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Use of Simulation-Based Medical Education for Advanced Resuscitation of In-Hospital Cardiac Arrest Patients With Suspected or Confirmed COVID-19

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ABSTRACT

Cardiac arrest is common in critically ill patients with coronavirus disease 2019 (COVID-19) and is associated with poor survival. Simulation is frequently used to evaluate and train code teams with the goal of improving outcomes. All participants engaged in training on donning and doffing of personal protective equipment for suspected or confirmed COVID-19 cases. Thereafter, simulations of in-hospital cardiac arrest of patients with COVID-19, so-called protected code blue, were conducted at a quaternary academic centre. The primary endpoint was the mean time-to-defibrillation. A total of 114 patients participated in 33 "protected code blue" simulations over 8 weeks: 10 were senior residents, 17 were attending physicians, 86 were nurses, and 5 were respiratory therapists. Mean time-to-defibrillation was 4.38 minutes. Mean time-to-room entry, time-to-intubation, time-to-first-chest compression and time-to-epinephrine were 2.77, 5.74, 6.31, and 6.20 minutes, respectively; 92.84% of the 16 criteria evaluating

RÉSUMÉ

L'arrêt cardiaque est fréquent chez les patients atteints de la maladie à coronavirus 2019 (COVID-19) en phase critique et est associé à une faible survie. La simulation est souvent utilisée pour évaluer et former les équipes chargées de répondre à un code d'urgence afin d'améliorer les résultats de l'intervention. Tous les participants ont suivi une formation sur la façon de mettre et d'enlever l'équipement de protection individuelle pour les cas de COVID-19 présumés ou confirmés. Par la suite, des simulations d'intervention en cas d'arrêt cardiaque de patients atteints de la COVID-19 en milieu hospitalier, selon la procédure de « code bleu protégé », ont été effectuées dans un hôpital universitaire de soins quaternaires. Le critère d'évaluation principal était le délai moyen avant la défibrillation. Au total, 114 participants ont pris part à 33 simulations d'interventions de « code bleu protégé » sur une période de 8 semaines, à savoir 10 résidents de dernière année, 17 médecins traitants, 86 infirmières et 5 inhalothérapeutes. Le délai moyen avant la défibrillation a été de 4,38 minutes. Les

Cardiac arrest is common in critically ill patients with COVID-19 and is associated with poor survival.[1,2] Among 5019 patients with COVID-19 from 68 intensive care units across the United States, 701 (14.0%) patients suffered in hospital-cardiac arrests, from which only 48 patients (12.0%) survived at discharge.[1] More recently, a retrospective cohort of 63 consecutive patients with COVID-19 who suffered in-hospital cardiac arrest reported a 0% survival rate at discharge.[2] Despite poor reported outcomes in this context, literature regarding the efficiency and the quality of resuscitation efforts is lacking.

Health care workers have a high professional risk for contracting COVID-19, and cardiopulmonary resuscitation (CPR) carries an additional infectious risk. CPR implies performance of several aerosol-generating procedures (eg, chest compressions, establishment of an advancement airway), proximity of rescuers to each other and the patient, and a high-stress emergency climate in which the urgent needs of patient may result in omission of infection-control practices. The challenge is to find the correct balance between the risk to the health care worker when undertaking CPR on a patient with possible or confirmed COVID-19 and the risk to that patient if CPR is delayed.

Of late, simulation has demonstrated its effectiveness to achieve, measure and maintain skills in many clinical procedures, including advanced cardiovascular life support (ACLS).[3] We report on the use of simulation-based medical education for advanced resuscitation of in-hospital patients with cardiac arrest and suspected or confirmed COVID-19.

the proper management of patients with COVID-19 and cardiac arrest were met. Mean time-to-defibrillation was longer than guidelines-expected time during protected code blue simulations. Although adherence to the modified advanced cardiovascular life-support protocol was high, breaches that carry additional infectious risk and reduce the efficacy of the resuscitation team were observed.

délais moyens avant l'entrée dans la chambre, avant l'intubation, avant la première compression thoracique et avant l'administration d'épinéphrine étaient de 2,77, 5,74, 6,31, et 6,20 minutes, respectivement; 92,84 % des 16 critères d'évaluation de la prise en charge appropriée des patients atteints de la COVID-19 en arrêt cardiaque ont été satisfaits. Le délai moyen avant la défibrillation était plus long que celui indiqué dans les lignes directrices durant les simulations d'interventions correspondant au code bleu protégé. Si le protocole modifié de réanimation cardiovasculaire avancée a été bien respecté, des écarts à ce protocole susceptibles d'accroître le risque d'infection additionnelle et de réduire l'efficacité des efforts de réanimation de l'équipe ont cependant été observés.

