erythrocyte sedimentation rate (ESR), CRP, procalcitonin, ferritin, and lactate dehydrogenase (LDH) enzymes.

Data Collection and Procedures

Data collection was done by reviewing the patient's medical records during admission. Patients' demographic characteristics (age and sex) and presence of chronic comorbidities were acquired via database form; laboratory findings and results of cardiac examinations (ECG, cardiac biomarkers, and echocardiography findings) were retrieved from the electronic health records. Cardiac biomarker level, high-sensitivity troponin I, and ECG findings acquired on admission and throughout hospital stay were determined. The clinical outcomes (admission, length of stay, discharges, and mortality) were monitored. Interventions given will be noted as either standard of care, treated with antibiotics, or any medications. All outcomes were obtained with standardized data collection forms (modified form shared by WHO). One researcher independently reviewed the data collection forms to double-check the data collected. The outcome measures were extracted from this tool. No personal interviews, procedures, or further laboratory tests will be required for the study.

Sampling and Sample Size

No formal sample size estimation was made because there were no published nationwide data on COVID-19 regarding cardiovascular events when this article was written.

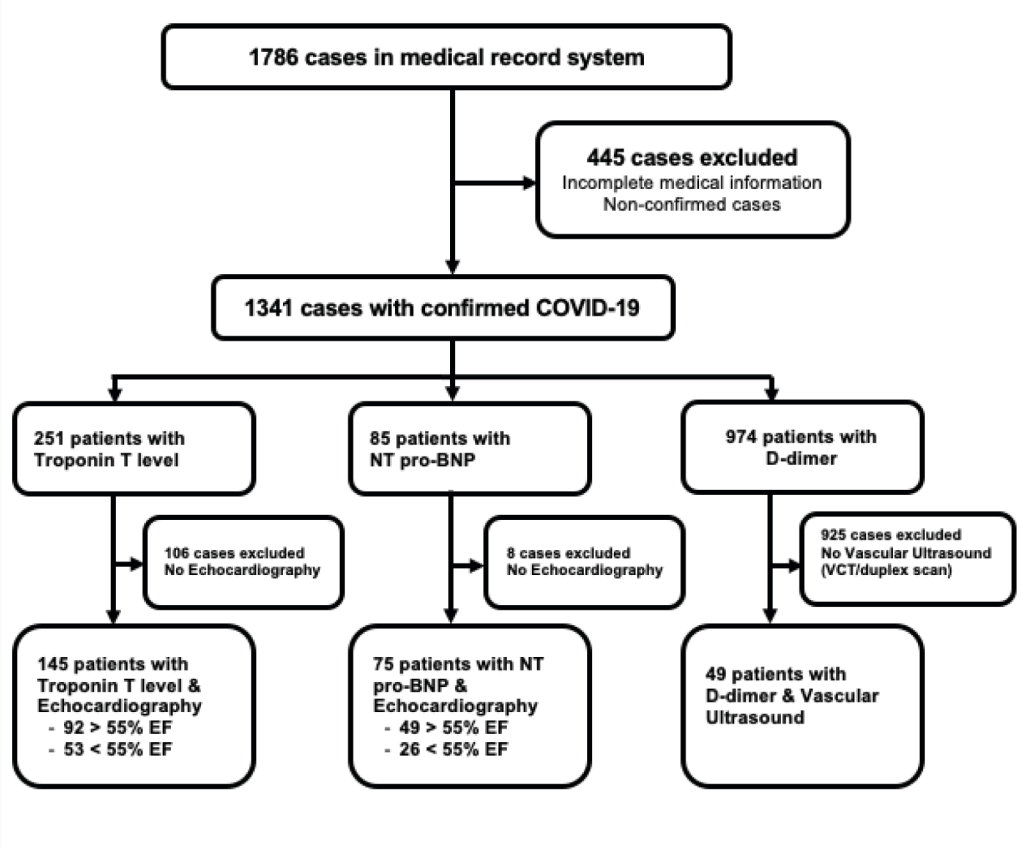

Figure 1. Flowchart of the study.

