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Nationwide Analysis of the Clinical Outcomes of Patients Admitted With COVID-19 Infection With Myocarditis and Racial Disparities in Mortality

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Abstract: Coronavirus-19 (COVID-19), while primarily a respiratory virus, affects multiple organ systems, including the cardiovascular system. The relationship between COVID-19 and Myocarditis has been well established, but there are limited large-scale studies evaluating outcome of COVID-19 related Myocarditis. Using National Inpatient Sample (NIS) database, we compared patients with Myocarditis with and without COVID-19 infection. The primary outcome was in-hospital mortality. Secondary outcomes were acute kidney injury requiring hemodialysis, vasopressor use, mechanical ventilation, cardiogenic shock, mechanical circulatory support, sudden cardiac arrest, and length of hospitalization. A total of 17,970 patients were included in study; Myocarditis without COVID

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Patients with COVID-19 and myocarditis had higher in-hospital mortality compared to those with myocarditis alone (30.7% vs 6.4%, odds ratio 4.8, 95% CI 3.7-6.3, \( P < 0.001 \)). That cohort also had significantly higher rates of vasopressor use, mechanical ventilation, sudden cardiac arrest, and acute kidney injury requiring hemodialysis. Given the poor outcome seen in COVID-19 related myocarditis cohort, further work is needed for development of directed therapies for COVID-19-related myocarditis.

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Introduction

Coronavirus-19 (COVID-19) is primarily a respiratory virus caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). It was declared a pandemic in March 2020 by the World Health Organization, and since then, research has shown that infection with COVID-19 affects multiple organ systems, including the cardiovascular system. In one study, cardiac complications were found in 20-30% of patients with COVID-19 and were linked to worse patient outcomes. Currently, large-scale studies evaluating outcomes in patients with COVID-19-related myocarditis are limited.

The association between COVID-19 and myocarditis is well-established. Myocarditis is a disease process related to the inflammation of cardiac muscle due to a variety of infectious and noninfectious etiologies. In the United States, viral etiologies are the most common. Signs and symptoms of myocarditis include fatigue, chest pain, sinus tachycardia, new onset heart failure, cardiogenic shock, atrial and ventricular arrhythmias, and death. Endomyocardial biopsy is the gold standard for diagnosis of myocarditis. However, non-invasive imaging such as cardiovascular magnetic resonance imaging can be used for supporting diagnosis in cases with high clinical suspicion.

The pathophysiology of myocarditis in concurrent COVID-19 infection is not well understood but has generally been hypothesized to be related to potential combination of 1) immune-mediated, 2) auto-immune mediated, and 3) direct virus-induced damage of myocardium. The multiorgan involvement of COVID-19 has been hypothesized to be related to the angiotensin-converting enzyme 2 (ACE2) receptors found on pneumocytes as well as renal, gastrointestinal, and in our study’s
primary focus, cardiovascular tissues. The expression of ACE2 receptor facilitates viral entry into the host cell.13

The objective of our study was to use the National Inpatient Sample (NIS) to compare clinical outcomes in patients diagnosed with Myocarditis with and without concurrent COVID-19 infection. The primary outcome was in-hospital mortality. Secondary outcomes included acute kidney injury requiring hemodialysis, vasopressor use, mechanical ventilation, cardiogenic shock, mechanical circulatory support, sudden cardiac arrest, and length of hospitalization.

Materials and Methods

This retrospective study utilized the Agency for Healthcare Research and Quality (AHRQ) 2020 NIS dataset, which is based on hospitalizations from January 1, 2020, to December 31, 20207. All patients 18 years of age and older admitted to the hospital with Myocarditis and COVID-19 infection with concomitant Myocarditis were included in this study. International classification of diseases 10th - clinical modification (ICD-10-CM) codes were used to retrieve patient samples with comorbid conditions, and ICD-10procedure codes were used to identify inpatient procedures. A detailed code summary is provided in supplementary table 1. Patients who were under the age of 18 years or were transferred out of the hospital were excluded from this study.

Covariates

The NIS database contains data regarding in-hospital outcomes, procedures, and other discharge-related information. Variables were divided into patient-related, hospital-related, and indicators of illness severity as below:

a Patient: age, race, sex, comorbidities, insurance status, mean income in Patient’s zip code, and disposition.
b hospital: location, teaching status, bed size, and region.
c Illness severity: length of stay (LOS), mortality, hospitalization cost, Elixhauser comorbidity score, in-hospital complications, mechanical ventilation, circulatory support, and vasopressor use.

