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Comparison of Mortality, Length of Stay, and Hospitalization Costs of Hospitalized COVID-19 Patients with Cardiac and Non-Cardiac Disease

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Abstract

Background: The COVID-19 pandemic has presented unprecedented challenges to global healthcare systems. As the pandemic unfolded, it became evident that certain groups of individuals were at an elevated risk of experiencing severe disease outcomes. Among these high-risk groups, individuals with pre-existing cardiac conditions emerged as particularly vulnerable. **Objective:** This study aimed to investigate the relationship between the length of stay, mortality, and costs of COVID-19 patients with and without a history of cardiac disease. **Design:** This retrospective study was conducted in Jam Hospital in Tehran, Iran, from March 21, 2021, to March 21, 2022. All patients with laboratory-confirmed COVID-19 who were hospitalized during this period were included. **Results:** A total of 500 COVID-19 patients were hospitalized, with 31.6% having a history of cardiac disease and 68.4% without any cardiac disease. Patients with cardiac disease were significantly older (median [range] age, 69.35 [37 - 94] years) compared to non-cardiac patients (54.95 [13 - 97] years) ($p < 0.001$). Hypertension (39.2%) and diabetes (28.6%) were the most prevalent comorbid conditions. According to the Cox regression model, patients with cardiac disease did not have a statistically higher risk of death than those without cardiac disease. However, age and underlying disease were significant risk factors for mortality with COVID-19, with high hazard ratios (HRs) of 1.041 (95% CI, 1.041 - 1.070) and 2.297 (95% CI, 1.152 - 4.581), respectively. The median length of stay (LOS) in cardiac patients was seven days, with an average total cost of $1865.77 per patient, significantly higher than in patients with no cardiac history (p-value: 0.004, <0.001). **Conclusion:** Patients with cardiac disease who are hospitalized with COVID-19 have a higher mortality rate, longer hospital stays, greater disease severity, ICU

admission, and higher costs. Therefore, improved prevention and management strategies are crucial for these patients.

Keywords

COVID-19, Cardiac Disease, Length of Hospital Stay, Costs, Mortality

1. Introduction

The new virus, which first appeared in December 2019, has had a global impact on health and the economy [1].

Patients infected with the virus can present with a wide range of clinical symptoms, but those with pre-existing cardiovascular disease, hypertension, or other associated illnesses are more likely to experience severe outcomes [2].

Research indicates that cardiovascular disease is present in up to 30% of COVID-19 patients [3], putting them at a higher risk for severe illness [4].

Treatment priorities for people with COVID-19 should be based on the presence of chronic underlying diseases in these individuals, such as cardiovascular disease, respiratory disease, and kidney disease [5].

As hospitals struggle with limited resources, including personal protective equipment (PPE) and medical staff, the costs associated with treating COVID-19 patients have increased [6]. Complicating matters further, COVID-19 can lead to serious complications, such as neurological, cardiovascular, renal, and gastrointestinal involvement, particularly in patients with underlying conditions, resulting in prolonged hospitalization and higher costs [7] [8].

In this study, we aimed to compare the mortality, length of stay, and hospitalization costs between patients with a history of cardiac disease and those without. We hypothesized that patients with pre-existing cardiac conditions would have worse outcomes, including increased mortality, prolonged hospitalization, and higher costs.

2. Method

This retrospective study was conducted at Jam Hospital in Tehran, Iran. The study included 500 COVID-19 patients who were hospitalized at the hospital between March 21, 2021, and March 21, 2022. Among them, 158 patients had a history of cardiac diseases such as Coronary Artery Disease (CAD), Percutaneous Coronary Intervention (PCI), Coronary Artery Bypass Graft Surgery (CABG), and Congestive Heart Failure (CHF), while the remaining 342 did not have any cardiac history. Data were obtained through the Hospital Information System (HIS) and patient records. Information about patients' costs was also obtained from the hospital's financial unit.

The data collection included demographic information, medical history, vital signs, radiological findings, length of stay, and hospitalization costs. All COVID-19 patients with confirmed disease through laboratory real-time PCR

tests. The severity of pulmonary involvement was categorized as mild, moderate, or severe based on radiological findings.

We classified the severity of COVID-19 based on CT reports obtained from the radiology unit of Jam Hospital using the following criteria: Mild: for cases with lung involvement less than 25%, Moderate: for cases with lung involvement between 25% and 70%, and Severe, for cases with lung involvement greater than 70%.

Patients who died or were discharged within the first 24 hours, transferred to another hospital, or hospitalized during data collection were excluded from the study to prevent bias in calculating the length of stay.

