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Authors

Youssef, Fady A
Patel, Monique
Park, Hyunsoon
[et al.](#)

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BMJ Open Quality Protected code blue: using in situ simulation to develop a protected code blue and modify staff training protocol—experience in a large community teaching hospital during the COVID-19 pandemic

Fady A Youssef ^{1,2}, Monique Patel,³ Hyunsoon Park,¹ Jay V Patel,¹ James Leo,¹ Maged A Tanios^{1,2}

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¹Department of Medicine, Division of Critical Care Medicine, MemorialCare - Long Beach Medical Center, Long Beach, California, USA

²Department of Medicine, Division of Pulmonary and Critical Care Medicine, University of California Irvine, Irvine, California, USA

³Department of Medicine, University of California Irvine, Irvine, California, USA

Correspondence to
Dr Maged A Tanios;
mtanios@yahoo.com

ABSTRACT

The surge in clinical demand, shortage in personal protective equipment and high-exposure risk for healthcare workers during the COVID-19 pandemic has challenged hospital common practices and forced a reassessment of care delivery models. Code blue teams are highly specialised units that partake in life-saving situations that can jeopardise the safety of team members. There is a paucity of guidance in regards to proper infection control measures to protect the responders. This study describes a methodical approach to assessing vulnerabilities to transmission of SARS-CoV-2 within existing code blue practices, modalities to limit the number of code blue team responders and modifications to the protocol at a large community teaching hospital. The effort undertaken faced challenges due to the nature of the pandemic and the increased demand on healthcare workers. Quality improvement methods facilitated our protocol design and implementation. To this date, there has been no identified COVID-19 disease in any protected code blue (PCB) team members. We recommend that similar practices be considered and adopted widely and practised periodically.

PROBLEM

Code blue and airway response teams (emergency response team (ERT)) are complex teams that require a high level of expertise and the need to respond expediently. As the SARS-CoV-2 pandemic impacted the healthcare system, there was a paucity of guidance in regards to proper infection control measures to protect the responders. The guidance was largely based on prior pandemics, and the quality of evidence was low to moderate.

MemorialCare-Long Beach Medical Centre is a community teaching hospital that serves a large catchment area in Long Beach, California. The hospital offers more than 400 beds and treats a significant indigent population

with a high illness acuity. In our hospital, the ERT is typically led by an internal medicine resident and/or an intensivist. The team includes critical care nurses and respiratory therapists (RTs).

Given the vulnerability that a droplet or an airborne pandemic posed to the ERT, we embarked on a quality improvement project to identify areas of vulnerability to minimise healthcare worker (HCW) exposure.

BACKGROUND

The surge in clinical demand, shortage in the supply of personal protective equipment (PPE) and high risk of exposure for HCW during the COVID-19 pandemic have challenged hospital common practices and forced a reassessment of care delivery models.¹ This is especially true in practices around ERT, as those present unique and challenging situations for HCW. In April 2003, nine HCWs caring for a patient with SARS-CoV-1 contracted the disease likely during or after intubation.² Despite wearing the recommended PPE at the time of intubation, the six airway responders contracted the disease. The recommended PPE included gown, gloves, N95 mask, and goggles with or without a face shield.² This event highlighted the need for a protected code blue team. However, given the limited nature of prior outbreaks, protected code blue simulations and protocols have not been widely implemented in the USA.

We describe a methodical approach to assessing vulnerabilities within existing code blue practices, tactics to limit the number of code blue team responders and

implementation of resulting modifications to the protocol in a large community teaching hospital.

