INTRODUCTION

COVID-19 is spread by droplet and contact contamination, and through viral aerosolization during aerosol generating medical procedures (AGMPs) such as intubation and bag-mask ventilation (BMV).[1,2] Previous research has demonstrated that health care workers (HCWs) are at higher risk of viral transmission during these AGMPs.[1,3] During the COVID-19 pandemic, the heightened need to protect HCWs[4,5] as well as shortages in personal protective equipment (PPE) has led to a rapid proliferation of improvised, repurposed and innovative techniques to minimize exposure. Considering 46-90% of HCWs have been shown to self-contaminate during doffing PPE[11-13], contamination of gowns and equipment may be an important source of HCW infection after airway management. Potential solutions under consideration at our institution included a clear plastic drape and a plexiglass box around the patient's head as a barrier during intubation. Both of these techniques have been described on social media and been adopted in many centres, despite limited evidence demonstrating that they reliably reduce contamination[6-8].

Currently, our protocol for intubation of patients with suspected COVID-19 has prioritized rapid airway establishment with only essential personnel to limit the exposure of HCWs. Consistent with other guidelines[9,10], preoxygenation in a negative pressure room is followed by rapid administration of induction agents, avoidance of BMV and intubation with videolaryngoscopy. Currently, our practice is to place a plastic sheet over the patient's head immediately following induction to reduce contamination but our clinical impression is that this technique results in additional contamination and is an impediment to intubation. In addition, whether this is the best approach remains unclear.[8,10] After local development of a Plexiglas box, we aimed to conduct a systematic comparison of these different techniques to inform our institutional practice. Our primary objective was to compare contact contamination of personnel between the plastic sheet, plexiglass box and no barrier using a simulated model of droplet contamination during intubation. Secondarily, we compared contamination between the intubator and the assistant, and aimed to qualitatively assess both the anatomic range of contamination and the ease of intubation using each technique.

METHODS

After review by our local research ethics board, formal approval and informed consent was waived as the study was considered a quality assurance project. We used a simulated intubation protocol to compare a no barrier technique with two barrier techniques for use during COVID-19 intubations at our institution; a plastic sheet and a plexiglass intubation box.

Study Population

Participants were selected amongst staff and fellows in the Department of Anesthesiology who were involved in preparing the institutional COVID-19 intubation protocol. Both male and female participants with a range of heights were selected to participate. All participants were familiarized with the simulation manikin prior to starting the study and each participant intubated the manikin using all three barrier techniques. In each trial, both an intubator and an assistant were present, similar to our clinical practice during intubation. The sequence of each technique was determined using simple randomization immediately prior to the start of the trial.

Study Procedures

This study had three arms: 1) control group (no additional protective devices); 2) plastic sheet over the patient; and 3) plexiglass intubation box. Prior to each procedure, the intubator and assistant donned the standardized PPE, which consisted of a gown, nitrile non-sterile gloves, surgical mask, full face shield, and disposable head covering. N95 masks were not used in this study to preserve the supply for clinical use. Prior to each procedure, both participants were inspected with a UV light to ensure that there was no fluorescing material on the PPE at baseline. An intubating manikin head was equipped with a MADgic® laryngo-tracheal mucosal atomizing device (Teleflex, USA) directed out of the mouth with the nozzle situated at the teeth. This MAD device was connected to an infusion line and infusion pump (BBraun, Mississauga, ON) under the bed. With the intubator standing at the head of the bed and the assistant to the right of the manikin, 5 mL of fluorescein 2 mg/mL (AKORN Pharmaceuticals, Lake Forest, USA) was injected through the MAD device in a standardized fashion over 22 seconds to simulate surface contamination present prior to intubation. A bag valve mask (BVM) (Ambu®, Copenhagen, Denmark) was then placed over the mouth and nose by the intubator and the fluorescein injection repeated in the same manner to simulate contamination during preoxygenation. The BVM was then held in place for a further 60 seconds to simulate the elapsed time to wait for onset of paralysis during recommended rapid sequence induction of anesthesia. Following this, the intubator proceeded to intubate with a styletted 6.5 size endotracheal tube using a McGrath video laryngoscope (Medtronic, Kirkland, QC). Once the endotracheal cuff was inflated and the endotracheal tube was connected to the BVM, the trial was considered complete, and the two subjects (intubator and assistant) stepped away from the manikin for evaluation by the assessors, as described below. Between each trial procedure, the manikin and all equipment were thoroughly cleaned and visually inspected with a UV light to ensure adequate removal of fluorescein. The PPE donned by the intubator and assistant were changed between each trial.