Study Outcomes

The primary outcome was in-hospital mortality. Secondary outcomes included: mechanical ventilation, vasopressor use, sudden cardiac arrest,
cardiogenic shock, acute kidney injury requiring hemodialysis, length of stay, health care utilization costs, and disposition

**Statistical Methods**

STATA 17 (StataCorp LLC, College Station, TX) was utilized for statistical analysis. The unweighted sample was 6.34 million observations, and the weighted sample was around 31.71 million discharges for the year 2020. Patients who were admitted with STEMI were retrieved with ICD-10-CM codes, and this group was further divided based on COVID status. Chi-square the test was used to compare categorical variables, and linear regression was used for continuous variables. For the primary outcome, univariate logistic regression was used to calculate the unadjusted odds ratio for variables of interest, and \( P \) values of \(<0.2\) on univariate logistic regression were used to build a multivariate logistic regression model to adjust for potential confounders. A multivariate linear regression model was used for continuous variables (LOS and total hospital charge). A 2-tailed \( P \)-value of 0.05 was considered significant.

**Results**

**Demographics and Baseline Comorbidities**

A total of 1,659,040 COVID-19 patients were hospitalized between January 1 to December 31, 2020, and 6455 (0.4%) were diagnosed with Myocarditis. During this time, we identified 11,515 patients with Myocarditis who were hospitalized without COVID-19 infection. COVID-19 patients with Myocarditis were significantly older (42.2% of patients were above the age of 70 years vs 16%, \( P < 0.001 \)), had a greater proportion of Hispanics (23.2% vs 12.2%, \( P < 0.001 \)), and were more likely to have a household income below $50,000 (30.7% vs 24.9%, \( P = 0.003 \)) when compared to non-COVID-19 patients with Myocarditis.

There was not a significant difference between non-COVID-19 patients and COVID-19 patients in regards to cardiac comorbidities, including coronary artery disease (23.6% vs 26%, \( P = 0.118 \)), previous MI (6.1% vs 5.6%, \( P = 0.509 \)), or prior history of PCI (0.3% vs 0.39%, \( P = 0.677 \)) aside from the prior history of CABG, in which COVID-19 did have higher rates of Myocarditis (1.3% vs 3.7%, \( P < 0.001 \)). Patients with COVID-19 also had higher proportions of uncomplicated diabetes mellitus (7.8% vs 11.1%, \( P < 0.001 \)), complicated diabetes mellitus (11.4% vs 31.1%, \( P < 0.001 \)), chronic kidney disease (6.8% vs 14.8%, \( P < 0.001 \)),
obesity (19.9% vs 26.7%, \(P < 0.001\)), hyperlipidemia (4.4% vs 13.1%, \(P < 0.001\)), and hypertension (18.9% vs 25.6%, \(P < 0.001\)).

There was some variability in the geographic distribution of the patients, and most patients with Myocarditis, with or without COVID-19 infection, were seen at urban teaching hospitals (77.5% and 80.1%, respectively). Moreover, the COVID-19 cohort had a higher proportion of Medicare beneficiaries (53.5% vs 27.8%, \(P < 0.001\)) and a lower proportion of private insurance (27.2% vs 44.7%, \(P < 0.001\)) when compared to the non-COVID-19 cohort. Table 1 outlines the baseline characteristics of the study cohort.

**In-hospital Mortality**

After multivariate adjustment for age, sex, race, income level, insurance status, discharge quarter, elixhauser comorbidities, hospital location, teaching status, and bed size, we found patients presented with COVID-19 infection with Myocarditis were associated with significantly higher in-hospital mortality compared to the myocarditis cohort without COVID-19 infection (30.7% vs 6.4%, adjusted OR: 4.8 [95% CI 3.7-6.3, \(P < 0.001\)]). We also examined subgroup mortality and found that among the COVID-19 with Myocarditis, Hispanics (23.3% vs 8.4%, \(P < 0.001\)) had increased in-hospital mortality compared to the non-COVID-19 myocarditis cohort. Conversely, a higher proportion of in-hospital mortality was observed in the Caucasian population in the non-COVID-19 myocarditis group (45.3% vs 62.9%, \(P < 0.001\)). Patients aged >70 hospitalized with Myocarditis and COVID-19 also had higher rates of mortality when compared to patients similar in age group without COVID-19 with Myocarditis (52.02% vs 37.2%, \(P < 0.001\)) Table 3.