DESIGN

A multidisciplinary focus group of critical care physicians, critical care resident nurses (CCRN), RTs and pharmacists was formed. We conducted a literature review regarding prior and current practices from SARS-CoV-1, Ebola and SARS-CoV-2. At the time of our project, the most concrete and coherent data regarding the risk of transmission and mitigation strategies was noted to be in the body of literature following the SARS-CoV-1 pandemic. Next we ran a structured educational programme followed by two PCB simulations in different areas of the hospital. Observers from each of the involved parties was invited to the PCB simulation. After the PCB simulation, a debriefing was conducted, and further areas for improvement were identified:

1. It was unclear when and how a PCB is activated.
2. The number of responders was in excess of what is needed to run a successful code blue.
3. Bag mask ventilation (BMV) was often carried out by one CCRN or RT with poor technique leading to a large leak.
4. No viral filters were in use for BMV.
5. Airway securement tended to happen much later in the sequence of a code.
6. Appropriate PPE for a PCB was not uniformly agreed on across different units and access to it was lacking, even when requested.
7. The absence of anterooms posed a challenge for the doffing sequence and potential bystander exposure.
8. A large number of bystanders were noted to be present in the vicinity of the code.

STRATEGY

The multidisciplinary focus group convened three times to evaluate the process, reach final decisions and implement changes. Twice-weekly PCB simulations were enacted, and feedback was incorporated in the final protocol.

Definition of PCB

During the acute phase of the pandemic, we considered every code blue as a protected code blue. The overhead call was changed to 'Code Blue PPE' to serve as a reminder. The long incubation period and the varying rates of false negative testing results informed that decision. While this approach did use more PPE than a more restricted approach would have, we consciously and methodically decreased the number of responders to every code blue, offsetting the additional PPE use as described below.

PCB team composition

Given PPE shortages and exposure risk, we aimed to minimise personnel needed to be in the room. During our simulated codes, we were able to ascertain which

roles could be consolidated and which were essential. We modified the roles, as follows: (A) nursing: three RNs; (B) Airway responders: two RTs and anaesthesia attending; (C) code team leader: senior resident or intensivist; (D) pharmacist; and (E) safety monitors. The team members inside the isolation room were the primary nurse, two CCRNs, two RTs and one code team leader. The pharmacist and safety monitors were positioned outside the room. Finally, the addition of an automated chest compression device was recommended to further reduce the number of responders needed.

Responsibilities of first responders

There is currently no high-quality evidence regarding the association of chest compressions and aerosolisation. One study did note an increase in the odds of infection while also noting that chest compressions and intubation were highly correlated. The distinction between the two was not possible.³ Given the above, we advised bedside nurses to mask the patient and don an N95 mask prior to initiating chest compressions pending the PCB team arrival.

Bag-valve masking and endotracheal intubation have been linked to aerosolisation and exposure to HCW.⁴⁻⁶ Retrospective data showed that suctioning before intubation and endotracheal intubation during the Toronto SARS outbreak were associated with a relative risk of HCW infection of 4.2 (1.5–11.4).^{7,8} In order to maximise success on the first intubation attempt and minimise aerosol generation, PCB airways were managed by anaesthesiologists as the most experienced airway experts.

Pending the anaesthesiologist's arrival, it was found that a single RT bag-masking the patient created the potential for a leak around the mask. This led to the conclusion that two respiratory therapists (RTs) would be ideal, with one RT creating a two-handed tight seal on the mask and another respiratory therapist bagging the patient. Additionally, when the endotracheal tube was in place but not connected to the ventilator, clamping of the tube was implemented to minimise aerosolisation.⁴ The outlined plan above preceded the interim guidance by the American Heart Association but was in line with the recommendations.⁹ The respective department leaders were engaged, and the new proposed roles were discussed. Continuous in-service and skill-set monitoring were done (table 1).

Recommended PPE for PCB

Heavily influenced by the failure of 'proper PPE' during the SARS-CoV-1 Toronto outbreak, powered air-purifying respirators (PAPRs) were provided for the code blue team in lieu of N95 masks. The majority of patients were not housed in an airborne infection isolation rooms (AIIR), creating the need for additional protection with PAPR use. PAPR use included neck and shoulder covers to reduce skin contamination.

