REVIEW ARTICLE

Cardiopulmonary Resuscitation during COVID-19 Pandemic: Outcomes, Risks, and Protective Strategies for the Healthcare Workers and Ethical Considerations

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Abstract

The crisis caused by Coronavirus disease-2019 (COVID-19) pandemic has led us to safeguard ourselves and our colleagues against transmission of this highly contagious infection, while aiming for the same goals of care. In spite of the stringent measures adopted by affected countries, rising number of healthcare workers (HCWs) are getting infected, dwindling the scarce manpower at our disposal. In the pre-COVID-19 times, cardiopulmonary resuscitation (CPR) was offered unhesitantly to all patients, who had even a slim chance of achieving return of spontaneous circulation. In COVID-19 era, CPR, due to some components being high aerosol-generating procedures (AGPs), has become high-risk procedure for the HCWs. Instead of "*Primum non nocere*" (first do no harm), we are forced to change to "*Primum non nocere ad te*" (first do no harm to yourself). The challenge is therefore to provide best possible chance of survival to deserving patients, whose COVID-19 status might be unknown, without causing harm to the HCWs. In this review, we discuss the current data regarding infected HCWs, outcomes of inhospital and out-of-hospital cardiac arrests, components of CPR which are high-risk AGPs, how to safeguard the HCWs while offering CPR, and the ethical considerations when CPR is considered, in this COVID-19 era. We wish to emphasize here that there is NO EMERGENCY in a pandemic, and time must be made for donning appropriate PPE. We feel that clear policies need to be developed by the institutions to deliver CPR to correct population, in this challenging period.

Keywords: Aerosol-generating medical procedures, Cardiopulmonary resuscitation, COVID-19, Personal protective equipment, Transmission of infection.

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Introduction

Coronavirus infections disease-2019 (COVID-19) pandemic, caused by highly contagious SARS-CoV-2 virus, has overwhelmed health infrastructure around the world, in spite of stringent measures. The healthcare workers (HCWs) dealing with COVID-19 patients directly have the highest risk of infection transmission. The WHO reported that as of April 21, 2020, over 35,000 HCWs were infected.[1] The Chinese Center for Disease Control (China CDC) and Prevention found that of 44,672 (62%) confirmed cases, 1,716 (3.8%) were HCWs.[2] In Wuhan, a very high (63%, 1,080 of 1,716) proportion of HCWs were infected. Of these 247 (14.8%) had critical infections and 5 died.[3] In India, the incidence of confirmed COVID-19 cases among HCWs was 5%.[4]

Cardiopulmonary resuscitation (CPR) is offered to most inpatients suffering from cardiac arrest, unless advance directives are present, or the patient has a known do-not-resuscitate (DNR) status. The reports from China, France, and Italy suggest that outcomes of COVID-19 patients, who suffer either inhospital or out-of-hospital arrest, are poor.[5–8] Since many components of CPR generate aerosol, the WHO has listed CPR as an aerosol-generating procedure (AGP).[9] Infected HCWs pose a "triple threat" in current circumstances, loss of a HCWs to, and addition of a new patient (the HCW) to the overburdened healthcare systems, and a source of infection to coworkers and community.[10] The normal dictum *"Primum non nocere"* (*first do no harm*) needs to be altered to *"Primum non nocere ad te"* (*first do no harm to yourself*) at present.

In this review, we discuss the risk of infection transmission to the HCWs and protective measures for them. We also summarize the ethical principles in providing and withholding CPR. Finally, we suggest a protocol for preventing transmission of infection to the HCWs, during CPR (Table 1).

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Outcomes of Cardiac Arrest in COVID-19 Patients

Inhospital Cardiac Arrests in COVID-19 Patients

Shao et al. reported outcomes of inhospital cardiac arrests (IHCAs) in 136 patients, during early days of COVID-19 pandemic in a Wuhan hospital.[5] Most (113, 83.1%) arrests occurred in general wards and respiratory arrest was the most frequent (119, 87.5%). The commonest initial rhythm was asystole (89.7%), followed by shockable rhythms (5.9%) and pulseless electrical activity (PEA,

Table 1: Suggested protocol for preventing transmission of infection to healthcare workers during cardiopulmonary resuscitation, in the coronavirus disease-2019 era

