

# A Multicenter Evaluation of Survival After In-Hospital Cardiac Arrest in Coronavirus Disease 2019 Patients

**IMPORTANCE:** In-hospital cardiac arrest survival among coronavirus disease 2019 patients has been reported to range from 0% to 12%. These numbers are significantly lower than reported prepandemic in-hospital cardiac arrest survival rates of approximately 20–25% in the United States for non-coronavirus disease 2019 patients.

**OBJECTIVE:** To assess the incidence of in-hospital cardiac arrest survival of coronavirus disease 2019 patients.

**DESIGN:** A retrospective cohort study of adult patients with coronavirus disease 2019 subsequently found to have in-hospital cardiac arrest and underwent cardiopulmonary resuscitation (cardiopulmonary resuscitation).

**SETTING:** Multiple hospitals of the Cleveland Clinic Health System.

**PATIENTS:** All adult patients (age  $\geq 18$  yr) admitted to Cleveland Clinic Health System with a diagnosis of coronavirus disease 2019 who experienced in-hospital cardiac arrest requiring cardiopulmonary resuscitation.

**MEASUREMENTS AND MAIN RESULTS:** From March 01, 2020 to October 15, 2020, 3,555 patients with coronavirus disease 2019 were hospitalized; 1,372 were admitted to the ICU; 58 patients had in-hospital cardiac arrest. Median age of this cohort was 66.5 years (interquartile range, 55.0–76.0 yr). Patients were predominantly male (62.5%), White (53.4%), with a median body mass index of 29.7 (interquartile range, 25.8–34.6). Most in-hospital cardiac arrests were in critical care environments (ICU), 51 of 58 (87.9%); seven of 58 (12.1%) were on ward locations. Thirty-four of 58 patients (58.6%) were on mechanical ventilation prior to in-hospital cardiac arrest with a median duration of mechanical ventilation of 9 days (interquartile range, 2–18 d). Twenty-four of 58 patients (44%) were on vasopressors prior to arrest. Initial arrest rhythm was pulseless electrical activity at (63.8%), asystole (29.3%), and pulseless ventricular tachycardia/fibrillation (6.9%). Of the 58 patients, 35 (60.3%) attained return of spontaneous circulation, and 13 of 58 (22.4%) were discharged alive.

**CONCLUSIONS:** We report a 22% survival to discharge after in-hospital cardiac arrest in coronavirus disease 2019 patients, a survival rate similar to before the coronavirus disease 2019 pandemic.

**KEY WORDS:** cardiac arrest; cardiopulmonary resuscitation; coronavirus disease 2019; resuscitation; severe acute respiratory syndrome coronavirus 2, survivorship

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There is paucity of studies on outcomes from in-hospital cardiac arrest (IHCA) in patients with coronavirus disease 2019 (COVID-19) disease caused by the severe acute respiratory syndrome coronavirus 2 virus. The initial studies from China and the United States reported markedly low IHCA survival ranging from 0% to 2.9% (1–3), and many healthcare systems considered a universal do-not-resuscitate (DNR) order for IHCA in COVID-19 patients (4, 5). Two studies from United States reported a 12% survival to hospital discharge after COVID-19–related IHCA (6, 7). The most recent study from the United States again reported zero survival after IHCA (8). These poor IHCA survival rates in COVID-19 patients are in stark contrast to previously reported national IHCA survival rates of 22.3% before the pandemic (9). Data suggesting poor survival and the risk of exposure to healthcare workers during resuscitation may lead to implicit bias toward early termination of cardiopulmonary resuscitation (CPR) efforts or discussion of universal DNR status for hospitalized COVID-19 patients (1–3, 8, 10). During the current surge of COVID-19, there is therefore a pressing need to understand the current survival rate after IHCA as these findings have significant implications toward resource allocation for hospitals and policy-makers (11). We aimed to measure the survival rate after IHCA for COVID-19 patients in a large U.S. healthcare system.

## MATERIALS AND METHODS

Cleveland Clinic Health System (CCHS) is a network of eleven hospitals in Northeast Ohio. We included all adult patients (age  $\geq 18$  yr) admitted to one of the CCHS hospitals with COVID-19 between March 01, 2020, and October 15, 2020, who subsequently experienced IHCA and received resuscitation efforts. Patients with a DNR order or patients who were on comfort measures were excluded from the study. Diagnosis of COVID-19 was confirmed using a Clinical Laboratory Improvement Amendments approved polymerase chain reaction test. The study was approved by Cleveland Clinic Institutional Review Board.

