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

Laurie-Anne Boivin-Proulx MD,[1] Amélie Doherty RN MSc,[2] Nicolas Rousseau-Saine MD[2], Serge Doucet MD,[2] Hung Q. Ly MD SM,[2] Patrick Lavoie RN PhD,[2] Nicolas Thibodeau-Jarry MD MSc.[2]

1. CHUM Research Center and Cardiovascular Center, Montreal, Canada
2. Montreal Heart Institute, Montreal, Canada

Author of correspondence:

Laurie-Anne Boivin-Proulx MD
Centre de recherche du CHUM (CRCHUM)
Cardiology, CHUM
850, rue St-Denis
Montréal, QC, Canada
H2X 0A9
laurieanneboivinproulx@gmail.com

Brief summary: 60 words (maximum 60 words)
Abstract: 188 words (maximum 250 words)
Text: 1430 words (maximum 1500 words)

Brief Summary

Cardiac arrest is common in critically-ill coronavirus disease 2019 (COVID-19) patients and is associated with poor survival. Simulations of in-hospital cardiac-arrest of COVID-19 patients at a quaternary center demonstrated time-to-defibrillation longer than guidelines-expected time. While adherence to the COVID-19 cardiac arrest protocol was high, breaches carrying an additional infectious risk and reducing the efficacy of the resuscitation team were observed.

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 a training on personal protective equipment donning and doffing for suspected or confirmed COVID-19 cases. Thereafter, simulations of in-hospital cardiac-arrest of COVID-19 patients, so-called “protected code blue”, were conducted at a quaternary academic center. The primary endpoint was the mean time-to-defibrillation. A total of 114 individuals 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 the proper management of a COVID-19 cardiac arrest patient were met. Mean time-to-defibrillation was longer than guidelines-expected time during “protected code blue” simulations. While adherence to the modified advanced cardiovascular life support protocol was high, breaches that carry an additional infectious risk and reduce the efficacy of the resuscitation team were observed.

Cardiac arrest is common in critically-ill patients with coronavirus disease 2019 (COVID-19) and is associated with poor survival.[1, 2] Among 5,019 COVID-19 patients from 68 intensive care units across the United States, 701 (14.0%) patients suffered an in hospital-cardiac arrest, from which only 48 patients (12.0%) survived at discharge.[1] More recently, a retrospective cohort of 63 consecutive COVID-19 patients 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.

Healthcare workers have a high professional risk for contracting COVID-19 and CPR carries an additional infectious risk. CPR implies performance of several aerosol-generating procedures (e.g. chest compressions, establishment of an advancement airway), proximity of rescuers to one another 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 healthcare 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 cardiac arrest patients with suspected or confirmed COVID-19.

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 center (Montreal Heart Institute). The objective of the simulations was for resuscitation team members to rehearse the modified ACLS protocol for suspected or confirmed COVID-19 patients (**Supplementary Figure S1**). Prior to the simulations, already trained participants reviewed personal protective equipment (PPE) donning and doffing for suspected or confirmed COVID-19 patients through a video demonstration.

Participants attended the simulations in groups comprising: senior residents or attending physicians (n=1-2), nurses (n=2-4), including an infectious disease prevention nurse, and respiratory therapists (n=1-2). 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”, i.e. a N95 mask, a gown, gloves and a protective face shield or eyeglasses. A manikin was used to simulate the suspected or confirmed COVID-19 cardiac arrest patient. Simulations occurred in situ, in an unused room of target units where medical personal are expected to manage COVID-19 cardiac arrests patients. Each simulation session followed the same standardized scenario and included the following steps:

1) Briefing;

2) Review of PPE donning and doffing for suspected or confirmed COVID-19 patients through a local video;
3) Simulation of “protected code blue” according to the local COVID-19 cardiac arrest protocol for hospitalized patients;
4) 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 Figure 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 through a 16-point checklist regarding the proper management of COVID-19 cardiac arrest patient, by a physician and a nurse trained in healthcare simulation.

Results

A total of 114 individuals 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**. 92.84% of the 16 criteria on the evaluation form were met on average.

Percentage of the criterion met for two elements on the checklist could not be reported because of missing data.

