Comparison of the Effectiveness of Different Barrier Enclosure Techniques in Protection of Healthcare Workers During Tracheal Intubation and Extubation

Mohamed Ibrahim, MD, MSc,* Ejaz Khan, MD,* Rovnat Babazade, MD,† Michelle Simon, MD,* and Rakesh Vadhera, MD*

The coronavirus disease 2019 (COVID-19; SARS-CoV-2) pandemic has created serious challenges to anesthesiologists. As hospitalized patients' respiratory function deteriorates, many will require endotracheal intubation. Airway management of infected patients risks aerosolization of viral-loaded droplets that pose serious hazards to the anesthesiologist and all health care personnel present. The addition of an enclosure barrier during airway management minimizes the hazard by entrapping the droplets and possibly the aerosols within an enclosed space adding additional protection for health care workers. The aim of this study was to compare the effectiveness of different barrier enclosure techniques during tracheal intubation and extubation. (A&A Practice. 2020;14:e01252.)

GLOSSARY

COVID-19 = coronavirus disease 2019; **OR** = operating room; **PPE** = personal protective equipment; **SARS-CoV-2** = severe acute respiratory syndrome coronavirus 2

The respiratory system is the one most immediately involved in coronavirus disease 2019 (COVID-19; SARS-CoV-2) infection and dyspnea, with cough and impaired oxygenation being the most common symptoms. The disease is variable in presentation, but many patients with severe conditions will need intubation. Physicians performing intubations are at significant risk of exposure as viral load in the patient's airway is typically very high¹; the same risk applies to other health care workers present in the room, especially with emerging evidence for a possible airborne route of transmission.² Special consideration and precautions are needed for the safety of physicians and other health care workers caring for COVID-19 patients, beyond those commonly used in normal clinical practice.

Multiple articles regarding the perioperative safety for health care workers dealing with COVID-19 patients have been published recently,^{3,4} including one proposing use of an aerosol box for intubation in areas of inadequate personal protective equipment (PPE).⁵ Canelli et al⁵ did a

simulation study by inducing cough using fluorescent dye and suggested applying protective barriers in conjunction with standard PPE that physicians may have as added protection during intubation.

Our study highlights the importance of limiting the spread of infection from its source (ie, the patient) by entrapping droplets and possibly aerosols to an enclosed space during the airway management. While most studies that focused primarily on the safety of the anesthesia provider, but most of them ignored a potential contamination of the room and other health care personnel.

The aim of this study was to compare the effectiveness of different barrier enclosure techniques during tracheal intubation and extubation.

METHODS

We conducted a simulation study to determine the degree of protection with different protective barriers by inducing cough in our mannequin using fluorescent dye. Improvised double plastic drapes ($\geq 120 \times 100$ cm) were made from operating room (OR) disposal bags by creating a facial opening in the lower layer sufficient to pass through the mannequin's head (a circle with radius of 12–15 cm), forming a seal around the mannequin's neck and creating a side opening (7 cm long) on the lateral side of the upper plastic drape (at same level of facial drape opening), allowing the anesthesiologist's hand access for airway maneuvers, for example, preoxygenation, bag mask ventilation, intubation, and extubation. After taping the proximal end, this created a sealed enclosure on all sides.

The proximal edge of drapes is taped to the table overhead, and the distal edge is taped at the patients' clavicle level to create enough space between the 2 drape layers for maneuvering during intubation/extubation. For the modified aerosol box, a single-layered drape with similar width

From the *Department of Anesthesiology, The University of Texas Medical Branch at Galveston, Galveston, Texas; and †Department of Outcomes Research, Outcomes Research Consortium, Cleveland Clinic, Cleveland, Ohio.

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Address correspondence to Mohamed Ibrahim, MD, MSc, Department of Anesthesiology, The University of Texas Medical Branch, 301 University Blvd, Galveston, TX 77555. Address e-mail to moibrah1@utmb.edu.

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and height of the box walls is added, attaching it to the box sides and top surface.

In our study, cough was induced by instilling fluorescent dye in the endotracheal balloon placed in the mannequin's oral cavity. The balloon was inflated with 30 mL of fluorescent dye initially and inflated until the balloon burst, the explosion of the balloon and spread of dye representing a crude simulation of a cough. Though we were not able to accurately simulate the aerosol produced during cough, we were able to detect relatively smaller droplet particles when fluorescent dye and ultraviolet light were used, that previously were not visible to the naked eye. We repeated the experiment 4 times (1) with no enclosure barrier, (2) using the aerosol box, (3) using a modified aerosol box with plastic drape covering the anterior open surface, and (4) using modified double plastic drapes as shown in Figure 1. Ultraviolet light was used to illuminate and visualize the spread of the fluorescent droplets as shown in Figure 2.

RESULTS

Experiment 1 was done with the provider is wearing conventional PPE only. In the absence of any enclosure barriers, droplets were detected on the operator gown, gloves, different locations on the bed, and the floor on both sides of the bed. The physician assistant in the room did get contaminated, and fluorescent droplets were detected on his scrubs, face, head cover, and mask (Supplemental Digital Content, Video 1, <http://links.lww.com/AACR/A326>).

Experiment 2 using the aerosol box resulted in contamination of the inner surfaces of the box, part of bed under

the box, and the operator's gloves. Droplets were also noted on the sheet covering the mannequin's body, mostly around the middle and the sides of the bed level, as droplets spread through the open anterior side of the box (Supplemental Digital Content, Video 2, <http://links.lww.com/AACR/A327>).