This was a single healthcare system, retrospective cohort study with data collected from multiple hospitals of the CCHS in Northeast Ohio. The study was approved by Cleveland Clinic Institutional Review Board (IRB), IRB number: 20-901. Patients were

cohorted into designated COVID-19 ICUs at every hospital, and when the designated ICUs were full at a particular hospital, patients were transported to other designated ICUs across the healthcare system. IHCA was defined as loss of pulse followed by resuscitative measures. CPR was defined as initiation of either manual or mechanical chest compressions. Sustained return of spontaneous circulation (ROSC) was defined as having a restored pulse for at least 20 minutes after CPR. Duration of the arrest was manually extracted from the resuscitation sheet. Time zero was identified as the time when a healthcare worker identified the patient in cardiac arrest with no palpable pulse. End of the resuscitation effort determined the total duration of arrest. Resuscitation efforts ended either due to ROSC or if the decision was made by a family member to stop the resuscitation with the goal to allow for natural death and a change in the code status to DNR. Cerebral Performance Category (CPC) scoring was used to classify neurologic outcomes at the time of discharge. All patients were treated according to the recommended Advanced Cardiovascular Life Support guidelines and hospital-level resuscitation protocols.

Patients' demographics, clinical characteristics, comorbidities, ICU variables, and relevant management data were extracted and compiled using the Cleveland Clinic quality data registry and Cleveland Clinic COVID-19 registry. Relevant data were extracted manually from the electronic medical records and supplemented with the Cleveland Clinic e-research platform. For included patients, resuscitation records (code sheets) were reviewed, and IHCA event data were manually extracted. Data were stored in a secured internet-based platform (Research Electronic Data Capture; Vanderbilt University, Nashville, TN). The primary outcome of the study was to identify survival to hospital discharge after IHCA. Additional data extracted included the following: duration of arrest; initial rhythm of arrest including pulseless electrical activity (PEA), asystole, pulseless ventricular tachycardia (pVT), and ventricular fibrillation (VF); and time to sustained ROSC. Survival outcomes were collected, including 24-hour survival, survival to ICU discharge, length of stay, and survival to discharge. For disease severity, we used the Acute Physiology and Chronic Health Evaluation (APACHE) II score at admission.

Patients were divided into cohorts of those who survived to discharge and those who died during their

hospital stay. Descriptive statistics were used to characterize the patient cohorts. Data were analyzed using mean  $\pm$  SD and as median (25–75th interquartile range) for all continuous variables and counts and percentages for all categorical variables. Wilcoxon rank-sum test for continuous variables and Fisher exact test or chi-square test for categorical variables were used to detect significant differences between different groups. All analyses were two tailed and were performed at a significance level of 0.05. A standard statistical software package (SAS 9.4; SAS Institute, Cary, NC) was used for all analyses.

## RESULTS

From March 01, 2020 to October 15, 2020, 3,555 patients with COVID-19 were admitted to the CCHS in Northeast Ohio. Of these, 1,372 were admitted to the ICUs. We identified 315 patients who had a

rapid response or cardiac arrest notification during the study period. After detailed review of these 315 medical records, we identified 58 patients (18%) with confirmed IHCA who received CPR (**Fig. 1**). Patient characteristics of this IHCA cohort are shown in **Table 1**. The 257 patients who did not receive CPR included patients who did not have a loss of pulse (no cardiac arrest; rapid response only) and those with DNR orders in place.

### Baseline Characteristics of Patients

The median age of this cohort was 66.5 years (interquartile range [IQR], 55.0–76.0 yr). Patients were predominantly male (62.5%), White (53.4%), with a median body mass index (BMI) of 29.7 (IQR, 25.8–34.6), and an admission APACHE II score of 14 (IQR, 9.0–20.0). More than half of the patients (34/58 [58.6%]) were on