Patient confidentiality was maintained throughout the study.

3. Statistical Analysis

Continuous variables are presented as either mean ± SD or median (interquartile range [IQR]), while categorical variables are presented as numbers and proportions. Categorical variables were compared using Fisher's exact test or chi-square test, while continuous variables were compared using an independent two-sample t-test or Mann-Whitney U test, depending on appropriateness. Survival curves were plotted using the Kaplan-Meier method, and the log-rank test was used to compare them between cardiac and non-cardiac patients. A Multivariable Cox regression model was used to identify independent risk factors for death during hospitalization. The statistical software package SAS version 9.2 for Windows (SAS Institute Inc., Cary, NC, USA) was utilized for statistical analysis. All p-values were two-tailed, with $p \leq 0.05$ considered statistically significant.

4. Results

4.1. Patient Characteristics

The study involved 500 COVID-19 patients, of which 158 (31.6%) had a history of cardiac disease. Notably, patients with cardiac disease were significantly older (mean ± SD age: 69.35 ± 12.34 years) compared to those without cardiac disease (mean ± SD age: 54.95 ± 15.12 years) ($p < 0.001$). Gender distribution did not show a significant difference between the two groups ($p = 0.142$). Fever, cough, and shortness of breath were the most common symptoms, while hypertension (196 [39.2%]) and diabetes (143 [28.6%]) were the most common co-existing conditions. Patients with cardiac disease had a higher incidence of comorbidities. The severity of pulmonary involvement was significantly different between patients with and without cardiac disease ($p < 0.001$). A higher percentage of cardiac patients required ICU admission (31 [19.6%]) and died (25 [15.8%]). Vital sign measurements showcased nuanced variations between the groups. Pulse rate ($p = 0.014$), systolic blood pressure ($p < 0.001$), and diastolic blood pressure ($p = 0.138$) demonstrated statistically significant differences (**Table 1**).

4.2. Cardiac Disease Impact on Mortality

The mortality rate was higher in patients with cardiac disease than in non-cardiac

Table 1. Clinical and demographic characteristics of patients.

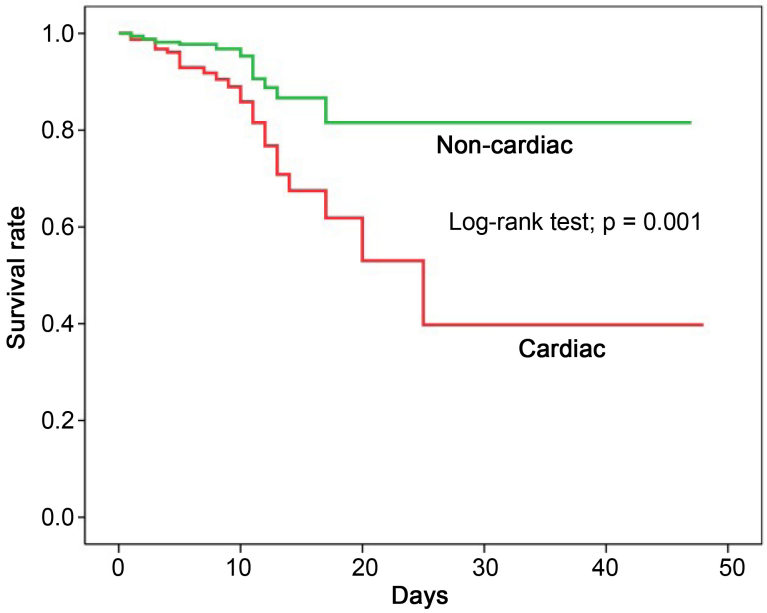
Characteristic	All (n = 500)	Cardiac (n = 158)	Non-Cardiac (n = 342)	P value
Age (year) mean ± SD (range)	59.50 ± 15.78 (13 - 79)	69.35 ± 12.34 (37 - 94)	54.95 ± 15.12 (13 - 97)	<0.001*
Gender				
Female	252 (50.4)	72 (45.6)	180 (52.6)	0.142
Male	248 (49.6)	86 (54.4)	162 (47.4)	
Signs and symptoms at admission		**Patients n (%)**		
Fever	219 (43.8)	74 (46.8)	144 (42.1)	0.321
Cough	218 (43.6)	83 (52.5)	136 (39.8)	0.007*
Shortness of breath	183 (36.6)	59 (37.3)	124 (36.3)	0.815
Sore throat	13 (2.6)	3 (1.9)	10 (2.9)	0.763
Headache	23 (4.6)	7 (4.4)	16 (4.7)	0.902
Weakness and lethargy	89 (17.8)	35 (22.2)	54 (15.8)	0.084
nausea and vomiting	39 (7.8)	11 (7.0)	28 (8.2)	0.635
Myalgia	73 (14.6)	25 (15.8)	48 (14.0)	0.599
Chronic medical illness				
Hypertension	196 (39.2)	99 (62.7)	97 (28.4)	<0.001*
Diabetes	143 (28.6)	75 (47.5)	68 (19.9)	<0.001*
Hyperlipidemia	35 (7.0)	18 (11.4)	17 (5.0)	0.009*
Other diseases[1]	65 (13.0)	26 (16.5)	39 (11.4)	0.118
Chest radiography findings (severity)				
Mild	136 (27.2)	46 (29.1)	90 (26.3)	
Moderate	141 (28.2)	10 (6.3)	131 (38.3)	<0.001*
Severe	223 (44.6)	102 (64.6)	121 (35.4)	
Clinical outcome				
ICU[2]	67 (13.4)	31 (19.6)	36 (10.5)	0.006*
Death (in hospital)	40 (8)	25 (15.8)	15 (4.3)	<0.001*
Frist Vital Signs (mean ± SD)				
Temperature, ˚C	37.2 ± 0.82	37.3 ± 0.74	37.28 ± 0.89	0.135
Pulse rate, minutes	84.73 ± 15.35	82.51 ± 15.95	87.03 ± 14.04	0.014*
Systolic blood pressure, mm Hg	122.57 ± 16.47	126.55 ± 16.42	118.41 ± 15.52	<0.001*
Diastolic blood pressure, mm Hg	74.33 ± 10.07	75.21 ± 10.57	73.42 ± 9.48	0.138
Respiration rate, minutes (Median, IQR[3])	18 (18 - 20)	18 (18 - 20)	18 (18 - 20)	0.397
spO_2 (Median, IQR)	90 (86 - 94)	91 (85 - 94)	90 (86 - 94)	0.962
Height, m (median ± SD)	167.97 ± 10.09	168.52 ± 10.01	167.51 ± 10.18	0.454
Weight, kg (median ± SD)	77.91 ± 14.55	77.16 ± 14.50	78.55 ± 14.61	0.475
BMI[4] (median ± SD)	27.63 ± 4.81	27.26 ± 5.24	27.95 ± 4.41	0.280