1. Treat all the patients as having COVID-19 infection, unless proved otherwise.
2. First don the PPE, the minimum delay causes it is OK!
3. Remember, there is no emergency in a pandemic!!!
4. Follow ABC rather than CAB, sealing of the airway is important to prevent aerosolization.
5. Use muscle relaxant for intubations in peri-arrest conditions
6. Insert a supraglottic airway device early or intubate with a videolaryngoscope, if expertise is available, to avoid Bag-Mask ventilation
7. Use a HEPA filter between the airway and ventilating device, as soon as it is secured.
8. If already intubated, ventilate using the ventilator, at low rate (10 bpm) and low tidal volume [6 mL/kg ideal body weight (IBW)].
9. If not already ventilated, connect with ventilator as early as possible.
10. Attach closed in-line suction.
11. Maintain a closed circuit.
12. Change the person giving chest compression frequently, if possible every minute.
13. If available, use mechanical chest compression devices.
14. If the patient is in prone position, defibrillate with pads positioned anteroposteriorly or in both axillae.
15. If patients is intubated, start chest compressions in prone position, monitor $ETCO_2$ and Systolic blood pressure (with arterial line)
16. If $EtCO_2$ <10 mm Hg, turn patient supine and continue chest compressions.
17. If the patient is prone but not intubated, turn supine before starting CPR.
18. If initial rhythm was asystole, and ROSC not achieved in 30 minutes, stop CPR.
19. Decontaminate equipment used in CPR as per local institutional protocol.

4.4%). In spite of arrests occurring in monitored patients and CPR within 1 minute, return of spontaneous circulation (ROSC) was achieved in only 18 patients. Four patients survived, while one had a favorable neurological outcome at 30 days. The reasons for the poor outcomes may be shortage of medical resources and lack of good-quality CPR. Contrary to this, in the same center in 2016 the main cause was cardiac (47.6%), followed by other (unspecified) etiologies (20.5%) and then respiratory (17.5%) causes. Return of spontaneous circulation was achieved in a higher proportion of (35.5%) patients; more (9.1%) patients were discharged alive and many (6.4%) had good neurological recovery.[11]

An earlier review of ventilated patients with pneumonia and sepsis with IHCA also had different pattern, in that arrest occurred due to cardiac reasons (50–60%), and then respiratory insufficiency (15–40%).[12] The initial rhythm was asystole or PEA in majority (87%) of patients, and 60% patients were on vasopressor infusions. The rate of survival to discharge was 12.5%. The rate of survival with no or moderate neurological disability was 9.2%, and only 6.2% had good neurological outcome. The authors suggested that till outcome data from COVID-19 patients are available, this data could be used. They suggested that universal DNR orders, COVID-19 era are not warranted.

Out-of-hospital Cardiac Arrests in COVID-19 Patients

Baldi et al. reported a higher (a 58% increase) incidence of out-of-hospital cardiac arrests (OHCAs) during the pandemic, as compared to 2019.[7] The median time taken to provide EMS was longer and number of patients who received bystander CPR was less (by 15.6%), which increased the incidence of deaths (by 14.9%). The increase in the number of OHCAs was mostly due to an increase (77.4%) in the number of patients with suspected or proven COVID-19. This points toward the poor outcome of OHCAs in COVID-19 patients. The French data are similar to the Italian data. Marijon et al. reported that the over a period of 4.5 weeks, weekly OHCA incidence doubled to 26.64 from 13.42, per million inhabitants, in the beginning of pandemic, before returning to baseline.[8] The increase in OHCAs was mostly due to 30% increase in COVID-19 cases. Marijon et al. speculated that poor outcomes were caused by lockdown, behavior changes in bystanders, and an overwhelmed EMS.

CPR and the Risk of Transmission of COVID-19 Infection

Cardiopulmonary resuscitation is a complex maneuver that includes chest compression, defibrillation, and airway management, and many of these can generate aerosol.[9] As studies about aerosol generation with many components are inconclusive, we need to be cautious in interpreting the results.[13]

Chest Compressions and Defibrillation during CPR and Aerosol Deneration

The evidence about chest compressions and defibrillation being AGPs is very weak. Tran et al. reported that the odds ratio (OR) for SARS transmission due to chest compression was 1.4 (95% CI 0.2–11.2).[13] Couper et al. said that very little evidence exists that either chest compressions or defibrillation are AGPs.[14] Chest compressions might generate very small tidal volumes; however, whether this is enough to carry a significant risk of transmission of infection is unknown.[15] Ott et al. photographed aerosol spread, in a simulation study during chest compressions. Mostly aerosol spread toward the person giving compressions.[16] With a facemask, aerosol moved toward the patients forehead. Insertion of supraglottic airway device (SAD) with filter attached stopped the spread completely. Early insertion of SAD connected to a filter may produce a twofold benefit: treatment of hypoxia and protection of the HCWs. The European Resuscitation Council avers that both chest compressions and CPR are potential AGPs and, HCWs should don PPE during resuscitation.[17] However, it may be worthwhile to try defibrillation for shockable rhythm, before donning PPE, since ROSC may occur, preventing the need for CPR. Use of mechanical chest compression devices is suggested for anticipated prolonged resuscitation. In any case, during cardiac arrest, patients will also need ventilation or their airway secured, which are more likely to generate aerosols.