Frequently addressed topic during the debriefing from our simulations included: unclear distribution of roles for both nurses and doctors, material forgotten outside the room (e.g. CPR board, automatic chest compression device), 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 one minute, time-to-first-defibrillation of less than or equal to two 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 five minutes.[4] Delayed initiation of CPR, defibrillation or epinephrine treatment were associated with lower survival.[5]

The impact of prolonged time-to-defibrillation in COVID-19 cardiac arrest patients remains unsettled. It may differ from the general population given that CPR is 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 due the high rate of acute respiratory failure or pulmonary embolism in this population.[1] Significant delays in the management of COVID-19 cardiac arrest patients were expected given the modified ACLS protocol, but a significant time gap between time-to-room-entry and time-to-first defibrillation was noted. While 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 a shock.

In spite of the fact that providers' performance in terms of how to manage a COVID-19 cardiac arrest patient was good overall, certain steps of the protocol had a success rate of less than 90%. While it remains controversial if chest compressions are considered an aerosol-generating medical procedure 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 healthcare 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, since delayed defibrillation (more than 2 minutes) is associated with lower survival after in-hospital cardiac arrest.[4]

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 a training in medical education. Second, stickers were used to simulate the airborne PPE, preventing adequate assessment of PPE donning and doffing and introducing a bias in measures of efficacy. Finally, as this study was conducted in a quaternary center that was not designated to receive

COVID-19 patients, these results are not necessarily indicative of clinical practice in community centers or other Canadian academic centers. A larger scale study including COVID-19 designated centers is warranted.

While some question the futility of resuscitation given the poor survival of cardiac arrest COVID-19 patients, 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 reduce the infectious hazard to healthcare workers. Also, many patients are considered COVID-19 suspect and are placed in isolation awaiting test results. In case of a cardiac arrest, they have to be managed as a COVID-19 proven patient, even if their prognosis is probably better than a COVID-19 patient. Our study sheds light on the efficiency and quality of resuscitation efforts in the setting of in-hospital cardiac arrest of COVID-19 patients. While delays in time-to-first-defibrillation, time-to-first-chest-compression, 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.

Conclusion

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. While adherence to the stepwise approach to a

COVID-19 suspect patient with cardiac arrest was overall high, breaches in the protocol that may carry an additional infectious risk to the healthcare workers and reduce the efficacy of the resuscitation team were observed. Simulation-based medical education of in-hospital cardiac arrest of COVID-19 patients 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.

References

1. Hayek, S.S., et al., *In-hospital cardiac arrest in critically ill patients with covid-19: multicenter cohort study.* BMJ, 2020. **371**: p. m3513.
2. Shah, P., et al., *Is Cardiopulmonary Resuscitation Futile in Coronavirus Disease 2019 Patients Experiencing In-Hospital Cardiac Arrest?*.* Critical Care Medicine, 2021. **49**(2): p. 201-208.
3. Wayne, D.B., et al., *A longitudinal study of internal medicine residents' retention of advanced cardiac life support skills.* Acad Med, 2006. **81**(10 Suppl): p. S9-s12.
4. Neumar, R.W., et al., *Part 8: Adult Advanced Cardiovascular Life Support.* Circulation, 2010. **122**(18_suppl_3): p. S729-S767.
5. Bircher, N.G., P.S. Chan, and Y. Xu, *Delays in Cardiopulmonary Resuscitation, Defibrillation, and Epinephrine Administration All Decrease Survival in In-hospital Cardiac Arrest.* Anesthesiology, 2019. **130**(3): p. 414-422.