Statistical Analysis

Baseline clinical characteristics are reported as means and standard deviations for continuous variables, whereas frequencies and proportions are for categorical variables. Group comparisons were made using Mann-Whitney *U* test for categorical variables. We used bivariate analysis to investigate the relationship between the clinical profile and in-hospital mortality. This was done using correlation and χ^2 tests. For multivariable models, multiple and logistic regression models were used with 2-sided $P < 0.05$ to determine clinical significance.

Ethical Considerations

The protocol of this study adhered to the ethical considerations and principles set out in relevant guidelines, including the Declaration of Helsinki, WHO guidelines, the International Conference on Harmonization–Good Clinical Practice, the Data Privacy Act of 2012, and the National Ethics Guidelines for Health Research. As for the consent, no informed consent is needed for this research.

Data Safety, Privacy, and Confidentiality

Patient confidentiality was respected by ensuring the anonymity of patient records. Each patient document was coded and did not contain any identifying information to ensure confidentiality. Subject information was kept in a secure office, with access available only to research team members. Computerized study information was stored on a secure network with password access. All identifiable information and data were given a code number. All study-related documents, such as all protocol versions, ethical clearance, data collection forms, and hard copies of source documents, were kept and stored by the principal investigator in strict confidentiality for at least 5 years, after which they will be shredded. All study data were recorded, and investigators were responsible for the integrity of the data, that is, accuracy, completeness, legibility, originality, timeliness, and consistency.

RESULTS

Patient Characteristics

A flowchart of the study is shown in Figure 1. We studied 1341 patients diagnosed with COVID-19 infection from March 1, 2020, to May 31, 2022. Most of the patients were men, comprising 713 (53.2%) of the total patients with a mean age of 50 (50.25 ± 17.59) years. The most common family history was hypertension ([32.2%] 432 of 1341), followed by diabetes mellitus ([25.8%] 346 of 1341) and heart disease ([1.8%] 24 of 1341). Two hundred thirty patients (17.2%) were smokers, 252 (18.4%) were alcoholic drinkers, and 127 (9.5%) had a history of travel outside the country. Apart from having COVID-19 infection, 728 patients (54.3%) had hypertension, 393 (29.3%) had diabetes mellitus, 136 (10.1%) had known heart disease, and 114 (8.5%) were previously diagnosed with CAD (Table 1).

Table 1. Baseline Characteristics and Laboratory Findings of Patients With COVID-19 Infection

Characteristics	Total (n = 1341)	Critical Care Unit (n = 175)	Non–Critical Care Unit (n = 1166)	*P**
Age, y	50.25 ± 17.59	55.70 ± 17.85	64.08 ± 13.20	<0.01
Sex				
Male	713	601	112	0.011
Female	628	564	63	
Family history				
Hypertension	432	139	293	<0.01
Diabetes mellitus	346	75	271	0.49
Heart disease	24	14	10	<0.01
Comorbidity				
Hypertension	728	608	120	<0.001
Diabetes mellitus	393	325	68	0.001
CAD	114	94	20	0.14
Heart disease	136	118	18	0.89
Social history				
Smoking	230	195	35	0.28
Alcoholic beverage	252	220	32	0.92
With travel history	127	110	17	0.07
Signs and symptoms				
Fever (T_{max} 37.8°C)	1099	172	927	0.04
Dyspnea	964	149	815	0.03
Chest discomfort	892	101	791	0.02
SBP, mm Hg		126.81 ± 18.9	138.64 ± 25.6	<0.001
DBP, mm Hg		79.88 ± 26.89	79.77 ± 13.09	0.936
Laboratory findings				
Hemoglobin, g/dL	12.3 (11.3-14.6)	12.1 (11.9-13.2)	12.4 (10.6-12.8)	.02
Leukocytes, $\times 10^6$/μL	6800 (4300-8200)	9710 (6210-15,200)	7500 (5200-8000)	.02
Lymphocytes ($\times 10^6$/μL	850 (600-1200)	910 (400-900)	750 (600-1100)	.02
Platelets, $\times 10^3$/μL	211 (186-272)	164 (101-123)	243 (180-290)	.01
Procalcitonin,† ng/mL	8.4 (123)	10.5 (105)	4.10 (26.43)	.09
ESR†	62.9 (47.2)	51.4 (30.69)	49.81 (32.67)	.56
CRP†	28.50 (54.8)	20.81 (37.32)	23.03 (27.90)	.50
LDH†	402 (392)	363.6 (387)	327 (146)	0.02
Ferritin†	1469 (3118)	1447 (2150)	1357 (3319)	0.67
D-Dimer†	1285 (4275)	1163 (3474)	1099 (2832)	0.82
Qtc at baseline,† mm		787 (67.8)	119 (10.3)	0.83
		219 (18.9)	35 (3.0)	
Troponin T,† ng/L	1498 (1321)	1424 (1317)	1051.97 (1321)	0.86
NT-proBNP, pg/mL	18,735 (20,656)	13,362 (27,364)	5692 (12,085)	0.51