**In-hospital Complications**

Patients presented with COVID-19 with myocarditis required more mechanical ventilation (42.6% vs 14.8%, adjusted OR: 4/6 [95% CI 3.7-5.7, \(P < 0.001\)]), higher vasopressors use (10.4% vs. 4.8%, adjusted OR: 1.9[95% 1.33-2.75, \(P < 0.001\)]) at higher rates despite no difference in cardiogenic shock and mechanical circulatory support (10.6% vs. 10.6%, adjusted OR: 1.2[95% CI 0.88-1.58, \(P = 0.98\)]) and (2.9% vs 4.5%, adjusted OR: 0.8[95% CI 0.5-1.4, \(P = 0.26\)]) respectively. These patients also had statistically significant higher rates of acute kidney injury requiring hemodialysis (9.22% vs. 3.21%, adjusted OR: 2.8[95% CI 1.9-4.1,
TABLE 1. COVID-19 and myocarditis unmatched patient-level characteristics

| Characteristics                      | Non-COVID Myocarditis | Myocarditis with COVID-19 | \(P\) value |
|--------------------------------------|------------------------|---------------------------|-------------|
| \(N = 17,970\)                      | \(N = 11,515\)         | \(N = 6,455\) (36%)      |             |
| Sex (Female)                         | 42.73%                 | 38.57%                    | 0.017       |
| Mean age years (SD)                  |                        |                           | <0.001      |
| Male                                 | 46.25 (18.28)          | 61.16 (18.27)             |             |
| Female                               | 52.34 (18.36)          | 65.57 (17.02)             |             |
| Age groups                           |                        |                           | <0.001      |
| \(\geq 18-29\)                      | 19.24%                 | 6.12%                     |             |
| 30-49                                | 32.31%                 | 16.27%                    |             |
| 50-69                                | 32.39%                 | 35.4%                     |             |
| \(\geq 70\)                         | 16.07%                 | 42.22%                    |             |
| Race                                 |                        |                           | <0.001      |
| Caucasians                           | 62.62%                 | 46.06%                    |             |
| African American                     | 17.03%                 | 20.8%                     |             |
| Hispanics                            | 12.24%                 | 23.19%                    |             |
| Asian or Pacific Islander            | 3.19%                  | 4.22%                     |             |
| Native American                      | 0.84%                  | 1.35%                     |             |
| Others                               | 4.08%                  | 4.38%                     |             |
| Median household income              |                        |                           | 0.003       |
| \(<49,999\$)                        | 24.93%                 | 30.76%                    |             |
| 50,000-64,999\$                     | 27.4%                  | 28.15%                    |             |
| 65,000-85,999\$                     | 23.22%                 | 22.08%                    |             |
| \(>86,000\$)                        | 24.45%                 | 19.01%                    |             |
| Insurance status                     |                        |                           | <0.001      |
| Medicare                             | 27.83%                 | 53.46%                    |             |
| Medicaid                             | 20.11%                 | 14.56%                    |             |
| Private                              | 44.66%                 | 27.18%                    |             |
| Self-pay                             | 7.41%                  | 4.8%                      |             |
| Hospital division                    |                        |                           | <0.001      |
| New England                          | 6.86%                  | 5.03%                     |             |
| Middle Atlantic                      | 15.46%                 | 19.44%                    |             |
| East North Central                   | 15.72%                 | 15.18%                    |             |
| West North Central                   | 6.86%                  | 7.67%                     |             |
| South Atlantic                       | 18.98%                 | 16.73%                    |             |
| East South Central                   | 4.73%                  | 6.35%                     |             |
| West South Central                   | 10.33%                 | 11.54%                    |             |
| Mountain                             | 6.69%                  | 5.73%                     |             |
| Pacific                              | 14.37%                 | 12.32%                    |             |
| Hospital bedsize                     |                        |                           | 0.001       |
| Small                                | 16.93%                 | 19.13%                    |             |
| Medium                               | 26.44%                 | 30.36%                    |             |
| Large                                | 56.62%                 | 50.5%                     |             |
| Hospital teaching status             |                        |                           | 0.008       |
| Rural                                | 4.78%                  | 7.59%                     |             |
| Urban non-teaching                   | 14.24%                 | 14.87%                    |             |
| Urban teaching                       | 80.98%                 | 77.54%                    |             |
| Comorbidities                        | Non-COVID              | Myocarditis with COVID-19 |             |