*p-value < 0.05; [1]such as cancer, kidney disease, hypothyroidism, and, hepatitis; [2]Intensive care unit; [3]interquartile range; [4]Body mass index.

patients (25 [15.8%] vs. 15 [4.3%]; p < 0.001) as can be seen from Table 1 and the Kaplan-Meier survival curves in Figure 1.

The multivariate Cox regression analysis was conducted to explore the risk factors associated with mortality among COVID-19 patients. The results of this analysis are presented in Table 2.

Among the factors examined, age emerged as a significant predictor of mortality (Hazard Ratio [HR] = 1.04, 95% Confidence Interval [CI] = 1.01 - 1.07, p = 0.003). This finding indicates that for every one-unit increase in age, the risk of



No. at risk						
Cardiac	158	40	6	2	2	0
Non-Cardiac	342	61	7	4	1	0

Figure 1. Mortality during hospitalization in cardiac and non-cardiac patients: Kaplan-Meier survival curves.

Table 2. Risk factors related to death by multivariate Cox Regression analysis.

Factor	Hazard ratio (95% CI)	p-value
Cardiac vs non-cardiac	1.42 (0.67 - 2.99)	0.349
Gender (female vs. male)	1.05 (0.54 - 2.04)	0.875
Age	1.04 (1.01 - 1.07)	0.003*
Hypertension	1.45 (0.68 - 3.07)	0.326
Diabetes	0.89 (0.43 - 1.82)	0.759
Hyperlipidemia	0.76 (0.17 - 3.28)	0.713
underlying disease	2.29 (1.15 - 4.58)	0.018*
Severity Mild: reference	1.88 (0.43 - 8.17)	0.169

*p-value < 0.05.

mortality increased by approximately 4%.

Furthermore, underlying diseases such as cancer, kidney disease, hypothyroidism, and hepatitis were also identified as significant predictors of mortality (HR = 2.29, 95% CI = 1.15 - 4.58, p = 0.018). Patients with underlying diseases faced a 2.29 times higher risk of mortality compared to those without such conditions.

In contrast, the presence of cardiac disease did not exhibit a statistically significant association with mortality (HR = 1.42, 95% CI = 0.67 - 2.99, p = 0.349). While patients with cardiac disease appeared to have a higher hazard ratio for mortality compared to non-cardiac patients, this difference did not reach statistical significance.