Abbreviations: CAD, coronary artery disease; CRP, C-reactive protein; DBP, diastolic blood pressure; ESR, erythrocyte sedimentation rate; LDH, lactate dehydrogenase; NT-proBNP, amino-terminal pro–brain natriuretic peptide; Qtc, corrected Qt; SBP, systolic blood pressure.

**The P value is for patients admitted at the intensive care unit versus patients admitted at the non–intensive care unit.*

†Normal values: procalcitonin <0.05 ng/mL; ESR 0–15 mm/h; CRP 0–0.8 mg/L; LDH 85–227 U/L; ferritin 21.81–274.60 ng/mL; D-Dimer 0–24ng/L, 6 pg/mL; Qtc 350–440 mm; troponin T level is <50.00; NT-proBNP level is 20–459 pg/mL.

Table 2. Complications and Clinical Outcomes of Patients With COVID-19 Infection

	Total	Critical Care Unit	Non–Critical Care Unit	*P**
Complications (n = 217)				
Acute cardiac injury	65 (30%)	48	17	0.011
Heart failure	84 (39%)	72	12	0.3
Arrhythmia	65 (30%)	55	10	0.2
Electrocardiographic changes				
Atrial fibrillation	11	7 (64)	4 (36)	—
Conduction blocks	15	9	6	—
Suggestive of ischemia	18	—	—	—
Prolonged QT	17	—	—	—
Pericardial effusion†	2	2	—	—
Cardiomyopathy‡	1	1	—	—
Clinical outcomes				
Discharged	1238	126	1112	<0.01
Died	100	48	52	<0.01

**The P value is for patients admitted at the intensive care unit versus patients admitted at the non–intensive care unit.*
†Mild and moderate pericardial effusion was seen in echocardiography.
‡Suspected Takotsubo cardiomyopathy seen in echocardiography.

The most common symptom was fever (1099 [82%]). This was followed by dyspnea and chest discomfort in 964 (72%) and 892 patients (67%), respectively. Upon admission, patients initially had elevated blood pressure, with the highest systolic pressure of 210 mm Hg (126.81 ± 18.92 vs 138.64 ± 25.55 mm Hg, regular ward vs critical care unit, respectively; $P < 0.001$) and diastolic pressure of 110 mm Hg (79.88 ± 26.89 vs 79.77 ± 13.09 mm Hg; $P = 0.936$, regular ward vs critical care unit, respectively). Patients admitted under the critical care unit have more often comorbidities such as hypertension (608 [46.6%] vs 120 [9.2%]), diabetes mellitus (325 [26.2%] vs 68 [5.5%]), heart disease (118 [9.2%] vs 18 [1.4]), and CAD (94 [7.3%] vs 20 [1.6%]). A complete list of clinical profiles is shown in Table 1.