(continued)
Patients with COVID-19 and Myocarditis had an increased mean length of stay (11.8 days vs 6.4 days), adjusted length of stay of 4.5 days, \( P < 0.001 \) higher than Myocarditis without COVID-19 patients. They had higher mean total hospitalization cost (180,405 USD vs 127,184 USD, adjusted total cost 38,948 USD \( P < 0.001 \)). Of those patients who survived, fewer patients in the COVID-19 with myocarditis cohort were able to be discharged to home (78% vs 52%, \( P < 0.001 \)) and required skilled care.
nursing or long-term acute care compared to the non-COVID-19 with myocarditis group (27.8% vs 8.4%, \( P < 0.001 \)) Table 2.

Discussion

Between January 1 to December 31, 2020, 17,970 patients were identified with a diagnosis of Myocarditis. Major findings of this study include 1) patients with a co-diagnosis of COVID-19 and Myocarditis had a significantly higher rate of in-hospital mortality compared to the non-COVID-19 cohort. 2) There was no significant difference between groups regarding the presence of cardiogenic shock despite increased use of vasopressors and mechanical ventilation in the COVID-19 cohort. 3) Patients

| Variable                                | Non-COVID Myocarditis | Myocarditis with COVID-19 | \( P \) value |
|------------------------------------------|------------------------|---------------------------|--------------|
| Disposition                              | 77.99%                 | 51.96%                    | <0.001       |
| Home/Routine                             | 8.35%                  | 27.76%                    |              |
| SNF/LTAC/Nursing home                    | 11.92%                 | 19.69%                    |              |
| AMA                                      | 1.74%                  | 0.59%                     |              |
| Vasopressor use                          | 4.82%                  | 10.38%                    | <0.001       |
| Mechanical ventilation                   | 14.8%                  | 42.6%                     | <0.001       |
| Sudden Cardiac Arrest                    | 4.69%                  | 9%                        | <0.001       |
| Acute Kidney Injury on HD                | 3.21%                  | 9.22%                     | <0.001       |
| Cardiogenic Shock                        | 10.64%                 | 10.61%                    | 0.980        |
| Mechanical Circulatory Support (LVAD or pVAD or ECMO) | 4.52%                  | 2.94%                     | 0.022        |
| In-hospital mortality (N =2720)          | 6.43%                  | 30.7%                     | <0.001       |
| Mean total hospitalization charge ($)    | 127,184$               | 180,405$                  | <0.001       |
| Mean length of stay (days)               | 6.4                    | 11.8                      | <0.001       |

\(^1\)Adjusted for age, sex, race, income level, insurance status, discharge quarter, elixhauser comorbidities, hospital location, teaching status and bed size. Abbreviations: AMA, Against medical advice; ECMO, extracorporeal membrane oxygenation; HD, Hemodialysis; LTAC, A long-term acute care hospital; LVAD, Left ventricular assistance device; pVAD, Percutaneous Ventricular Assist Device; SNF, Skilled nursing facility.
with co-diagnosis of Myocarditis and COVID-19 had longer hospital stays and higher hospitalization costs, along with an increased risk of AKI requiring hemodialysis and sudden cardiac death. 4) Hispanics had remarkably higher mortality when co-diagnosed with COVID-19 and Myocarditis compared to other racial groups. 5) Patients aged greater than 70 years old with a diagnosis of COVID-19 and Myocarditis also were at greater risk of in-hospital mortality compared to younger cohorts of patients.

