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## Impact of the COVID-19 Pandemic on Cardiac Arrest Systems of Care

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### Abstract

**Purpose:** The emergence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus, which causes coronavirus disease 2019 (COVID-19), led to the declaration of a global pandemic by the World Health Organization on March 11, 2020. As of February 6, 2021, over 105 million persons have been infected in 223 countries and there have been 2,290,488 deaths. As a result, emergency medical services and hospital systems have undergone unprecedented healthcare delivery reconfigurations. Here, we review the effects of the COVID-19 pandemic on out-of-hospital cardiac arrest (OHCA) epidemiology and systems of care.

**Recent Findings:** Areas severely affected by the pandemic have reported increased incidence of OHCA, lower rates of successful resuscitation, and increased mortality. COVID-19 has significantly impacted patient outcomes through increased disease severity, decreased access to care, and the reshaping of emergency medical response and hospital-based healthcare systems and policies. The pandemic has negatively influenced attitudes towards resuscitation and challenged providers with novel ethical dilemmas provoked by the scarcity of healthcare resources.

**Summary:** The COVID-19 pandemic has had direct, indirect, psychosocial, and ethical impacts on the cardiac arrest chain of survival.

### Keywords

COVID-19; cardiac arrest; outcomes; management; review

## INTRODUCTION

SARS-CoV-2 is an enveloped  $\beta$ -coronavirus with >80% genetic similarity to SARS-CoV-1 and bat coronavirus RaTG13 that is transmitted via respiratory droplets, infects cells through interaction of the viral spike protein with the angiotensin-converting enzyme 2 receptor, and leads to the clinical syndrome of coronavirus disease 2019 (COVID-19) (1). COVID-19 initially presents with fever, upper respiratory symptoms, myalgias, and other non-specific symptoms and progresses to severe infection in 14% of cases at a median of 6-8 days from

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CONFLICTS OF INTEREST

None

exposure (2–4). Severe COVID-19 is characterized by progressive pneumonia and a profound hyper-inflammatory state complicated by acute respiratory distress syndrome, cardiovascular complications, shock, and death in 42% of patients admitted to intensive care (5–7). The World Health Organization (WHO) declared a global pandemic on March 11, 2020 and as of February 6, 2021, over 105 million persons have been infected and 2,290,488 have died (8). Severely affected areas have reported increased incidence of out-of-hospital cardiac arrest (OHCA), lower rates of successful cardiopulmonary resuscitation (CPR), and increased mortality (9–11). Several small cases series have shown low survival of in-hospital cardiac arrest (IHCA) in patients with COVID-19, but whether IHCA outcomes differ between patients with and without COVID-19 is uncertain (12–14). Further investigation is currently ongoing to explore outcomes from cardiac arrest given this ongoing pandemic. Here we review the epidemiology and pathogenesis of COVID-19-related OHCA, discuss the impact of healthcare system restructuring on patient outcomes, explore the influence of COVID-19 on attitudes towards resuscitation, and describe novel ethical challenges provoked by the scarcity of healthcare resources during the pandemic.

## **EPIDEMIOLOGY AND PATHOGENESIS OF CARDIAC ARREST DURING THE COVID-19 PANDEMIC**

Communities and regions severely impacted during the early stages of the COVID-19 pandemic reported increased incidence of OHCA, lower rates of successful resuscitation, and increased mortality (9–11, 15). Compared to the prior year, return of spontaneous circulation (ROSC) after OHCA fell from 25% to 11% in New York, 31% to 18% in Northern Italy, and 23% to 13% in Paris (9–11). An international meta-analysis of 10 studies and 35,379 OHCA found a 2.2-fold increased incidence and significantly decreased survival (OR 0.67, 95% CI 0.49-0.91;  $p=0.01$ ) during the pandemic as compared to 2019 (16). Lim and colleagues also noted increased frequency of OHCA occurring at home, increased prevalence of non-shockable rhythms, decreased rates of intubation, and decreased survival to both hospital admission and discharge. An analysis from the Cardiac Arrest Registry to Enhance Survival (CARES) registry of 19,303 OHCA occurring in the United States (US) from March 16 to April 30 in both 2019 and 2020 showed increased incidence of OHCA ( $88.5 \pm 64.1$  vs.  $69.7 \pm 49.8$  per million residents;  $p < 0.01$ ), decreased rates of ROSC (23.0 vs. 29.8%; adjusted rate ratio [ARR], 0.82 [95% CI, 0.78-0.87];  $p < 0.01$ ), and decreased survival to hospital discharge (6.6 vs. 9.8%; ARR, 0.83 [95% CI, 0.69-1.00];  $p=0.048$ ), especially in communities that were moderately to severely affected by COVID-19 (17).