Experiment 3 used the aerosol box with the addition of plastic drape covering the box anterior surface. This resulted in less room contamination. Droplets were only detected in the area within the box and on the provider's gloves, but no fluorescent droplets were found out of the box (Supplemental Digital Content, Video 3, <http://links.lww.com/AACR/A328>).

In experiment 4, the cough induction under the double plastic drapes curtailed the droplets within the drapes. Droplets were detected around the mannequin's head within the enclosed double drapes, on the operator's gloves, with no fluorescent droplets detected out of the double drapes, similar to modified aerosol box (Supplemental Digital Content, Video 4, <http://links.lww.com/AACR/A329>).

DISCUSSION

Coughing is a droplet and aerosol-generating process commonly encountered at the time of extubation/intubation, putting the anesthesiologists and other operating personnel nearby under considerable risk.⁶ We developed a double-draped technique applied on the patient to minimize exposure of the staff, as well as the room environment, for example, OR, critical care room, emergency room, that can be easily utilized during both the intubation or extubation. The double drapes create a seal around the patient head and create an enclosed space where airway devices can be placed, for example, endotracheal tube, C-Mac blade, mask, oral airway, etc. On extubation, doffing of the double drapes included folding in the double drapes (rolling in from outside to inside) starting from patient's head, while the contaminated endotracheal tube or other airway adjuncts can be retained in the enclosed space between both drapes layers to prevent their exposure to the room environment. While the modified aerosol box with drape covering the anterior open end as shown in Figure 3 will confine the droplets and possibly the aerosols to the enclosed spaced and limit their spread to the OR, but will contaminate the enclosed part of the operating table/bed (Figure 4).

Multiple articles regarding safety of health care workers in the perioperative setting have been recently published,

Figure 1. Double drapes covering the mannequin during airway management.

Figure 2. Droplets are seen enclosed within the double drapes with no spread seen out of the enclosed space.

Figure 3. The Modified Aerosol Box after adding the additional plastic drape.

Figure 4. Droplets are contained within the box and detected on box surfaces and the plastic drape.

including PPE in combination with goggles and full protective head gear,⁷ and these recommended techniques focus on the protection and safety of anesthesiologist while ignoring the contamination of the room and assisting personnel. While use of any barrier enclosure techniques would provide some protection, the modified aerosol box and the double plastic drapes were able to minimize further spread by creating almost a total enclosure. We found that while the modified aerosol box experiment included contamination of all objects under the box including the bed, the double drapes method minimized the contamination to a greater extent when compared to the modified aerosol box as no leak to the bed existed and all contaminated materials have been discarded while within the drapes avoiding any exposure to the room or personnel.

One of the limitations of using the aerosol box was the hard circular ports for the provider's hands to work through, as it limits movement during the intubation process. This can be challenging, especially if a difficult intubation is anticipated. The double layer plastic drapes had the following advantages: it avoided the limitation of hand maneuvering experienced with the box, it minimized contamination to a greater extent; and the presence of it created an enclosed space between the 2 layers where extubated materials can be retained until time of disposal.

On the other hand, it is expected that the proximity of the plastic drapes to an awake patient's face can create a sense of discomfort or distress to the patient, though the presence of oxygen mask might ease patient anxiety. Another limitation we encountered with the double drapes' technique was the limited vertical space available for the endotracheal tube maneuvering compared to the space available under the aerosol box. However, that did not affect our ability to successfully intubate the mannequin.

Our study has some limitations. These include the qualitative assessment of the dye spread, rather quantitative measurement due to the lack of proper scanning equipment that can provide us with a quantified assessment, and the subjective assessment of 3 different providers present in room during the tests. We were not able to differentiate between aerosols and droplets, but we included all detected

fluorescent particles regardless to their size. More studies focusing on aerosol spread are recommended, due to limited time and resources, under the COVID-19 conditions, we were not able to scan for aerosols. Another limitation was that the cough simulation did not precisely simulate a patient's cough, but restricted access to our simulation center under COVID-19 conditions had led us to use expired endotracheal tubes and pivot balloon explosions.

CONCLUSIONS

The presence of a barrier enclosure technique provides protection to the anesthesiologist and to all health care workers present in room. Both suggested techniques, the modified aerosol box and the double drapes enclosure barrier, have limited the spread of the fluorescent dye to the enclosed space compared to the aerosol box with an open anterior surface. We recommend that the provider becomes aware of the limitations of each technique and to practice their use on healthy patients before their use on COVID-19 patients. ■■

DISCLOSURES

Name: Mohamed Ibrahim, MD, MSc.

Contribution: The author helped with study design, conducting the study, literature research, manuscript composition, figures, video creation, and edits of the manuscript.

Name: Ejaz Khan, MD.

Contribution: The author helped with literature research, conducting the study, manuscript composition, figures, and video creation.

Name: Rovnat Babazade, MD.

Contribution: The author helped with writing the manuscript.

Name: Michelle Simon, MD.

Contribution: The author helped with writing the manuscript.

Name: Rakesh Vadhera, MD.

Contribution: The author helped with writing the manuscript.

This manuscript was handled by: Bobbiejean Sweitzer, MD, FACP.

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