Methods

We conducted simulations of in-hospital cardiac arrest for patients with suspected or confirmed COVID-19, so-called protected code blue, at a quaternary academic centre (Montréal Heart Institute). The objective of the simulations was for resuscitation team members to rehearse the modified ACLS protocol for patients with suspected or confirmed COVID-19 (Supplemental Fig. S1). Before the simulations, already trained participants reviewed donning and doffing of personal protective equipment (PPE) through a video demonstration for patients with suspected or confirmed COVID-19 .

Participants attended the simulations in groups comprising senior residents or attending physicians (n = 1 to 2), nurses (n = 2 to 4), including an infectious disease- prevention nurse and respiratory therapists (n = 1 to 2). Material available for each session was standardized and included a cardiac monitor, standard ACLS medication, an automated external defibrillator, an automatic chest-compression device, and/or CPR board and intubation material (including a video laryngoscope). Because of the shortage of PPE, stickers were used to simulate the airborne PPE worn during a protected code blue: that is, an N95 mask, a gown, gloves, and a protective face shield or eyeglasses. A manikin was used to simulate the patient with suspected or confirmed COVID-19 and cardiac arrest. Simulations occurred in situ, in an unused room of target units in which medical personal are expected to manage patients with COVID-19 and cardiac arrests. Each simulation session followed the same standardized scenario and included the following steps: briefing; review—through a local video—of donning and doffing of PPE for patients with suspected or confirmed COVID-19; simulation of protected code blue according to the local COVID-19 cardiac arrest protocol for hospitalized patients; and debriefing and review of the local COVID-19 cardiac arrest protocol for hospitalized patients.

The performance of the providers in each session was assessed in terms of quality and efficacy through a standardized evaluation form (Supplemental Fig. S2). Efficacy during each simulation was assessed through time-to-room entry, time-to-first defibrillation, time-to-intubation, time-to-first chest compression, and time-to-epinephrine. Quality of performance was assessed by a physician and a nurse, both trained in health care simulation, through a 16-point checklist related to the proper management of patients with COVID-19 and cardiac arrest.

Results

A total of 114 patients participated in 33 protected code blue simulations over 8 weeks: 10 were senior residents, 17 were attending physicians, 86 were nurses, and 5 were respiratory therapists.

Results of efficacy assessment are shown in Table 1. Mean time-to-room entry, time-to-first defibrillation, time-to-intubation, time-to-first chest compressions, and time-to-epinephrine were 2.77 minutes, 4.38 minutes, 5.74 minutes, 6.31 minutes, and 6.20 minutes, respectively.

Results for the quality of the providers' performance are presented in Table 2. On average, 92.84% of the 16 criteria on the evaluation form were met. Percentage of the criterion met for 2 elements on the checklist could not be reported because of missing data.

Frequently addressed topics during the debriefing from our simulations included unclear distribution of roles for both nurses and doctors, material forgotten outside the room (eg, CPR board, automatic chest compression device), and unclear directives by the infectious disease prevention nurse.

Discussion

The average time-to-first chest compression, time-to-first defibrillation, and time-to-epinephrine were substantially longer than guidelines suggest. Current guidelines recommend a time-to-first chest compression of less than or equal to 1 minute, time-to-first defibrillation of less than or equal to 2 minutes for ventricular tachycardia/ventricular fibrillation (VT/VF), and administration of epinephrine or vasopressin for pulseless events (pulseless VT/VF or pulseless electrical activity/asystole) within 5 minutes.[4] Delayed initiation of CPR, defibrillation, or epinephrine treatment were associated with lower survival.[5]

The impact of prolonged time-to-defibrillation in patients with COVID-19 and cardiac arrest remains unsettled. It may differ from the general population, given that CPR is

Table 1. Mean of different efficacy measures of protected code blue simulations

Time-to-room entry (minutes; mean [SD])	2.77 (1.18)
Time-to-defibrillation (minutes; mean [SD])	4.38 (1.43)
Time-to-intubation (minutes; mean [SD])	5.74 (1.83)
Time-to-first chest compression (minutes; mean [SD])	6.31 (1.97)
Time-to-epinephrine (minutes; mean [SD])	6.20 (3.27)

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Table 2. Percentage of each criteria of the evaluation form met during simulations of in-hospital patients with cardiac arrest and suspected or confirmed COVID-19