**TABLE 1.**  
Demographics, Comorbidities, and Subgroup Analysis by Discharge From Hospital Alive

Characteristics	Total (n = 58)	Died (n = 45)	Discharged Alive (n = 13)	p
Age (yr), median (IQR)	66.5 (55–76)	66 (57–76)	68 (46–73)	0.46
Age, n (%)				0.49
Age $\leq$ 60	17 (29.3)	12 (26.7)	5 (38.5)	
Age > 60	41 (70.7)	33 (73.3)	8 (61.5)	
Sex, n (%)				0.48
Male	36 (62.1)	26 (57.8)	10 (76.9)	
Female	21 (36.2)	18 (40.0)	3 (23.1)	
Others	1 (1.7)	1 (2.2)	0 (0.0)	
Race, n (%)				1
White	31 (53.4)	24 (53.3)	7 (53.8)	
Black	17 (29.3)	13 (28.9)	4 (30.8)	
Other	10 (17.2)	8 (17.8)	2 (15.4)	
Ethnicity, n (%)				1
Hispanic	5 (8.6)	4 (8.9)	1 (7.7)	
Non-Hispanic	53 (91.4)	41 (91.1)	12 (92.3)	
Body mass index, median (IQR)	29.7 (25.8–34.6)	29.8 (25.8–35.5)	28.5 (25.8–33.6)	0.90

(Continued)

**TABLE 1. (Continued).**  
**Demographics, Comorbidities, and Subgroup Analysis by Discharge From Hospital Alive**

Characteristics	Total (n = 58)	Died (n = 45)	Discharged Alive (n = 13)	p
Comorbidities, n (%)				
Coronary artery disease	16 (27.6)	14 (31.1)	2 (15.4)	0.32
Congestive heart failure	13 (22.4)	10 (22.2)	3 (23.1)	1
Hypertension	38 (65.5)	31 (68.9)	7 (53.8)	0.31
Diabetes mellitus	24 (41.4)	19 (42.2)	5 (38.5)	1
Chronic obstructive pulmonary disease	14 (24.1)	9 (20.0)	5 (38.5)	0.27
Asthma	8 (13.8)	7 (15.6)	1 (7.7)	0.67
Chronic kidney disease	22 (37.9)	17 (37.8)	5 (38.5)	1
On renal replacement therapy, n (%)	11 (19.0)	8 (17.8)	3 (23.1)	0.70
Acute Physiology and Chronic Health Evaluation II score at admission, median (IQR)	14 (9–20)	14 (9–21)	14 (9–17)	0.72
Coronavirus disease 2019–related management, n (%)				
Dexamethasone	35 (60.3)	28 (62.2)	7 (53.8)	0.59
Interleukin-6 receptor antagonist	13 (22.4)	9 (20.0)	4 (30.8)	0.46
Hydroxychloroquine	16 (27.6)	10 (22.2)	6 (46.2)	0.09
Convalescent plasma	11 (19.0)	7 (15.6)	4 (30.8)	0.24
Remdesivir	24 (41.4)	19 (42.2)	5 (38.5)	1.00
Pao <sub>2</sub> /Fio <sub>2</sub> ratio before cardiac arrest, median (IQR)	66 (100–235)	163 (99–218)	192 (125.4–271)	0.22
Intubation days before cardiac arrest				0.57
n	34	28	6	
Median (IQR)	9 (2–18)	8.5 (2–17)	10.5 (2–29)	
On vasopressor before the cardiac arrest, n (%)	24 (41.4)	21 (46.7)	3 (23.1)	0.20
Diagnosis of venous thromboembolism during the admission, n (%)	8 (13.8)	7 (15.6)	1 (7.7)	0.67

IQR = interquartile range.

mechanical ventilation prior to IHCA with a median duration of mechanical ventilation of 9 days (IQR, 2–18 d); 24 of 58 patients (44%) were on vasopressors. Initial arrest rhythms were as follows: PEA, 63.8%; asystole, 29.3%; and pVT or VF, 6.9% (Table 1). Most IHCA events took place in the ICU (51/58; 87.9%), and the rest (7/58; 12.1%) occurred on the regular wards (Table 2 and Fig. 2).