Laboratory Findings

The laboratory findings are also shown in Table 1. In the overall study population, inflammatory markers were elevated, including procalcitonin (8.4 ng/mL), ESR (62.9 mm/h), CRP (28.50 mg/L), LDH (402 U/L), and ferritin (1469 ng/mL), whereas the median values of other laboratory tests, such as hemoglobin, leukocytes, lymphocytes, and platelets, were within the reference range.

In terms of comparison, patients admitted to a critical care unit had relatively higher procalcitonin levels (10.5 [105] vs 4.10 [26.43]), ESR (51.4 [30.69] vs (49.81 [32.67]), LDH (363.6 [387] vs 327 [146]), and ferritin levels (1447 [2150] vs 1357 [3319]).

D-Dimer was also elevated in patients admitted to the critical care unit (1163 [3474] vs 1099 [2832]).

In terms of biomarkers, patients admitted to the ICU showed significantly elevated D-Dimer (1163 [3474] vs 1099 [2832]), troponin T (1424 [1317] vs 1051.97 [1321]), and NT-proBNP (13,362 [27,364] vs 5692 [12,085]) (Table 2).

During hospitalization, 100 patients (7.4%) died, with 52 patients admitted to the non–critical care unit and 48 to the critical care unit. The incidence of cardiac complications among patients admitted with COVID-19 infection is 16% (217 of 1341). Among the cardiac complications, 65 patients (4.8%) had acute cardiac injury, 84 (6.2%) had heart failure, 65 (4.8%) had arrhythmia, 11 (17%) had atrial fibrillation, and 15 (23%) had conduction blocks. The complete right bundle-branch block was the most common conduction block (5 of 15 [33%]). Three of them had third-degree atrioventricular block and underwent temporary pacemaker insertion. Two patients had noted to have mild and moderate pericardial effusion.

One patient was suspected of having Takotsubo cardiomyopathy and was admitted to the critical care unit as seen by echocardiography. The most common ECG finding was ST-segment changes suggestive of ischemia (18 of 1341 [18%]) and prolonged QTc (17 of 1341 [17%]). Atrial fibrillation was observed in 11% (11 of 1341) with initial rhythm upon admission of sinus rhythm.

Cardiac Complications

Acute Myocardial Injury

Table 3 compares patients with COVID-19 with normal versus elevated troponin T levels. Among COVID-19 patients admitted, 251 (18.7%) had troponin T levels tested during admission, and 186 (74%) showed normal levels, with a high proportion of patients having preexisting conditions. In terms of the inflammatory markers, patients who had acute cardiac injury had higher values of inflammatory markers, particularly CRP

Table 3. Comparison of COVID-19 Patients With Normal Troponin Versus Patients With Elevated Troponin

Comorbidities	Total (n = 251)	Troponin T Level*		*P*†
		Normal (n = 186)	Elevated (n = 65)	
Hypertension	65	43	22	0.79
Diabetes	35	21	14	0.50
Heart disease	13	7	6	0.43
Coronary artery disease	9	5	4	0.70
Laboratory findings‡				
ESR	54 (29.36)	52.6 (26.47)	55.05 (33.21)	0.71
CRP	24 (20.11)	15.69 (19.05)	27.87 (22.86)	0.02
LDH	403 (188.69)	326.74 (167.29)	1032.34 (198.86)	0.01
Ferritin	1291 (1427)	1229.71 (1171)	2412 (2717)	0.01
Patients with 2D echo and troponin T (n = 145 of 251)				
EF >55%	92	76	24	0.18
EF <55%	53	21	32	0.13

Abbreviations: 2D echo, two-dimensional echocardiography; COVID-19, coronavirus disease 2019; ESR, erythrocyte sedimentation rate; CRP, C-reactive protein; LDH, lactate dehydrogenase.
**Normal troponin T level is <50.00.*
†The P value is for patients with normal troponin level versus patients with elevated troponin T level.
‡Values are in mean (standard deviation).