Criteria	Percentage (%)
1. Put on personal protective equipment before entering the room	96.00
2. Dressing sequence respected	100.00
3. Put the pads to analyze the rhythm	95.45
4. Recognize ventricular fibrillation	95.45
5. Defibrillate the patient before starting cardiac compressions or intubating the patient	86.36
6. Analyze postdefibrillation rhythm before starting cardiac compressions or intubating	91.30
7. Recognize that the patient is in asystole	90.91
8. Proceed with the intubation before starting the cardiac compressions	86.36
9. Do not bag the patient before the intubation	100.00
10. Use the video laryngoscope to intubate	84.21
11. Successful intubation of the patient	100.00
12. Start cardiac compressions	100.00
13. Properly remove personal protective equipment	N/A*
14. Minimize the number of providers in the room	89.47
15. Roles are clearly identified both for physicians and for nurses	N/A*

*N/A, not available because of missing data ≥ 50%.

not administrated before and after defibrillation until the patient is intubated and that initial cardiac rhythms are commonly pulseless electrical activity and asystole rather than ventricular tachycardia and ventricular fibrillation because of the high rate of acute respiratory failure or pulmonary embolism in this population.[1] Significant delays in the management of patients with COVID-19 and cardiac arrest were expected, given the modified ACLS protocol, but a significant time gap between time-to-room entry and time-to-first defibrillation was noted. Although defibrillation did not precede chest compressions or intubation in 13.64% of the stimulations, we speculate that the first person to enter the room on those occasions may not have received the training to install the pads, recognize a shockable rhythm, and administer shock.

In spite of the fact that providers' performance in terms of how to manage a patient with COVID-19 and cardiac arrest was good overall, certain steps of the protocol had a success rate of less than 90%. Although it remains controversial whether chest compressions are considered to be aerosol-generating medical procedures or not, using the video laryngoscope for endotracheal intubation and minimizing the number of providers in the room are established key steps in limiting aerosolization of the virus and the infectious risk to health care workers and should be reinforced. The importance of early defibrillation before proceeding to intubation or chest compressions in the modified ACLS protocol should also be emphasized, as delayed defibrillation (more than 2 minutes) is associated with lower survival after in-hospital cardiac arrest.[4]

Limitations

Certain limitations must be acknowledged. First, no validated tool to assess the performance of code blue teams administrating modified ACLS to in-hospital COVID-19 cardiac arrest exists in the literature. An evaluation tool was created by a consensus of experts with training in medical education. Second, stickers were used to simulate the airborne PPE, preventing adequate assessment of donning and doffing of PPE and introducing a bias in measures of efficacy. Finally, as this study was conducted in a quaternary centre that was not designated to receive patients with COVID-19, these results are not necessarily indicative of clinical practice in community centres or other Canadian academic centres. A larger-scale study, including COVID-19–designated centres, is warranted.

Although some question the futility of resuscitation, given the poor survival of patients with cardiac arrest and COVID-19, simulation-based medical education in this context may be an effective way to train and assess the performance of resuscitation teams, which may lead to better patient outcomes and help to reduce the infectious hazard to health care workers. Also, many patients are considered COVID-19 suspects and are placed in isolation awaiting test results. In case of a cardiac arrest, they have to be managed as COVID-19–proven patients, even if their prognoses are probably better than that of patients with COVID-19. Our study sheds light on the efficiency and quality of resuscitation efforts in the setting of in-hospital cardiac arrest of patients with COVID-19. Although delays in time-to-first defibrillation, time-to-first chest compression, and time-to-epinephrine were expected with the modified ACLS protocol, an alarming delay between room entry and defibrillation was observed. Adequate training of all hospital personal in basic cardiac life support and rehearsal of the modified protocol to ensure defibrillation before proceeding to intubation and chest compressions may help shorten the time-to-first defibrillation.

Conclusions

COVID-19 cardiac arrest protocol for hospitalized patients resulted in time-to-first defibrillation, time-to-first chest compression, and time-to-epinephrine longer than guidelines-expected times. Although adherence to the stepwise approach to a COVID-19 suspect patient with cardiac arrest was high overall, breaches in the protocol that may carry an additional infectious risk to health care workers and reduce the efficacy of the resuscitation team were observed. Simulation-based medical education of in-hospital cardiac arrest of patients with COVID-19 may help the training and the evaluation of the performance of resuscitation teams, with the hope of improving patient outcomes and reducing the infectious hazard to the providers.

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Disclosures

The authors have no conflicts of interest to disclose.

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Supplementary Material

To access the supplementary material accompanying this article, visit the online version of the *Canadian Journal of Cardiology* at www.onlinecjc.ca and at doi:10.1016/j.cjca.2021.03.012.