### CPR Outcomes

Of the 58 patients who had IHCA, 35 (60.3%) attained ROSC. Twenty-seven (46.6%) were alive at 24 hours, 15 (25.9%) were discharged alive from the ICU, and 13 of 58 (22.4%) were discharged alive from the hospital. Forty-one of 58 (70.6%) received manual CPR, and 17 of 58 (29.3%) received mechanical CPR (Table 1). Targeted temperature management was initiated for

**TABLE 2.**  
**Study Outcomes Subgroup Analysis by Discharge From Hospital Alive**

Characteristics	Total (n = 58)	Died (n = 45)	Discharged Alive (n = 13)	p
Initial rhythm, n (%)				0.09
Asystole	17 (29.3)	16 (35.6)	1 (7.7)	
Pulseless electrical activity	37 (63.8)	27 (60.0)	10 (76.9)	
Pulseless ventricular tachycardia/ventricular fibrillation	4 (6.9)	2 (4.4)	2 (15.4)	
Location of cardiac arrest, n (%)				1
Regular nursing floor	7 (12.1)	6 (13.3)	1 (7.7)	
ICU	51 (87.9)	39 (86.7)	12 (92.3)	
Duration of resuscitation (min), median (IQR)	9.5 (5–20)	10 (5–21)	6 (3–10)	0.09
Chest compression type, n (%)				0.31
Manual	41 (70.7)	30 (66.7)	11 (84.6)	
Mechanical	17 (29.3)	15 (33.3)	2 (15.4)	
Received defibrillation, n (%)	13 (22.4)	10 (22.2)	3 (23.1)	1
Cerebral Performance Category score at discharge from hospital, score (%)				— <sup>a</sup>
n	13	0	13	
Score 1–2	6 (46)	a	6 (46)	
Score 3–4	7 (54)	a	7 (54)	
Change in code to do not resuscitate after cardiac arrest, n (%)	30 (51.7)	28 (62.2)	2 (15.4)	0.004
Post return of spontaneous circulation, hypothermia protocol has been initiated, n (%)	7 (12.1)	4 (8.9)	3 (23.1)	0.18
ICU LOS (d), median (IQR)	10.5 (3.9–23)	9.2 (2.7–19.7)	17.3 (9.3–28)	0.03
Hospital LOS (d), median (IQR)	17 (9–29)	13 (5–22)	21 (17–37)	0.01

IQR = interquartile range, LOS = length of stay.

<sup>a</sup>No statistics are computed.

seven patients (20%). Following resuscitation, 30 of 58 (51.7%) had a change in code status from full code to DNR. Some patients had change in code status during resuscitation and some subsequently post ROSC. The code status was changed from full code to DNR in 28 of 45 nonsurvivors and two of 13 survivors to hospital

discharge. Nearly half of the patient had a CPC score of 1–2 (6/13; 46%), and the rest, CPC of 3–4 (7/13; 54%). There was no statistical difference in age, gender, BMI, race, ethnicity, comorbidities, disease severity (APACHE II), duration of arrest, location of arrest, initial rhythm of arrest between the two groups (Tables 1 and 2).

## Trend in Cardiac Arrest Frequency and Survival Over the Study Period

There were no temporal trends in the likelihood of survival across the duration of the study period. Although, there was an increase in the number of cardiac arrests from March to October per month, there was no change in the likelihood of survival over the study period (Fig. 3). During the same study period, ICU and regular nursing ward bed occupancy is shown in Fig. 4.