Other factors, including gender (female vs. male), hypertension, diabetes, hyperlipidemia, and disease severity, did not demonstrate statistically significant associations with mortality. These findings imply that, within the scope of this study and the provided data, these factors did not exert a significant independent influence on the risk of mortality among COVID-19 patients.

4.3. Length of Stay and Costs

The study found that the median length of stay (LOS) for COVID-19 patients was 6 days (IQR: 4 - 9), with a median LOS of 7 (IQR: 5 - 11) days for patients with a cardiac history, which was significantly different from those without cardiac history 6 (4 - 8) (p-value: 0.004).

The hospitalization costs for COVID-19 patients, stratified by patient type (cardiac vs. non-cardiac), are presented in Table 3.

The median total hospitalization cost for all patients was $1660.03 (range: $83.63 - $19174.24). Patients with a history of cardiac disease incurred a significantly higher median total cost of $1865.77 (range: $342.12 - $13889.01) compared to non-cardiac patients with a median cost of $1574.92 (range: $83.63 - $19174.24) (p < 0.001).

Table 3. Hospitalization costs for patients.

Type of costs (USD)	All		Cardiac		Non-Cardiac		p-value
	Median	Min-max	Median	Min-max	Median	Min-max	
Total	1660.03	83.63 - 19174.24	1865.77	342.12 - 13889.01	1574.92	83.63 - 19174.24	<0.001*
Bed and nursing	1246.82	6.36 - 11352.11	1459.17	232.78 - 7603.20	1216.70	6.36 - 11352.11	0.008*
Tests	99.04	0.55 - 2043.97	117.08	5.63 - 904.92	84.98	0.55 - 2043.97	<0.001*
Equipment	21.93	0.33 - 8228.85	27.12	4.04 - 8228.85	18.81	0.33 - 6226.36	<0.001*
Drugs	216.14	1.74 - 1777.59	227.31	14.80 - 1032.80	209.96	1.74 - 1777.59	0.076
Imaging	16.35	9.65 - 202.79	16.35	12.92 - 191.32	16.35	9.65 - 202.79	0.603
Physiotherapy	51.01	7.28 - 505	58.30	10.45 - 380.77	49.85	7.28 - 505	0.197

*p-value < 0.05.

Bed and nursing accounted for the highest percentage of costs at 75%, followed by drugs at 13%, laboratory tests at 5.9%, physician fees at 3%, medical equipment at 1.3%, and imaging at 0.9%.

Bed and nursing costs also demonstrated a statistically significant difference between the two patient groups. The median bed and nursing cost for all patients was $1246.82 (range: $6.36 - $11352.11). Cardiac patients had a median cost of $1459.17 (range: $232.78 - $7603.20), while non-cardiac patients had a median cost of $1216.70 (range: $6.36 - $11352.11) ($p = 0.008$).

The median testing cost for all patients was $99.04 (range: $0.55 - $2043.97). Cardiac patients had a median testing cost of $117.08 (range: $5.63 - $904.92), while non-cardiac patients had a median testing cost of $84.98 (range: $0.55 - $2043.97) ($p < 0.001$).

Equipment costs exhibited a significant difference between the two patient groups. The median equipment cost for all patients was $21.93 (range: $0.33 - $8228.85). Cardiac patients had a median cost of $27.12 (range: $4.04 - $8228.85), whereas non-cardiac patients had a median cost of $18.81 (range: $0.33 - $6226.36) ($p < 0.001$).

The total costs of COVID-19 episodes per patient were reported in US dollars, with a median cost of $1660.03 (IQR $1201.59 - 2477.42).

There was no statistically significant difference in drug costs between cardiac and non-cardiac patients. The median drug cost for all patients was $216.14 (range: $1.74 - $1777.59) for cardiac patients and $209.96 (range: $1.74 - $1777.59) for non-cardiac patients ($p = 0.076$).

Imaging and physiotherapy costs did not show statistically significant differences between the two patient groups. The median imaging cost for all patients was $16.35 (range: $9.65 - $202.79), and the median physiotherapy cost was $51.01 (range: $7.28 - $505). Cardiac and non-cardiac patients exhibited similar costs for both imaging ($p = 0.603$) and physiotherapy ($p = 0.197$).