Of 1,659,040 patients identified with COVID-19 between January 1, 2020 to December 31, 2020, 6,455 were identified to have a co-diagnosis

| Variable                  | Carditis-ve | Carditis +ve | P value |
|---------------------------|-------------|--------------|---------|
| Disposition               |             |              | 0.097   |
| Home/Routine              | 51.58%      | 51.17%       |         |
| SNF/LTAC/Nursing home     | 24.82%      | 28.31%       |         |
| Home health               | 22.08%      | 20%          |         |
| AMA                       | 1.53%       | 0.52%        |         |
| Vasopressor use           | 3.92%       | 9.89%        |         |
| Mechanical ventilation    | 15.77%      | 41.69%       |         |
| Acute kidney Injury       | 31.03%      | 50.38%       |         |
| Sudden Cardiac Arrest     | 1.79%       | 9.12%        |         |
| Cardiogenic Shock         | 0.6%        | 10.49%       |         |
| Mechanical Circulatory Support (LVAD or pVAD or ECMO) | 0.51% | 2.64% | 0.292 |
| In-hospital mortality (N =2560) | 13.13% | 30.52% | <0.001 |
| Mean total hospitalization charge ($) | 72,072$ | 173,226$ | <0.001 |
| Mean length of stay (days) | 8.4 | 11.6 | 0.007 |

Abbreviations: +ve, Positive; -ve, negative.
2Adjusted for discharge quarter, elixhauser co-morbidities, hospital location, teaching status and bed size.
of myocarditis (0.4%). Previous literature has noted a prevalence of COVID-19-related Myocarditis between 0.1% and 0.4%, similar to our data.4-6 During this same time frame, we were able to identify an additional 11,515 patients with Myocarditis without COVID-19. To our knowledge, this is the biggest sample of hospitalized patients evaluating COVID-19 association with Myocarditis and its outcomes. Previous reports, while extremely beneficial in describing the association between COVID-19 and Myocarditis, have been limited to mostly case reports and review articles with sample sizes in the hundreds except Boehmer et al. study, which included 2,116 patients with COVID-19 and Myocarditis from all age groups.4

Boehmer et al. study concluded that COVID-19 patients had a 15.7 times risk of developing Myocarditis as compared to patients without COVID-19.4 Their study showed a higher percentage of Myocarditis in males (59.3%) in the COVID-19 cohort, similar to our findings of 61.2%. Out of patients with Myocarditis with COVID-19, their study showed 11% were Hispanic, but in our sample size Hispanics were significantly more affected (23.2%) and had significantly higher mortality when compared to non-COVID-19 patients with Myocarditis (23.3% vs 8.4%, P < 0.001).4 Their study didn’t assess the outcomes and complications that is, mortality, in-hospital complications, length of stay and health-care utilization costs.

When adjusted for similar risk factors, patients with COVID-19 Myocarditis appear to have a higher risk of in-hospital mortality, at nearly 31%. Our data is consistent and supports the findings of previously published literature.6 Observed mortality during this study period may be higher due to lack of evidence based COVID-19 therapeutics and vaccination availability which were only become widely available in 2021.14 Our study also highlights racial disparities which exist during COVID-19 pandemic. We observed higher mortality in Hispanics and Native Americans race in patients with COVID-19 and Myocarditis 23.3% and 1.3% respectively. Previous studies have reported Native Americans and Hispanics are increased risk for severe COVID-19 infection and mortality.15,16 These disparities can be explained due to low socio-economic status, inequalities in access to health care and lack of trust in the system.17

Prior studies have noted that cardiogenic shock was the most common presenting symptom in patients with COVID-19 myocarditis.5 This study consisted of 14 case reports early on during the pandemic. We now have significant data showing that the majority of patients with COVID-19 related Myocarditis do not present in cardiogenic shock and do not
require mechanical circulatory support (LVAD, pVAD, ECMO) at higher rates compared to patients with Myocarditis without COVID-19 infection. Despite this, we have found they have higher in-hospital mortality which could be attributed to non-cardiac factors such as septic shock as patients with COVID had higher rate of vasopressors use. Relying on cardiogenic shock as an indicator of Myocarditis in COVID-19 patients may not be as beneficial as once thought. Workup including cardiac biomarkers and echocardiogram should be relied upon first when suspecting myocarditis.\textsuperscript{18-20} EKG changes are non-specific and vary from Patient to patient.\textsuperscript{21}

Previous studies have also looked at pre-existing cardiac disease as a risk factor for developing Myocarditis with COVID-19.\textsuperscript{19} This single center study based out of Wuhan, China evaluated 187 patients with COVID-19 and Myocarditis who had prior history of cardiovascular disease. With increased patient numbers, our study found that history of prior cardiac disease (CAD, prior MI, hx of PCI), did not necessarily mean elevated myocarditis risk, but that patients with hypertension and hyperlipidemia where at elevated risk, which is consistent with prior studies.\textsuperscript{22} Patients with obesity, diabetes, hyperlipidemia, and hypertension were all at greater risk for Myocarditis associated with COVID-19 infection. It is well known that these comorbidities lead to poorer outcomes with COVID-19 infection\textsuperscript{23} but with this new data, providers should be aware of their elevated risk for Myocarditis and consider appropriate workup should symptoms arise.