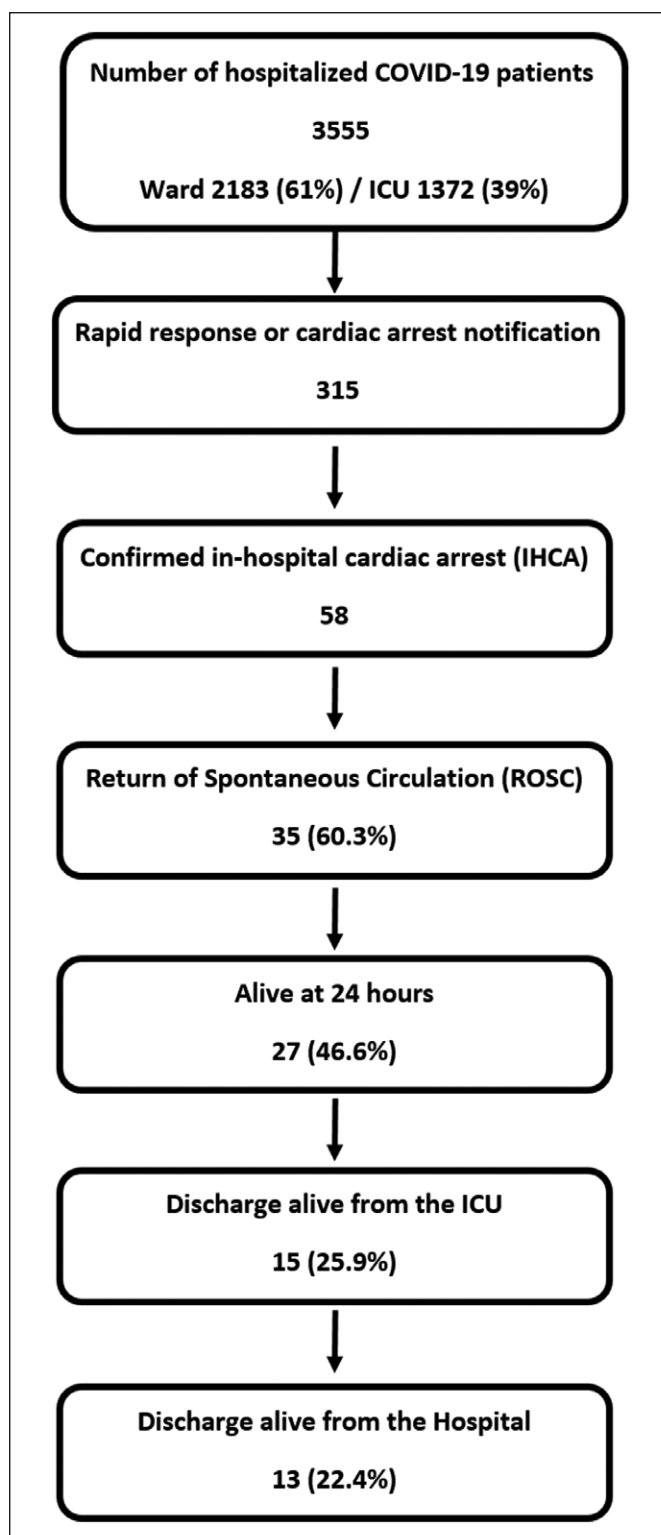
## DISCUSSION

In this retrospective cohort study from a large U.S. healthcare system involving multiple hospitals of the CCHS, we found that the overall survival after IHCA of COVID-19 patients was 22%. These numbers are comparable with the prepandemic reported survival of ~ 20–25% after IHCA and stand in contrast to previously reported outcomes from Wuhan, China, and the United States (1–3, 8, 9).

The first report on outcomes from IHCA in COVID-19 patients from Wuhan, China, by Shao et al (1) found that the majority (83.1 %) of the arrests occurred on general wards, the predominant initial arrest rhythm was asystole (89.7%), ROSC was achieved in 13.2% of a COVID-19 IHCA cohort, and 30-day survival was 2.9%. The authors hypothesized that the impact of lack of medical resources and uncertainty regarding quality of CPR probably contributed to the poor survival rate. In contrast, 87.9% of the patients in our study were resuscitated in the ICU with a much higher incidence of ROSC (60%) and a higher survival rate of hospital discharge to 22%.