The direct contribution of COVID-19 on excess OHCA incidence and mortality is unknown and has been limited by undertesting for SARS-CoV-2 among patients where resuscitation was not initiated or was terminated prior to hospital presentation (18, 19). The higher observed incidence and mortality of OHCA during the pandemic may be due to increased illness severity, akin to similar findings during influenza outbreaks (9, 20, 21). For some patients with COVID-19, cardiac arrest may be caused by acute hypoxemic respiratory failure, as evidenced by increased prevalence of non-shockable initial rhythms during the pandemic (16, 17). Nonetheless, COVID-19 has also been associated with cardiac

manifestations including vascular inflammation, myocarditis, and cardiac arrhythmias (22, 23). Myocardial injury in COVID-19 has multiple potential mechanisms and has been associated with negative patient outcomes (24, 25). However, a recent analysis suggested that myocardial injury in severe COVID-19 is a function of patient age and comorbidities and that the adverse prognosis of myocardial injury in COVID-19 relates primarily to critical illness and multi-organ injury, similar to patients with non-COVID acute respiratory distress syndrome (26). Finally, COVID-19 can cause a hypercoagulable state that has been associated with thrombotic events including acute myocardial infarction (MI), stroke, and pulmonary embolism (27, 28). Further studies are needed to fully understand the pathogenesis of COVID-19 and its implications for cardiac arrest management.

## **IMPACT OF HEALTHCARE SYSTEM RESTRUCTURING ON CARDIAC ARREST OUTCOMES**

System issues may have contributed to increased OHCA incidence and mortality early during the COVID-19 pandemic. Healthcare systems underwent a rapid and unprecedented reconfiguration to limit face-to-face contact and accommodate telemedicine and as a result many non-urgent cardiovascular diagnostic tests and elective procedures were deferred, postponed, or cancelled (29–34). These actions may have unintentionally limited or delayed access to care for patients at high risk of suffering OHCA. Patient fear of contracting COVID-19 may have led to avoidance of care (35). Indeed, recent studies have demonstrated that more than 25% of victims of OHCA interact with the healthcare system in the preceding 90 days and rates of hospitalization for acute MI, heart failure, and stroke markedly decreased during the pandemic (36–41). This fall in hospitalizations coincided with a nationwide decrease in emergency medical services (EMS) responses and a doubling of EMS-attended deaths (42). A single-center study in Denver observed a fall in ambulance activations and a 2.2-fold increased incidence of OHCA following a statewide “shelter-in-place” order that the authors attributed to increased MI-related OHCA and decreased access to care (43). Moreover, COVID-19 has disproportionately affected communities with low socioeconomic status, racial/ethnic minorities, and undomiciled or incarcerated persons that already suffer poor access to health care, lower rates of CPR, and delayed EMS response (44–48). Lai and colleagues found that Black, Hispanic, and Asian persons were at increased risk of COVID-19-related OHCA and death even after adjusting for comorbidities that unequally affect minority populations, underscoring the systemic inequalities in the US healthcare system both prior to and during the pandemic (9).

Healthcare system restructuring was not limited to hospitals and policy changes among EMS agencies aimed to protect frontline providers may have negatively impacted OHCA outcomes. These interim recommendations included screening 911 calls for likelihood of COVID-19, limiting the number responding personnel, pausing chest compressions during aerosolizing procedures such as intubation, and not transporting patients without ROSC to hospitals (49). A meta-analysis of 6 studies of OHCA during the COVID pandemic noted prolonged EMS response times, a reduction in EMS-initiated resuscitations, and lower rates of ROSC and survival to hospital discharge (50). However, this analysis was confounded by missing data and differences in outcome measures and thus subject to substantial

heterogeneity across studies. A subsequent analysis of OHCA across the US found no differences in EMS response times or duration of treatment during the pandemic as compared to prior years (17). However, the authors did note a substantial decrease in ROSC in all included communities, including those with low COVID-19 mortality rates, suggesting that interim recommendations may have been implemented overly broadly and thus unnecessarily hampered the ability of EMS personnel to effectively respond to OHCA in lower prevalence areas (17).