Table 4. Comparison of COVID-19 Patients With Normal NT-proBNP Versus Patients With Elevated NT-proBNP

Comorbidities	Total (n = 83)	NT-proBNP Level*		*P*†
		Normal (n = 18)	Elevated (n = 65)	
Hypertension	21	4	17	1.0
Diabetes	13	1	12	0.18
Heart disease	5	0	5	0.33
Coronary artery disease	4	0	4	0.55
Laboratory findings‡				
ESR	42 (22.38)	46.75 (20.46)	36.60 (24.67)	0.53
CRP	12.23 (18.46)	12.16 (20.22)	11.70 (16.81)	0.97
LDH	320.96 (539)	249.80 (134)	606 (992)	0.45
Ferritin	385 (495)	292 (336)	1136 (1240)	0.21
Patients with 2D echo and NT-proBNP (n = 75 of 83)				
EF >55%	49	11	38	0.21
EF <55%	26	2	24	0.19

Abbreviations: 2D echo, two-dimensional echocardiography; COVID-19, coronavirus disease 2019; CRP, C-reactive protein; EF, ejection fraction; ESR, erythrocyte sedimentation rate, LDH, lactate dehydrogenase; NT-proBNP, amino-terminal pro–brain natriuretic peptide.
**Normal NT-proBNP level is 20 to 459 pg/mL.*
†The P value is for patients with normal NT-proBNP versus patients with elevated NT-proBNP level.
‡Values are in mean (standard deviation).

(15.69 vs 27.87; $P < 0.02$), LDH (326.74 vs 1032.34; $P < 0.01$), and ferritin (1229 vs 2412; $P < 01$). Most patients with normal Troponin T levels had adequate contractility (76 of 92) based on two-dimensional echocardiography. Similarly, patients with acute cardiac injury had systolic left ventricular dysfunction (32 of 53) as low as 18% ejection fraction (EF).

Heart Failure

Table 4 compares admitted patients with COVID-19 in terms of NT-proBNP levels. Most patients with comorbidities have elevated NT-proBNP levels, predominantly hypertension and diabetes, including heart and CAD. As for the inflammatory markers, ferritin (1136 [1240] vs 292 [336]) and LDH (606 [992]

Table 5. Comparison of COVID-19 Patients With Normal D-Dimer Versus Patients With Elevated *D*-Dimer

Comorbidities		*D*-Dimer level		*P*†
	Total (n = 974)	Normal (n = 223)	Elevated (n = 751)	
Hypertension	516	124	392	0.35
Diabetes	268	69	199	0.10
Heart disease	82	19	63	0.89
Coronary artery disease	95	21	74	0.55
Cancer	85	18	67	0.21
Smoking history	165	36	129	0.92
Laboratory findings‡				
ESR	49.24 (31.13)	47.27 (29.50)	50.68 (30.80)	0.23
CRP	18.52 (23.64)	17.74 (22.11)	19.37 (25.41)	0.51
LDH	355 (228.97)	307.36 (166.48)	367.06 (543.71)	0.03
Ferritin	1185 (1694)	1129 (1660)	1225 (1746)	0.60
Procalcitonin	12.89 (48.71)	13.37 (53.65)	7.08 (44.37)	0.19
Patients with venous scan (VCT or venous duplex scan) and D-Dimer (n = 49 of 974)				
With thrombus	49	11	38	0.21
Proximal VT	18	2	16	0.17
Distal VT	31	9	22	0.13

Abbreviations: COVID-19, coronavirus disease 2019; CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; LDH, lactate dehydrogenase; VCT, venous compression test; VT, venous thrombosis.
**Normal D-Dimer level is 0 to 246 pg/mL.*
†The P value is for patients with normal D-Dimer versus patients with elevated D-Dimer level.
‡Values are in mean (standard deviation).

vs 249 [134]) were relatively higher in patients with raised NT-proBNP levels than in those with normal NT-proBNP levels. Most COVID-19 patients developed heart failure with preserved EF as displayed by normal systolic function with elevated NT-proBNP level (38 of 75 [51%]) compared with patients who had heart failure with left ventricular dysfunction (24 of 75 [32%]). Only two patients had left ventricular dysfunction with wall motion abnormalities but had average NT-proBNP levels. One patient with elevated NT-proBNP levels was previously diagnosed with aortic stenosis and presented with congestion, which may have caused increased levels due to valvular heart disease.