In addition to elevated in-hospital mortality, COVID-19 related Myocarditis was associated with higher rates of vasopressor use, mechanical ventilation, sudden cardiac arrest, and acute kidney injury requiring hemodialysis. Many of the previously mentioned findings require intensive care unit level of care, so it is no wonder that the cost of hospitalization in patients with COVID-19 related Myocarditis is increased compared to the average COVID-19 related stay, and length of stay is almost 5 days longer compared to patients without Myocarditis.

Management of COVID-19 related Myocarditis remains mostly supportive in nature and involves treating the underlying COVID-19 infection. There is limited data that steroid use in patients with COVID-19 related Myocarditis vs Myocarditis alone tended to have better outcomes (survival rate of 85\% vs 81\%).\textsuperscript{24} In patients who develop heart failure, they should be placed on guideline directed medical therapy (recently updated for 2022 to include ACEi/ARB/ARNi, beta blockers, mineralocorticoid receptor antagonists, and SGLT2i). There has been no increased
risk of harm in patients treated with ACEi or ARB with COVID-19 infec-
tion and this should not prevent placing Patient on full GDMT.\textsuperscript{25,26}

It should be noted that there has been concern about Myocarditis related
to the mRNA COVID-19 vaccine. These findings have also been limited to
case reports and limited sample size and appear to effect mostly young
males (average age 26) without concurrent COVID-19 infection.\textsuperscript{27} In Boz-
kurt et al’s review article, they noted of over 300 million vaccines adminis-
tered, only 61 cases of vaccine related Myocarditis were found.\textsuperscript{27} At this
time, the benefits of vaccination appear to greatly outweigh the risk.

This new data made available by the National Inpatient Sample,
stresses the importance of early recognition of COVID-19 related Myo-
carditis. It also emphasizes the importance of continued community
efforts to increase vaccination against COVID-19 to prevent infection
given serious cardiac complications. While treatment of these patients
remains relatively unchanged at this time, the management style may
necessitate closer monitoring of these patients with added telemetry while
inpatient and close cardiology follow up upon discharge to ensure resolu-
tion of symptoms and inflammation.

\textit{Limitations}

Data from our study was collected via the National Inpatient Sample
which likely has some inherent selection bias. Myocarditis was diagnosed
primarily at larger, urban teaching hospitals, were resources such as card-
diac MRI may be more readily available then at a smaller community
hospital where a diagnosis of Myocarditis may go unmade, even if it was
suspected. Data from the NIS also does not capture outpatient mortality,
so mortality from COVID-19 related Myocarditis may be underestimated.
Vaccination likely did not affect our results as the first COVID-19 vac-
cine was made available via EUA on December 11, 2020. It is likely that
vaccination of COVID-19 would alter COVID-19-related Myocarditis,
but the prevalence has yet to be studied. Also, the National inpatient sam-
ple does not have data about the labs values and imaging, so we have to
rely on discharge diagnosis. Myocarditis included in our study is based
on ICD-10 codes and is prone to errors. However large sample size miti-
gates the potential coding errors.

\textit{Conclusion}

COVID-19-related Myocarditis is associated with higher rates of in-
hospital mortality, increased hospitalization costs, and longer length of
FIG 1. Baseline Non-COVID and COVID-19 with myocarditis patients characteristics.
FIG 2. Baseline Co-morbidities of Non-COVID and COVID-19 with myocarditis patients.
FIG 3. In-Hospital outcomes of Baseline Non-COVID and COVID-19 with myocarditis patients.
stay. It can have long-lasting effects on patients, which providers and patients must be aware of. Currently, there are no specific therapies for COVID-19-related Myocarditis, but given the severe findings associated with this disease process, further research should be completed to assess ways to lower in-hospital mortality and improve outcomes in these patients (Fig. 1–3).

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.cpcardiol.2022.101481.

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