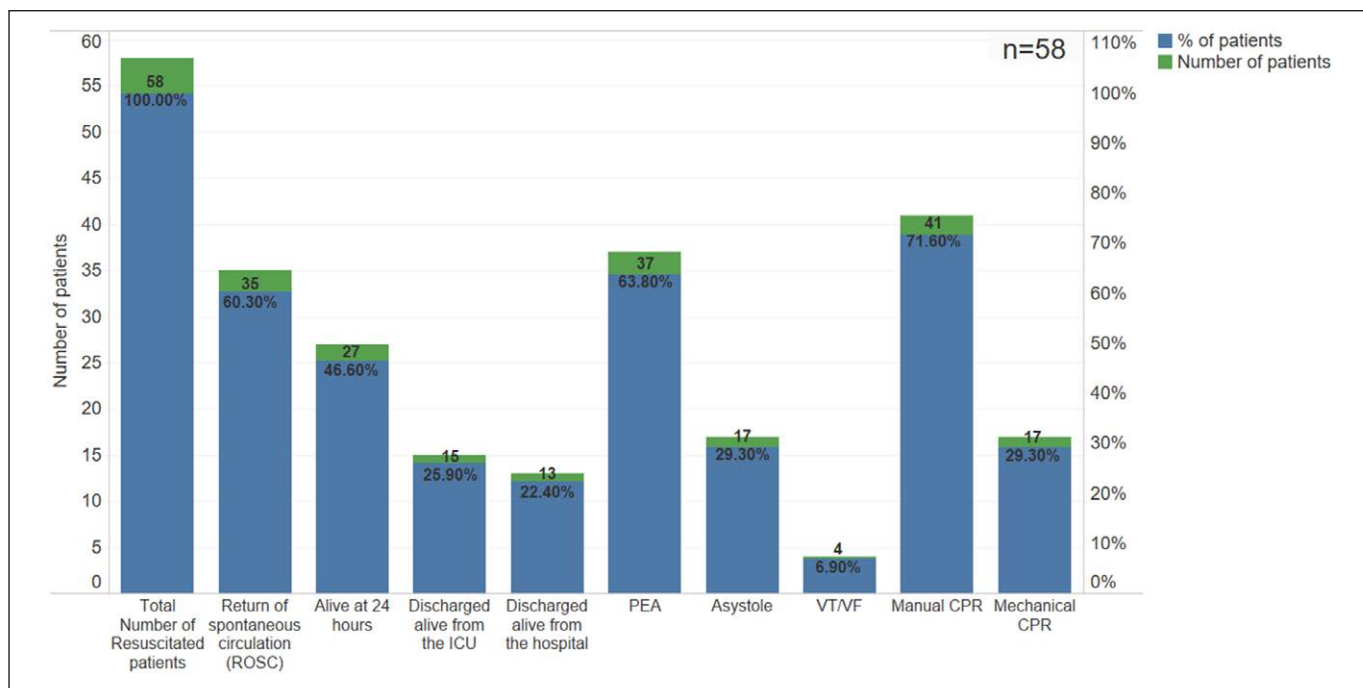
Our study outcomes are also different from previously reported outcomes of U.S. studies. Sheth et al (2) reported the first U.S. case series of 31 COVID-19 patients who experienced IHCA. ROSC was achieved in 65%, but none survived to hospital discharge. Similarly, Thapa et al (3) reported early COVID-19 IHCA experience from March to April 2020 in Michigan: 54 patients were included, ROSC was achieved in 54%, but, again, none survived to hospital discharge. Most recently, Shah et al (8) reported single healthcare system outcomes from IHCA in Georgia from March to August, with ROSC in 29 % and zero survival to hospital discharge.

Our study results are closer to the outcomes reported by Hayek et al (6), evaluating data from the multicenter



**Figure 1.** Flow diagram depicting study population, incidence of in-hospital cardiac arrest, cardiopulmonary resuscitation, and outcomes. COVID-19 = coronavirus disease 2019, IHCA = in-hospital cardiac arrest, ROSC = return of spontaneous circulation.

STOP-COVID registry and assessing outcomes from IHCA in COVID-19 patients between March and June 2020 (6). Study population included 5,019 patients, and



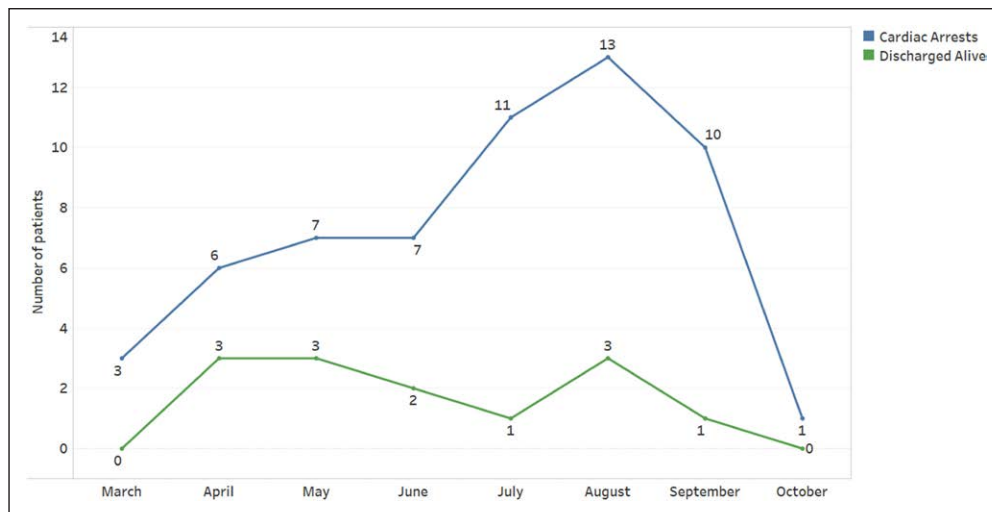
**Figure 2.** Shows resuscitation outcomes, initial rhythms, and cardiopulmonary resuscitation (CPR) delivery method (manual vs mechanical). PEA = pulseless electrical activity, ROSC = return of spontaneous circulation, VT/VF = ventricular tachycardia/ventricular fibrillation.