Finally, changes in the management strategy for emergent medical conditions, including acute MI, may have contributed to excess cardiac arrest mortality during the pandemic. As the first nation to be struck by COVID-19, China established a fibrinolysis-first strategy for ST-elevation MI (STEMI) to avoid provider exposure (51). However, subsequent studies have shown that this strategy was associated with lower rates of timely coronary reperfusion and increased rates of recurrent MI, cardiogenic shock, and heart failure (52). Despite major society guidelines advocating for the ongoing utilization of primary percutaneous coronary intervention (PCI) for STEMI during the pandemic, multiple international studies have shown significant reductions in PCI and prolonged door-to-balloon and total ischemia times which may have contributed to higher mortality (53–56). Notably, a study of 524 patients with OHCA complicated by acute MI in the United Kingdom observed lower rates of coronary angiography, longer time to reperfusion, and increased mortality during the pandemic (57). Anecdotal reports have suggested increased incidence of mechanical complications of MI during the pandemic, emphasizing the negative implications of delayed or missed patient presentation and reduced use of PCI (58, 59). Indeed, a hospital system in New York reported a 4.97-fold increase in OHCA with a concomitant 50% reduction in acute coronary syndrome admissions that correlated with a spike in COVID-19-related deaths (correlation coefficient 0.954;  $p < 0.0001$ ) (60). The recently announced North American COVID-19 STEMI (NACMI) registry may shed further light on the impact of COVID-19 on STEMI management and its association with OHCA outcomes (61).

## ATTITUDES TOWARDS RESUSCITATION DURING THE COVID-19 PANDEMIC

Early CPR and defibrillation provide OHCA victims with the highest likelihood of survival. CPR is described as an aerosol-generating procedure by the WHO considering case reports of coronavirus transmission during chest compressions (62). However, there is a paucity of evidence regarding whether CPR truly generates aerosols or is associated with transmission of COVID-19 (63, 64). Personal protective equipment (PPE) is recommended for healthcare workers performing aerosol-generating procedures during resuscitation of patients with unknown COVID-19 status to reduce risk of exposure (49, 65). Nevertheless, the majority of OHCA occurs in the home where bystanders are unlikely to have access to PPE (66). In these circumstances the rescuer is frequently a close personal contact of the victim and thus the provision of CPR is unlikely to significantly change their personal risk of infection (65).

Despite the clear benefits of early CPR for cardiac arrest, the COVID-19 pandemic has inculcated a culture of fear that may negatively influence the willingness of bystanders to perform resuscitative maneuvers due to a perception of increased risk of personal harm (67, 68). Newspapers have reported disturbing instances where bystanders did not perform CPR

for fear of contracting COVID-19 (68). A recent social media study with over 1,300 lay-person respondents from 26 countries showed a decreased willingness to assess an unresponsive stranger, perform chest compressions, or apply an automatic external defibrillator during the pandemic (69). However, determining whether perceptions of risk are influencing bystander CPR on a broader scale has been a challenge. Investigators in Northern Italy and Paris observed dramatically decreased rates of bystander CPR during the COVID-19 pandemic while data from Seattle, New York, and Pittsburgh have shown no significant change in bystander resuscitation (9–11, 18, 70) The CARES analysis found no significant difference in the rates of witnessed cardiac arrest (41.1 vs 43.7%; standardized difference [SD] 5.4%) bystander CPR (47.7 vs. 46.8%; SD 1.7%) or bystander defibrillation (5.7 vs 8.1%; SD 9.4%) in the US during the pandemic as compared to the same period in 2019 (17). The available data suggests that the rapid identification of pulselessness and prompt initiation of chest compressions by bystanders, with use of immediately available PPE or improvised PPE, should remain the preferred response to witnessed OHCA. Clearly, the willingness of the lay public to perform resuscitation is fragile and strong guidance and support from public health agencies, through CPR education and novel technologies, is needed to maintain a robust community response to OHCA and prevent a potentially disastrous and demoralizing decline in bystander CPR (71, 72).