5. Discussion

The impact of heart disease on mortality, length of stay, and cost of healthcare resources during the COVID-19 pandemic is estimated in this research. The study found that patients with a history of cardiac disease had a higher incidence of comorbidities, were significantly older, and had a higher severity of pulmonary involvement than those without cardiac disease. A higher percentage of cardiac patients required ICU admission and died. These findings emphasize the impact of pre-existing cardiac conditions on COVID-19 severity and adverse outcomes.

clinical and demographic findings of this study demonstrate that advanced age, gender distribution, symptoms at admission, chronic medical illnesses, radiographic severity, clinical outcomes, vital signs, and anthropometric measures all offer valuable insights into the nuanced interplay between cardiac history and COVID-19 presentations.

The influence of age on disease severity and outcome, aligns with previous re-

search that has highlighted advanced age as a crucial risk factor for adverse COVID-19 outcomes.

This study shows the importance of recognizing and managing pre-existing health conditions in the context of COVID-19 management, as these conditions can significantly contribute to disease severity and mortality.

The results of this study underscore the substantial financial implications of managing COVID-19 patients, particularly those with a history of cardiac disease. Hospitalization costs for cardiac patients were consistently higher across various categories, including total costs, bed and nursing costs, testing costs and equipment costs. These findings emphasize the need for healthcare systems to consider tailored resource allocation and cost-effective strategies for managing COVID-19 patients, especially those with underlying cardiac conditions.

Studies show that patients with pre-existing cardiovascular disease have a higher proportion of symptomatic infection and experience disproportionately worse outcomes with mortality rates ranging from 5 to 10-fold higher [9].

Additionally, COVID-19 patients with pre-existing cardiovascular disease, hypertension, or other related comorbidities have disproportionately worse outcomes. Several studies have identified hypertension, cardiovascular disease, and diabetes as common pre-existing conditions in COVID-19 patients. These conditions are substantial risk factors for the severity and fatality of COVID-19 infections and should be aggressively controlled in COVID-19 infection management [10] [11] [12].

On the other hand, the relationship between hypertension and worsening COVID-19 symptoms could be related to the higher incidence of comorbidities and an aging population. Hypertension was not found to be an independent factor affecting the outcome of COVID-19 in an Italian cross-sectional investigation [13].

According to studies in China and Italy, pre-existing cardiac disease increases the risk of mortality for patients suffering from COVID-19 [14] [15]. We also found that patients with cardiac disease had a significant impact on death.

The mechanism of increased risk of mortality is likely to be multifactorial, including older age in patients with cardiac complications and damage to the immune response caused by diabetes and age [16].

Patients with cardiac disease tend to have more severe acute illness, as evidenced by aberrant radiography findings such as higher levels of multiple spots and turbidity, and require more intensive care units.

However, the severity of the relationship between heart disease and COVID-19 outcomes varies across studies. Some studies have identified cerebrovascular disease or only coronary heart disease or heart failure as the most important risk factors for adverse outcomes.

Old age and the presence of underlying diseases are significant risk factors for adverse COVID-19 outcomes. Cardiac patients are usually older, and many of them also have other organ involvement, such as pulmonary disease, cirrhosis,

or renal failure, which can increase the risk of COVID-19-related death [16]. However, the study suggests that cardiac disease is not the most important risk factor for mortality in COVID-19 patients. Instead, old age and the presence of other underlying diseases are considered more significant risk factors. It is important to note that there is currently not enough evidence to make definitive recommendations [17].

Kevin J. Clerkin's study indicates that cardiovascular disease is more common among COVID-19 patients and puts them at higher risk of death. However, it is uncertain if the presence of cardiovascular comorbidity is an independent risk or if it is influenced by other factors, such as age [18].

Furthermore, the presence of underlying heart disease is associated with a longer length of stay and higher costs associated with COVID-19. This finding has important implications for the use of healthcare resources during the pandemic and for long-term planning to manage resources, particularly for intensive care beds and ventilators.

Given the increased risk of adverse outcomes in patients with pre-existing cardiac conditions, it is critical to understand the impact of COVID-19 on this patient population. This study's findings could help inform clinical decision-making and resource allocation for COVID-19 patients, particularly those with underlying cardiovascular disease.

We acknowledge the limitations of this study. Its retrospective nature makes it difficult to control for biases and confounding factors, as well as to establish cause and effect. We acknowledge the relatively limited sample size of our study population. In addition, probably this small sample size has caused us to not be able to obtain statistical significance with some variables in the Cox regression analysis.

6. Conclusion

This study suggests that patients with a history of cardiac disease are at a higher risk of mortality and longer hospital stays and higher costs associated with COVID-19. Therefore, healthcare decision-makers need to be aware of the impact of health crises on the health system, utilization of health resources, and potential medical costs to create effective pandemic management plans.

Conflicts of Interest

The authors declare no conflict of interest.

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