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

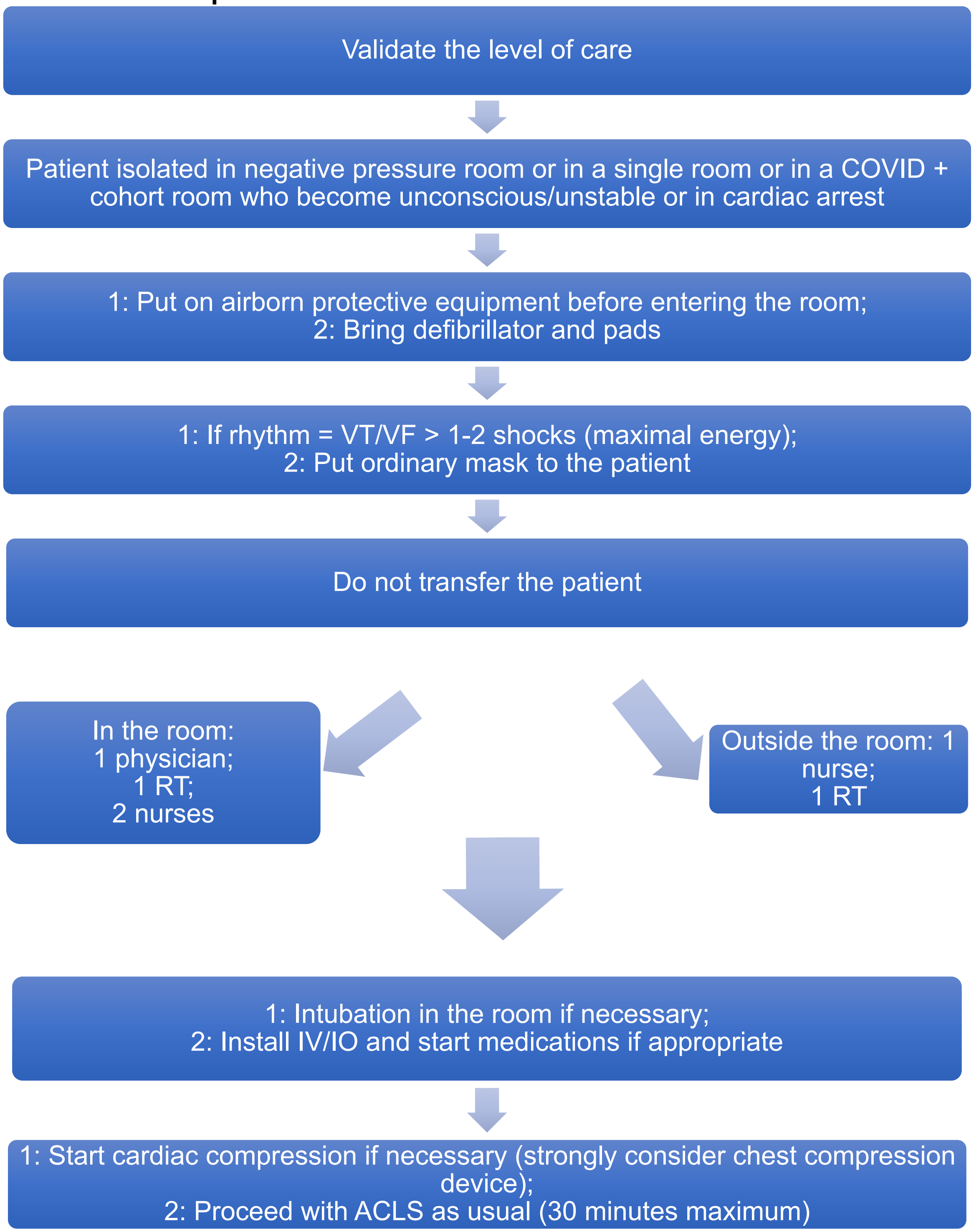
Time-to-room-entry (minutes; mean [standard deviation])	2.77 [1.18]
Time-to-defibrillation (minutes; mean [standard deviation])	4.38 [1.43]
Time-to-intubation (minutes; mean [standard deviation])	5.74 [1.83]
Time-to-first-chest-compression (minutes; mean [standard deviation])	6.31 [1.97]
Time-to-epinephrine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

Table 2. Percentage of each criteria of the evaluation form met during simulations of in-hospital cardiac arrest patients with 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 post-defibrillation 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; non-available because of missing data ≥50%.

Supplemental Figure S1. Montreal Heart Institute COVID-19 Cardiac Arrest Protocol for Hospitalized Patients.



Supplemental Figure S2. Evaluation form of simulations of in-hospital cardiac arrest patients with suspected or confirmed COVID-19.

Criteria	Yes	No	With reminder	Note
1. Put on personal protective equipment before entering the room				
2. Dressing sequence respected				
3. Put the pads to analyze the rhythm				
4. Recognize ventricular fibrillation				
5. Defibrillate the patient before starting cardiac compressions or intubating the patient				
6. Analyze post-defibrillation rhythm before starting cardiac compressions or intubating				
7. Recognize that the patient is in asystole				
8. Proceed with the intubation before starting the cardiac compressions				
9. Do not bag the patient before the intubation				
10. Use the video laryngoscope to intubate				
11. Successful intubation of the patient				
12. Start cardiac compressions				
13.Properly remove personal protective equipment				
14.Minimize the number of providers in the room				
15.Roles are clearly identified both for physicians and for nurses				
Time-to-room-entry				
Time-to-first-defibrillation				
Time-to-intubation				
Time-to-first-chest-compression				
Time-to-epinephrine				