Aerosol Generation and Risk of Transmission of Infection during Airway Management

Judson and Munster described how aerosol is generated in various medical procedures.[18] They divided AGPs into procedures that cause patient to generate aerosols (cough during tracheal intubation (TI) without paralytic agents) and those that cause mechanical generation of aerosols (e.g., bag-mask ventilation (BMV)). Bag-mask ventilation (BMV) and positive pressure ventilation (PPV) generate aerosols by forcing air into the respiratory tract, though the exact mechanism is unknown. Tran

et al. found that the pooled OR for COVID-19 transmission was 6.6 (95% CI 2.3–18.9) in four cohort and four case control studies.[13] The OR for transmission of infection during manual ventilation was 2.8 (95% CI 1.3–6.4) and after intubation was 1.3 (95% CI 0.5–3.2). BMV is the commonest method for providing breaths during CPR. Here ensuring tight mask fit is important. A two-handed grip, using C and E technique, minimizes leaks. The other advantage of SADs is that some SADs can act as conduit for intubation.[19]

TI allows uninterrupted chest compressions during ventilation. The most experienced operator, while interrupting chest compressions briefly, should perform TI. Use of videolaryngoscope by an experienced staff leads to fewer episodes of prolonged (>10 seconds) interruptions.[20] American Heart Association (AHA) in its interim guidelines recommended the use of videolaryngoscope for intubation in COVID-19 patients.[21] After TI, the endotracheal tube (ETT) should be connected to a ventilator circuit with a HEPA filter in the expiratory limb. The use of a closed circuit and closed in-line suction decreases the chances of aerosolization.[22] If already intubated, the patient should be immediately connected to the ventilator, FiO_2 changed to 1.0. The respiratory rate should be 10 bpm and the tidal volume should be 6 mL/kg IBW. Once ROSC is achieved, ventilator settings should be reset appropriately.[22]

Protective Measures during CPR

During IHCA, HCWs, in their zeal, will rush to save the patient. It must be emphasized, *there is NO EMERGENCY* in a pandemic and *time must be given to don appropriate PPE*. The *safety of the clinician should be the first priority!!!* Losing an HCW owing to infection means losing part of valuable taskforce, and subsequently more patients. *In spite of the likely delay, it is a must that we don PPE, before CPR.* In a simulation-based donning/doffing study, potential biosafety breaches, which may infect HCWs if not executed properly, have been mentioned.[23] Performing CPR with PPE is challenging and tiring, but you have to be cautious so that no breach occurs in PPE. Both donning and doffing of PPE should be practiced repeatedly—in accordance with standard guidelines by the WHO and the local hospital policy, along with adequate disposal of PPE.[24]

Difficulties in Performing CPR Due to PPE

Shao et al. described the problems (and the solutions) encountered during resuscitation.[25] They recommended that the team members should wear loose-fitting clothing and pay proper attention to the tying of the mask since it can slip during CPR. If the mask still slips, someone else should take over. They suggested frequent changes (every minute) of persons performing chest compressions, or use of mechanical compression devices, since performing chest compressions while wearing PPE causes rapid fatigue. Using a positive pressure respirator hood could help in protection.

Strategies to Protect the HCWs During CPR

Advanced Care Planning

Advanced care planning should be done in all patients. McIntosh suggested that all inpatients should mandatorily have a treatment escalation plan (TEP) filled at the time of admission, to be kept updated during stay.[26] There have been some calls for extreme recommendations, i.e., universal DNR orders. For example, University Hospitals Birmingham NHS Foundation Trust issued directions to doctors, not to offer CPR to patients not in the ED, unless doctors were wearing full PPE.[27] A joint statement of the Belgian Society of Emergency and Disaster Medicine and the Belgian Resuscitation Council suggested that CPR be avoided when provider safety cannot be guaranteed.[28] While we do not know the way COVID-19 patient will progress, we still need to evaluate these patients, before making drastic decisions.

Use of Plastic Sheets as Barriers

Allen et al. suggested using clear plastic sheets impervious to water over patients, during performance of AGPs such as BMV, TI, and CPR.[29] They suggested that patients should be covered completely. Further, if the HCWs made an opening in the sheet for some procedure, it should be taped shut, as soon as possible, to prevent aerosol escape. The sheets should remain on, till the procedure is done and be removed if no HCW can be at the patient's side. The sheet should be removed slowly, while being rolled upon itself to prevent spread of fomites, and disposed of appropriately.

Restricted Number of HCWs for CPR

A minimum number of providers should be involved in CPR so that total exposure can be reduced, and also resources such as PPE can be conserved.