We considered three critical issues regarding PPE: (1) having the proper PPE on and donning in a

Table 1 Describing the duties carried out by the different code team members

Role	Duties
Bedside RN	<ol style="list-style-type: none"> 1. With N95 mask on, apply nasal cannula and surgical mask (or N95 mask if supplies allow) to patient. 2. Initiate chest compression until the PCB code team's arrival. 3. Assisting floor nurse brings defibrillator into the room. Administer shock if needed.
CCRN	<ol style="list-style-type: none"> 1. Don proper PPE promptly with safety monitor assistance. 2. Bring prepackaged advanced cardiac life support (ACLS) medication bag into the room. 3. Crash cart to remain out of the room. 4. Administer medications and assist with chest compressions as needed. 5. Code narration.
RT	<ol style="list-style-type: none"> 1. Don proper PPE promptly with safety monitor assistance. 2. Ensure viral filter placement on Ambu bag. 3. RT#1 to apply two-handed tight seal on the mask. 4. RT#2 to deliver breaths per usual guidelines. 5. Avoid hyperventilation. 6. Avoid interruptions in the circuit.
Safety monitor	<ol style="list-style-type: none"> 1. Responsible for bringing PCB PPE cart. 2. Assist first responders with donning. 3. Check first responders' PPE prior to room entry and during the code. 4. Guide and assist with PPE doffing.
Pharmacist	<ol style="list-style-type: none"> 1. Assist with further medications needed in excess of what is present in the prepackaged ALCS medication bag.
Physicians	<ol style="list-style-type: none"> 1. Senior resident or intensivist serves as a code leader. 2. Anaesthesiologist for establishing an airway.
Physicians	<ol style="list-style-type: none"> 1. Senior resident or intensivist serves as a code leader. 2. Anaesthesiologist for establishing an airway.

CCRN, critical care resident nurse; PPE, personal protective equipment; RT, respiratory therapist.

time-conscious fashion; (2) maintaining proper PPE throughout the code; and (3) doffing properly to avoid self-contamination or exposure to other team members at various stages of doffing.³

We elected to use dual gowning to provide maximal protection and facilitate safe doffing. The first donned gown was a level 1 Association for the Advancement of Medical Instrumentation (AAMI) isolation gown. Level 3 or higher AAMI gowns provide better back coverage and improved imperviousness to fluids and served as the primary protection. This was noted during a COVID-19 simulation in Vancouver, Canada, when a simulated cough demonstrated the level 1 AAMI gowns are permeable to droplets, but the level 3 AAMI gowns showed no contamination under scrubs.^{10 11} Additionally, we elected for double gloving with special attention to ensure the wrists were well covered.

Physician responders' recommended PPE included: (A) PAPR with shroud for neck and shoulder coverage; (B) level 1 AAMI gown; (C) level 3 or higher AAMI gown; (D) double gloving with special attention to wrist coverage; and (E) knee high shoe covers, as demonstrated in figures 1 and 2. Similar recommendations were made for CCRNs and RTs. For PCB responders who remained outside of the room, N95 masking was recommended. The room door was kept shut as long as possible.

Safety monitors

In our simulated PCB, the donning process was noted to be time-consuming, lasting 4–5 min, which is consistent with prior published simulations.¹¹ Some responders aiming to expedite their entry to the room had donned items incorrectly or in the wrong order. Additionally, the doffing process was complicated by several instances of self-contamination. Given the nature of this pandemic, only urgent and emergent surgical cases were taking place in operating rooms, enabling redeployment of scrub technicians and OR nursing staff, who are familiar with regular donning and doffing of surgical attire, as safety monitors. OR staff proved to be extremely efficient in assisting donning of PPE by code team members, such that the first responders were able to enter the room reliably within the first 3 min of arrival. With reducing our code responders, having two safety monitors was sufficient for six responders.