authors reported a 14% (701/5,019) incidence of IHCA in the first 14 days of admission to ICU. More than half of the patients (400/701; 57%) received CPR. Similar to our study finding, the predominant initial rhythm was nonshockable (73%), ROSC was obtained in 33% of the patients with a 12% survival to hospital discharge. Authors also reported a lower likelihood to hospital discharge with older age and male gender. While we report better survival than Hayek et al (6), we were not able to identify predictors of survival or the specific reasons for improved outcomes. In our study, none of the baseline clinical and demographic factors such as age, gender, race, ethnicity, BMI, comorbidities, disease severity (APACHE II score), location of cardiac arrest, duration of resuscitation, or initial cardiac arrest rhythm predicted better outcomes or improved survival. Similarly, we found that neither the location of cardiac arrest nor the chest compression type (mechanical vs manual) or defibrillation predicted ROSC (Table 1).

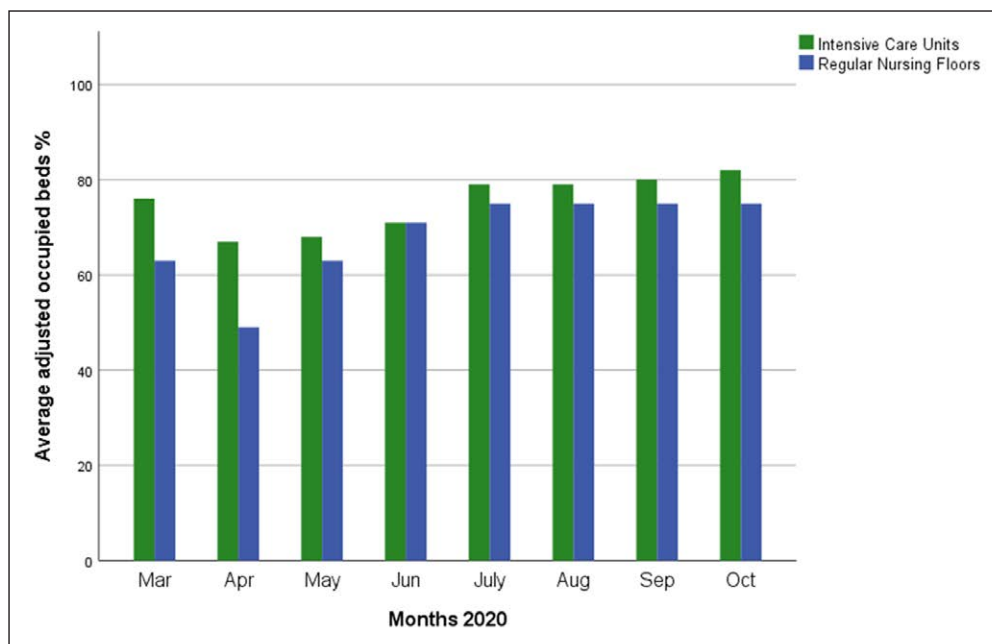
Although we report markedly different survival outcomes than previously published studies, we noticed similarities in the clinical characteristics of the patients. For example, nonshockable rhythms were the predominant initial arrest rhythms across all the studies, and the majority of patients were on invasive mechanical ventilation.

In our study, we found similar ROSC and higher survival to hospital discharge compared with previous studies of IHCA COVID-19 patients. One possible explanation for these large differences in outcomes is that our study spans a longer course of the pandemic (March to October) compared with other studies. It is possible that management approaches have improved over time.

Second, authors previously identified several hospital-level factors that may have affected survival after IHCA. These factors included institutional variation in protocols in management of COVID-19, availability of COVID-19-specific therapies, and available resources for personnel intensive therapies such as proning (12). Hospitals that experienced high-volume surge in the beginning of the pandemic may have worse outcomes related to hospital strain (13). For example, a study by Miles et al (14) compared the incidence of IHCA during the peak COVID-19 pandemic at their hospital with the outcomes for IHCA a year before using the Get With The Guidelines-Resuscitation registry. They reported a higher incidence of cardiac arrest on medicine wards during the pandemic (46% vs 19%) than in ICU (33 vs 60%), a shorter duration of CPR (11 min vs 15 min), and worse IHCA survival rates for COVID-19 patients (3% vs 13%) when compared with the year



**Figure 3.** Number of patients with in-hospital cardiac arrest and number of patients discharged alive during the study period from March till Mid October 2020.