Regarding wall motion and contractility, the most affected region was the interventricular septum from the mid to apical region, followed by global hypokinesia with the lowest ventricular EF of 18%.

VTE Occurrence

More than half of the patients tested had elevated D-Dimer (751 of 974). Comorbidities such as hypertension (392 vs 124), CAD (74 vs 21), and heart disease (63 vs 19) were observed in patients with elevated D-Dimer levels. Other factors that may increase D-Dimer levels include cancer (67 vs 18) and smoking history (129 vs 36). Based on venous ultrasound, venous thrombosis was reportedly high in patients with elevated D-Dimer levels (38 vs 11), mostly occurring in the proximal location. The most common locations observed were along the distal segments, particularly the popliteal, small saphenous, peroneal, and tibial veins. Three patients had extensive deep venous thrombosis that occluded the external iliac artery down to the popliteal vein. Six patients had venous thrombosis in the upper extremities along the internal jugular vein. Eight patients with venous thrombosis had chronic and four had subacute thromboses (Table 5).

DISCUSSION

To the best of our knowledge, this is the most extensive study of hospitalized patients diagnosed with COVID-19 in our local setting, in which the determination of cardiac complications has been systemically recorded. The incidence of cardiac complications among patients with COVID-19 infection (16%) presented in our study suggests the need for closer follow-up and cardiac monitoring in COVID-19 management.

Despite the significant manifestation of COVID-19 infection in the pulmonary system, many studies have shown that some patients have severe cardiovascular damage.[4] Patients with established cardiovascular risk factors may have an increased risk of death because they complicate the severity of COVID-19 infection. These were the most common comorbidities in patients admitted to the ICU. Blood pressure levels were significantly higher upon admission and those subsequently admitted to the ICU care unit (126.81 ± 18.9 vs 138.64 ± 25.6 mm Hg; $P < 0.001$) compared with patients in

the non-ICU care unit. This was observed in previous studies,[4–7] signifying the severe nature of COVID-19 infection. Studies have investigated the similarity of SARS-CoV-2 to beta coronavirus, in which the most common symptoms include fever and dyspnea. Regarding cardiac manifestations, chest pain has been noted to be the most common cardiac manifestation.[6,9,11] This is mainly due to inflammation demonstrated as the patient recovered from COVID-19 infection and showed myocardial inflammation on cardiac magnetic resonance imaging. The clinical implications of these findings may suggest that further studies must be conducted and explored in more extensive studies with longitudinal follow-up of patients as they may have residual cardiac complications.

In terms of myocardial injury, troponin T levels were higher in ICU-admitted patients (48 [74] vs 17 [26]; $P = 0.011$). Comparing the level of troponin T with the inflammatory markers, there was an elevated level, particularly in ESR, CRP, LDH, and ferritin, demonstrating a high inflammatory state in patients with acute cardiac injury. Note that the proportion of normal troponin T levels is high compared with elevated levels (186 vs 65). Previous smaller studies suggest that the change in troponin T levels may predominantly reflect the occurrence of demand ischemia and noncardiac causes rather than myocardial infarction and noncardiac causes. In a meta-analysis of critically ill patients admitted to the ICU due to trauma or sepsis, the troponin level was noted to be 43%,[20] demonstrating that the elevation is nonspecific. Hence, cautious observation must be followed when interpreting the results. Using troponin I level rather than troponin T may give us a better picture of myocardial causes, but this was not done due to the longer time of result delaying the management plan.