The safety monitors responded to every code with preprepared code blue attire and assisted every team member in donning the proper PPE in a prespecified fashion. In addition, they posted the doffing sequence on the doors and windows to assist the responders with proper doffing technique and sequence. In our assessment, the safety monitors are critical and key to establishing a successful and effective PCB sequence.



Figure 1 Healthcare worker's outermost PPE: PAPR with neck and shoulder cover, surgical gown and knee-high booties. PPE, personal protective equipment.



Figure 2 Healthcare worker demonstrating PPE attire under the surgical gown. PPE, personal protective equipment.

Donning and doffing sequence

The donning and doffing sequence was developed after several simulations and were heavily influenced by the available PPE at the time. We aimed to have responders don two layers of items to allow for doffing the outermost layer inside the room (figure 1) and the innermost layer outside of the room (figure 2). Clinical demand far outpaced availability of AIIR.

Implementation process

We underwent in situ biweekly mock simulation codes with all involved HCW to further education and improve response times. The mock simulation codes took place on a variety of patient care units and used the pre-existing equipment on said units. Despite the education and discussions, the team returned to their prior learnt behaviour under stress early on. However, with repeated simulations, there was a noticeable improvement in following the protocol and minimising self-contamination and exposure.

Lessons and limitations

The aim of the project was to limit HCW infections as a result in participating in ERT activity. To be successful, the system designed would have to be applicable to the various care delivery settings where the team has to

respond. One of the key lessons learnt is the importance of conducting simulations in the various settings where the team has had to respond.¹² The creation of the PCB sequence also highlighted the challenge of convincing long-time ERT members of the need to adopt the new protocol. For example, compliance with PAPR use was variable, and the PCB allowed for members to opt out of PAPR use if they wished. The composition of the team and the need to minimise participants was also an area where many members initially struggled with the proposed changes. Continued education and feedback solicitation proved to be key.

A key limitation to the project was the lack of quantitative measurement of satisfaction of the various ERT members. Due to the severity and acuity of the pandemic, the team conducting the project was simply overwhelmed. Overall, the feedback was positive and was further cemented by the absence of apparent transmission to HWC from partaking in emergency response team activity.

DISCUSSION

The COVID-19 pandemic has posed significant challenges to our healthcare system and highlighted several areas of weaknesses. A critical aspect of PCB is realising that the PPE requirements during usual care may not be

adequate for code blue and airway emergencies. Further investigation is needed.

In a post-COVID-19 world, frontline HCWs have earned new appreciation for the role they play, and protecting them is of the utmost importance for maintaining a functional healthcare system. Code blue teams are highly specialised teams that partake in life-saving situations that, in many circumstances, often renders them vulnerable to disease transmission. Every effort ought to be made to minimise and hopefully eliminate exposure of HCWs.

Relying on lessons learnt in responding to SARS-CoV-1 has disadvantages. The reports are retrospective in nature with several inherent confounding factors. Additionally, data regarding aerosol-generating procedures are weak. The current evidence was deemed to be of 'very low-quality' by the authors of a systematic review that analysed 10 studies.⁷ HCWs were disproportionately represented in the number of SARS cases.¹³ Until our understanding of COVID-19 disease transmission and mechanism(s) of HCW infection improves, adhering to a stricter interpretation of the data is likely to minimise exposure, ensure healthcare system readiness and reassure HCW.

CONCLUSION

In summary, we present our approach at a large community teaching hospital based on the available evidence at the time. To this date, there has been no identified COVID-19 disease in any PCB team members. We recommend that similar practices be considered and adopted widely and practiced periodically.

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Contributors All of the authors were involved with different aspects of the above project. FAY, HP and MAT were involved in every aspect of the described effort. FAY and MP were involved with the initial drafting of the manuscript. FAY and MAT were involved with the final editing and drafting of the manuscript. All authors were involved in the overall review of the manuscript.

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Author note ST has expressed her willingness to allow her image to be published, verbally and in writing.

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ORCID iD

Fady A Youssef <http://orcid.org/0000-0001-6123-970X>

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