**Figure 4.** Shows hospital bed occupancy during the study period from March to October 2020. Monthly average adjusted bed occupancy in percentage at Cleveland Clinic Health System during the study period from March 2020 to October 2020. Adjusted occupied bed %: the percentage of beds occupied by patients of the total available beds and adjusted for factors that make the bed unavailable for the day such as isolation, cleaning etc.

before. Similarly, Hayek et al (6) also reported that hospitals with fewer ICU beds were at greater IHCA risk. At CCHS we had the advantage of having one of the highest numbers of ICU beds available anywhere in the country along with large cohort of trained critical care staff. Compared with the studies reporting outcomes from Wuhan, NYC, and Michigan where hospitals were overwhelmed with volume, we were

able to leverage our hospital network and integrate regional centers to offload individual hospital and distribute the patients at the time of high census (15). As a result, in contrast to the study by Shao et al (1) and Miles et al (14), in our study, we found that almost 90% of the cardiac arrests occurred in the ICUs allowing for providing standard of care, possibly resulting in better outcomes. ICU and regular nursing floor bed occupancy during the study period from March to October 2020 is provided in Figure 4. Further, Fadel et al (16) have previously published that better preparedness and not being overwhelmed by the case surge led to better outcomes of COVID-19 patients in the CCHS of Northeast Ohio.

Last, based on previous pandemic experience and recognizing CPR as an aerosol generating event, studies recommend safety for rescuers (17, 18). These safety measure include use of personal protective equipment (PPE), minimizing healthcare professionals in the room, use of mechanical CPR where available, and the use of video laryngoscopy for intubation (10, 19). CCHS immediately adapted the American Heart Association interim guidelines on management of COVID-19 IHCA, and there was an enterprise-wide effort to train all providers to don PPE efficiently and quickly for emergencies. This allowed for prompt response to IHCA possibly contributing to better outcomes (15).



Previously reported low survival after IHCA can have significant effect on how the critically ill/ hospitalized COVID-19 patients are managed. These results impact the information we share although we are exploring goals of care and having code status conversations with patients and/or their loved ones. The low survival rate in conjunction with high exposure risk to healthcare workers during resuscitation could lead to more interest in pursuing a DNR status, comfort measures, and resource allocation decisions that will support early withdrawal of life-sustaining therapies. Our study highlights that COVID-19 disease in itself does not lead to worse outcome—it is the barrier to provide standard of care that led to poor outcomes, and hence, moving forward, we should strive for pre pandemic survival rate for IHCA for COVID-19 patients and work on the systems and processes to allow for that to happen.

One of the biggest strengths of the study is that we report outcomes after IHCA in COVID-19 patients over 8-month period of the pandemic. We also report extensive details of individual IHCA event after detailed chart review of each case. Our study has several limitations including small sample size. Our study is a single health system study. As a result, the findings may not be generalizable to smaller or resource limited hospital settings. Implicit bias of the healthcare team could have played a role in counseling the sickest patients or surrogates strongly against resuscitation. As result, it is quite possible that early goals of care conversation could have led to a sample bias leading to higher survival in patients who were less sick. Although the characteristics of patients based on demographics and disease severity seem to be similar, selection bias could drive the higher survival rates we are seeing in our study. We also lack details on quality of CPR metrics, such as chest compression fraction, time to initiation of chest compression, and time to defibrillation. Finally, although we demonstrated higher survival to hospital discharge than other COVID-19 IHCA studies, our data do not include long-term follow-up of the survivors.

## CONCLUSIONS

In summary, we report survival after IHCA in COVID-19 patients comparable with historical outcomes for IHCA in non-COVID-19 patients. Our findings represent a significantly higher survival rate after IHCA compared with what has been previously reported for COVID-19 patients. As the pandemic

surges in the United States, our study findings have significant implications in developing healthcare policies and resource allocation at individual hospital, health-care system, and health policy levels. These findings may also help guide clinicians for appropriate goals of care and code status discussions with patients and their loved ones.

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