An extensive global study,[21] including 169 hospitals, found that CAD and congestive heart failure were independent predictors of in-hospital death, with a mortality rate of 15.3%. Another study further investigated the pathophysiology of heart failure in patients.[22] Monocytes appear to produce more inflammatory markers. The intense, widespread systemic inflammatory response associated with severe COVID-19 infection requires enhanced cardiac performance, eventually exhausting the heart and leading to failure. Note that in our study there was an elevation of NT-proBNP, especially in patients admitted to the ICU unit. Interestingly, the development of heart failure in COVID-19 leads to preserved EF rather than a left ventricular systolic function. This portends to a problematic approach as the clinical implication might not be evident initially in the patient until it worsens and manifests in the later stages. The cause of new-onset heart failure in patients with COVID-19 may be the direct effect of the virus on systemic inflammation of the heart. A worse prognosis occurs in patients with heart failure, especially those with already established risk factors, as they experience worse prognoses and high mortality rates.[23] Seven patients also developed right ventricular failure, as seen in echocardiography, because of elevated pulmonary pressure caused by the hyperinflammatory state of COVID-19 affecting the right portion of the heart.

Regarding VTE occurrence, several studies have already proven that COVID-19 causes thrombosis because of its high prothrombotic state, which increases the risk of PE. The reported incidence of VTE of 27% to 46% in China and Western Europe without systematic screening was high. In a cohort study by Xu et al,[19] they reported that the most common comorbidities were hypertension (50%), obesity (27%), and hyperlipidemia (32%), which was evident in our study. However, one must take note that other causes of D-Dimer must also be investigated, such as smoking history and cancer.

In our study, the most common location of the thrombus was at the distal segments, particularly in the popliteal, small saphenous, peroneal, and tibial veins. A previous systematic review and meta-analysis of 33 studies by Longchamp and Blondon[24] demonstrated that most thromboses occur on the proximal deep venous thrombosis with an incidence of 21% in the ICU. This may be different in our study because the number of participants may be inadequate and may not reflect the overall incidence in our study.

The development of cardiac arrhythmia in patients with COVID-19 is of multivariate causes, not only direct cardiac injury brought about by SARS-CoV-2 infection.[22] In addition, some antiviral medications developed during infection, especially during the early phase, can contribute to electrolyte abnormalities (hydroxychloroquine, ritonavir, lopinavir) leading to arrhythmias. Most patients in our study had prolonged QTc, especially those admitted to the ICU (787 [67.8] vs 119 [10.3]; $P = 0.67$). The cause of prolongation might not represent a direct cause of COVID-19 because this can be attributed to hypoxia and electrolyte abnormalities, which are very common in the acute phases of severe COVID-19 illnesses.

Tables 6 and 7 summarize the factors associated with in-hospital mortality. The cardiovascular risk factor diabetes mellitus group had 2.714 times the odds of the non–diabetes mellitus group being deceased. In addition, the hypertensive group had 3.45 times the odds of the nonhypertensive group. This finding is consistent with previous studies and even demonstrated that exposure to COVID-19 was associated with a high propensity to develop longer cardiovascular risks.

The multiple logistic regression analysis in Table 7 shows that age and admission duration were significantly associated with mortality (with a $P < 0.05$). According to this fitted model, older people are more likely to die than younger people. The log odds of mortality increased by 0.091 units per year. The older the patient, the higher the number of comorbidities, increasing the risk of developing severe complications. With the admission duration of the patients, the log odds for mortality decreased by 0.099 units per year. The longer the admission of a patient, the lower the chance of death. This implies the emergence status of our institution, especially in our country, because of the lack of medical apparatus, medications, and physicians' availability during the pandemic peak. There was a significant increase in admissions, hoping to provide adequate

Table 6. Factors Associated With Mortality (Univariate Analysis)