CPR in Prone Position

Many patients with COVID-19 develop acute lung injury or acute respiratory distress syndrome (ARDS), causing acute hypoxic respiratory failure (AHRF). Acute respiratory distress syndrome may be atypical in some patients.[30] In two retrospective studies, ARDS developed in 31 and 65 patients.[31,32] After the PROSEVA trial, prone ventilation is being increasingly used for severe ARDS.[33] Elharrar et al. tried the prone position in COVID-19 patients with AHRF in the ward.[34] Only 63% patients tolerated the prone position for >3 hours, and oxygenation improved in only one-fourth, which was not sustained after change to the supine position in 50% patients. An Italian study reported an improvement in oxygenation and reduction in the respiratory rate in patients on NIV in the prone position.[35] The accompanying editorial was cautiously optimistic but suggested need for further research.[36] The ICS, UK, suggests the prone position, in conscious patients requiring 28% or higher inspired oxygen.[37]

Performing CPR in a prone position poses different challenges. It will depend on whether the patient is already intubated and not.[38] Prone CPR may generate higher systolic and mean arterial pressures.[39] In nonintubated COVID-19 patients, CPR may be delayed due to time required to don the appropriate PPE. The UK resuscitation council recommends defibrillation before chest compressions to avoid delay in the delivery of defibrillation. The ERC guideline suggests two defibrillator pad placement options for prone patients anterior-posterior or biaxillary.[17]

Nonintubated prone patients will need to be turned supine for airway control. This needs at least six people, with possible risk of dislodgement of tubes and lines, causing delay in chest compressions. However the HCWs must don PPE, before doing any of this, to protect themselves. For intubated patients in the ICU, there will be no delay in CPR, because the HCWs are in full PPE. To avoid delay, CPR can be attempted in a prone position, using $ETCO_2$ and arterial pressure waveform. During position change, the HCWs must have a clear understanding of when and how to clamp ETT, or temporarily stop ventilation, to reduce the risk.[17,40]

Cardiac Arrest in COVID-19 Patients: Causes and Treatment

It is of utmost importance that any reversible cause of a cardiac arrest should be identified and treated immediately before considering stopping CPR and it remains the same. Apart from the 5H's and

5T's that need to be identified and rectified as early as possible,[40] in dealing with COVID-19 patients, 6th and 7th H (hypomagnesemia and hydroxychloroquine) should also be considered.[41] Otherwise, the guidelines for pharmacotherapy during ACLS remain the same in COVID-19 patients except few considerations. Lignocaine use is preferred in case of arrhythmias, avoiding amiodarone, due to possible QT prolongation due to its interaction with drugs such as hydroxychloroquine and azithromycin that the patient may be receiving.[40,41]

Post-resuscitation Care and Debriefing

All the equipment used during CPR should be carefully handled and disposed of as per hospital policy. Once ROSC is achieved, the factors, which may have contributed to cardiac arrest, should be recognized and treated promptly. Post-resuscitation care is the same for COVID-19 patients.[42] Debriefing is an effective practice for refining clinician behavior, which is associated with enhanced technique and patient outcome.[43] Debriefing can be performed via video call interactions with other HCWs in the time of COVID-19.

Ethical Considerations and Dilemmas

Medical ethics is a branch of philosophy that involves recommending and defending concepts of right and wrong conduct. Ethical approaches to health care can be divided into the utilitarian (consequentialist) approach and the Kantian deontological approach.[44,45] In the utilitarian approach, decisions are made to obtain the greatest benefit obtained for the greatest possible number of individuals. This may cause harm to a few patients, while its overall outcome is beneficial to a large number of individuals. In the deontological approach, the decision is made for the best outcome of the individual patient, and may or may not be good for the society. Traditionally, medical profession is deontological in nature, and is the basis of long-term bond between doctor and patient.

In the context of the COVID-19 pandemic, which approach should we adopt? The calls by certain healthcare administrators for not resuscitating patients when outcomes are likely to be poor, and may also cause harm to the HCWs, even if they are wearing PPE, are utilitarian in nature. The same is true regarding thoughtful and appropriate allocation of ventilated beds and other resources, recently by others.[46,47] This is, we think, totally justifiable in the current scenario. The infected HCWs will be out of action for a long period of time due to illness and quarantine, meaning that a trained person is not available for future patients, in the current situation where HCWs are scarce and precious resources.

Conclusion

During current COVID-19 pandemic, we must consider every collapsed patient to be a COVID-19 patient. Risk of infection to HCWs is very real and a few have died already. CPR generates aerosols, which can infect the HCWs. Efforts to maintain PPE integrity is a must during CPR. We feel that a utilitarian approach, to achieve maximum good for the greatest number, is quite sensible. In patients with multiple comorbidities, and nonreturn of ROSC, a sensible policy to either not starting or not continuing CPR should be adopted. Adequate simulation training and drills in donning and doffing of PPE for CPR is advocated. All institutes should formulate guidelines for protecting HCWs during CPR.

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