## ETHICS OF RESUSCITATION DURING THE PANDEMIC

The COVID-19 pandemic has precipitated significant ethical challenges in the setting of strained and overcrowded hospitals, declining availability of resources, and the need to allocate scarce life-sustaining treatments. During crisis standards of care triggered by the COVID-19 surge, during which healthcare demand outpaced supply and clinical needs were unable to be met, the usual assumption that resuscitation should be provided unless a do-not-resuscitate (DNR) order exists has been challenged by a strain on resources (73, 74). Such concerns are not limited to decisions for initial resuscitation because resource availability for post-cardiac arrest care following a successful resuscitation must also be considered. Per Emanuel et al., classical ethical principles prevail for assigning scarce-resources during COVID-19 and have resulted in the following six recommendations: maximize benefits; prioritize health workers; do not allocate on a first-come, first-served basis; be responsive to evidence; recognize research participation; and equally apply these principles to both COVID-19 and non-COVID-19 patients (75). The American Medical Association has recommended that experienced teams perform triage duties during crisis standards of care to relieve the moral burden upon treating clinicians and minimize conflicts (76, 77).

While triage teams offer a deliberate approach to the ethical determination of inpatient resource allocation, pre-hospital and emergency services are frequently burdened with the ethical exigencies of making resuscitation decisions unexpectedly with limited consultative support. Physicians are not obligated to offer or provide CPR if medically inappropriate and should enlist a second physician who is uninvolved in the patients care to review their decision making. Family assent should be sought but is not specifically required to apply a unilateral DNR in the absence of agreement by the surrogate decision maker (74). Conversely, a selective approach has been proposed that would limit resuscitation to <6 minutes if ROSC is not achieved in cases of unwitnessed, asystolic, or recurrent arrest (78).

For other cardiac arrests, the authors endorse the use of the sequential organ failure assessment (SOFA) score to further guide resuscitative efforts (78).

Ultimately, the COVID-19 pandemic has underscored the vital importance of advanced care planning in serious illness and aging. Clear delineation of a medical decision maker, medical durable power of attorney, or healthcare proxy should be encouraged as a component of routine primary care. If feasible, patient wishes should be sought prior to a potential medical decompensation and supported during crisis. The provision of palliative care resources in the emergency setting is one method to ensure that patients and families are supported during the unexpected catastrophe of an OHCA during the COVID-19 pandemic.

## CONCLUSIONS

The incidence and mortality of OHCA has increased significantly during the COVID-19 pandemic due to a combination of the direct biological impact of the virus on patients, the indirect effects of healthcare system restructuring and associated changes in preventative and emergency care practice, and psychosocial attitudes towards resuscitation. Healthcare workers have faced ethical challenges in providing resuscitative care in the face of resource scarcity instigated by the pandemic. Despite the rapid pace of investigation, additional studies are needed to explore the effect of COVID-19 on the incidence and outcomes of OHCA among socioeconomically disadvantaged persons, the relationship between decreased access to care and COVID-19-related OHCA, and potential interventions to maintain a robust community response to OHCA. A thorough and complete understanding of the impact of COVID-19 on the cardiac arrest chain of survival may not occur until resolution of the pandemic. At the time of writing, recently approved vaccines raise hope for the future, yet challenges to immunization programs in acquiring and distributing sufficient doses to conclude the global pandemic are significant and their effect will not be immediate (79–81). Thus, it is imperative to continue investigating and addressing the effects of COVID-19 on cardiac arrest systems of care in order to improve the chances of meaningful survival for as many victims as possible and inform the response to future pandemics.

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**KEY POINTS**

1. Communities and regions severely impacted by the COVID-19 pandemic have reported increased incidence of OHCA cardiac arrest, lower rates of successful resuscitation, and increased mortality.
2. COVID-19 has disproportionately affected OHCA cardiac arrest outcomes in communities with low socioeconomic status, racial/ethnic minorities, and undomiciled or incarcerated persons.
3. System issues may have contributed to increased OHCA incidence and mortality during the COVID-19 pandemic.
4. Fear of contracting COVID-19 has influenced rescuer attitudes towards resuscitation.
5. Healthcare workers have faced ethical challenges in providing resuscitative care in the face of resource scarcity instigated by the pandemic.