Parameters	Crude Odds Ratio	Estimate (Coefficient)*	Standard Error	*P*
Age	1.083	0.079	0.02	<0.01
Duration	0.933	-0.069	0.022	0.003
Sex				
Male	0.532	-0.381	0.56	0.214
Female	0.623	-0.473	0.48	0.328
Risk factors				
Diabetes mellitus	2.714	0.998	0.46	0.029
Dyslipidemia	0.706	-0.348	0.78	0.657
Hypertension	3.449	1.238	0.48	0.011
Heart disease	3.310	1.197	0.90	0.182
CAD	3.425	1.231	0.75	0.099
Arrhythmia	0.000	-19.383	0.84	1.000
Other comorbidities				
CKD	2.629	0.966	0.87	0.266
Pulmonary disease	0.419	-0.870	1.06	0.412
Immunocompromised	0.000	-19.397	0.76	0.999
Neurologic	3.310	1.197	0.90	0.182
Family history				
Diabetes mellitus	0.280	-1.275	1.05	0.225
Hypertension	0.644	-0.439	0.65	0.502
Heart disease	6.455	1.865	1.43	0.193
Personal and social history				
Smoking	0.661	-0.413	0.78	0.597
Alcoholic beverage	0.316	-1.153	1.05	0.274
With travel history	3.425	1.231	0.75	0.099

Abbreviations: CAD, coronary artery disease; CKD, chronic kidney disease.
**If a patient's age is 1 unit more, he/she will have a 0.079-unit (estimate [coefficient] with age in the table above) more chance of being deceased based on the P value on the table (<0.01). If a patient's admission duration (no. of days admitted to hospital) is 1 unit more, he/she will have a –0.069-unit less chance of being deceased based on the P value on the table (0.003).*

treatment and intervention. Most patients under the moderate risk classification stayed longer and were eventually discharged stable. Regarding the ICU patients, there was a high mortality rate due to severe complications.

SCOPE AND LIMITATIONS

Our study has several limitations. Initiation of the study was conducted when there were still no established algorithms regarding the proper diagnostic test to be performed for patients diagnosed with COVID-19 infection. Most patients diagnosed with COVID-19 were confirmed with lower respiratory tract and no paired nasopharyngeal swabs to investigate if patients had SARS-CoV-2 infection. Despite the number of cases in the study, the participants did not undergo the same laboratory test requested during admission. Data regarding echocardiography, electrocardiography, cytokine level measurements, and cardiac biomarkers were lacking from the clinical examination at the time of analysis, limiting the determination of the potential for in-hospital mortality. Most two-dimensional echocardiographic acquisitions were performed under point-of-care ultrasound protocol to avoid exposure.

Similarly, the staff initially assessed the vascular scan, and the VTE rate may have been underreported or undetected. Second, the association between several risk factors for disease severity and mortality may be affected by multivariate processes. The study did not further include the medications administered or

Table 7. Factors Associated With Mortality (Multivariate Analysis)

Parameters	Adjusted Odds Ratio	Estimate (Coefficient)	Standard Error	*P*
Age	1.095	0.091	0.028	<0.01
Duration	0.906	–0.099	0.028	<0.01
Cardiovascular risk factors				
Diabetes mellitus	1.769	0.571	1.107	0.361
Hypertension	2.440	0.892	1.532	0.155
Preexisting cardiac disease				
Heart disease	0.339	–1.082	0.508	0.471
CAD	0.842	–0.172	0.914	0.874
Other comorbidities				
Neurologic	10.471	2.349	27.141	0.365
Family history				
Diabetes mellitus	0.152	–1.883	0.186	0.123
Heart disease	15.008	2.709	30.502	0.183
Personal and social history				
With travel history	5.108	1.631	5.413	0.124

Abbreviation: CAD, coronary artery disease.

the vaccination status of the patients, which might affect the severity of the condition and the test result. The findings of the statistical tests and *P* values should be interpreted cautiously, even if the values are not significant among ICU and non-ICU patients.

CONCLUSION

This large study highlights the demographic profile, clinical characteristics, and laboratory testing results of hospitalized patients diagnosed with COVID-19. This study demonstrated that acute cardiac injury is a common condition that may be helpful for strict monitoring of these patients and for expanding the knowledge of subsequent complications for public health officials. By understanding the role of preexisting CVDs and identifying the cardiac complications caused by COVID-19, this study emphasizes the importance of clinical surveillance and follow-up because these patients may develop long-term cardiac outcomes.

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