Plastic Sheet

In the plastic sheet study arm, a large clear plastic sheet (120cm wide x 150cm long) was placed on the bed in line with the shoulder of the manikin. After the simulated preoxygenation, the sheet was brought over the head of the manikin and intubation was performed with the arms of the intubator and assistant under the sheet.

Plexiglass Box

The intubating plexiglass box was created from 1/8" thick acrylic (Figure 1, CovidBox V 2.3, CovidBox, Canada). In the intubating box study arm, the clear plexiglass box was placed over the manikin head prior to start of the study procedures, and the simulated preoxygenation and intubation were performed with access through two holes in the box. The assistant accessed the manikin head through cutouts on the right side of the box.

Outcome Measures

The primary outcome was the total contamination score summed from all anatomic areas and both independent assessments. After each trial, two independent evaluators, blinded to the technique used, scored the degree of contamination on both the intubator and the assistant using a UV light in a dark room on a standardized scale: 0- no contamination, 1- light contamination, 2- heavy contamination (Figure 2). Parts of the body were scored separately and included: hand, forearm, upper arm, head, neck, torso, legs, and feet. At the end of the study, qualitative comments about the ease of intubation with each technique were solicited from the participants.

Statistical Analysis

A sample size of convenience of 5 subjects was chosen due to time and resource constraints during preparation for the pandemic. Data was described using percentage, mean (SD, standard deviation), median (interquartile range, IQR), and range, as appropriate. Differences in total score across the three groups were analyzed using a Friedman test for repeated measures on each subject. If significant ($p<0.05$), a post-hoc Wilcoxon signed-rank test for paired data was used to compare pairs with a Bonferonni correction to account for multiple comparisons, where a $p<0.017$ was considered statistically significant. A Wilcoxon rank sum test was used to compare total scores between intubators and assistants. All data analysis was performed using STATA 12.1 (StataCorp, Texas, USA) and a p-value <0.05 was considered statistically significant unless otherwise specified.

RESULTS

Five subjects participated in the study, including 3 women and 2 men. The mean height was 174 cm (range 159-190 cm).

Scores for contamination of each body part, stratified by role and presented as a sum of both assessors, are provided in Table 1. Most contamination was limited to the hands, arms and chests of the subjects. One intubator had light contamination of the head and neck, and another experienced light contamination of the lower body; both of these events occurred in the control group.

Total contamination score was statistically different between the three groups for the intubator (chi-squared 7.5, $p=0.0235$) but not the assistant (chi-squared 3.6, $p=0.1653$). For the intubator, the total contamination score was higher for the sheet compared to the control group ($z=-2.032$, $p=0.0422$) and for the sheet versus box ($z=2.032$, $p=0.0422$), but not for the control versus box ($z=-0.137$, $p=0.8913$), although these were not statistically significant after correcting for multiple comparisons ($p<0.017$).

Subjects performing intubation had higher total contamination scores than those acting as assistants (median 21 (IQR 15 to 25) vs 9 (IQR 6 to 11), respectively, mean difference 12 (95% confidence interval 6 to 17), $p=0.0002$).

All 5 subjects recorded narrative comments of intubating conditions with the sheet or box compared to no barrier. Four subjects reported challenging visualization of the videolaryngoscope screen using the sheet and all subjects reported challenges or difficulty intubating using the sheet compared to control. One subject reported altered visualization of the videolaryngoscope screen using the box and three out of five subjects reported some spatial or positioning limitations during intubation with the box compared to no barrier.

DISCUSSION

Our study results demonstrate that contact and droplet contamination during a simulated airway intervention was different between using three barrier techniques (no barrier, clear sheet, plexiglass box). We were not able to determine conclusively which method was superior, although the contamination scores appeared to be higher using the plastic sheet. The intubator experienced higher rates of contamination than the assistant, and contamination of the head and lower body were only observed in the no barrier technique. All subjects subjectively reported difficulty performing intubation using the sheet. Overall, the plastic sheet does not appear to result in any benefit over the other techniques, and may increase contact contamination while impairing intubation although our results must be interpreted cautiously given the small sample size and limited generalizability.

As a result of the COVID-19 pandemic, many airway management protocols have incorporated barriers to reduce viral spread through aerosolization and droplets, although few of these techniques have been studied and none are formally incorporated in recommendations. A plastic sheet covering the patient's head was introduced at our institution as a means to reduce droplet and aerosol transmission during COVID-19 intubations[14], and an intubating box was explored as an alternative barrier. Although benefits of barriers such as a sheet have been demonstrated in awake patients and during extubation[6], the benefits are less clear during intubation. In addition, the sheet is not typically placed over patients with respiratory compromise while awake, which may lead to further droplet contamination when the sheet is advanced during intubation. The intubation box used in our study was subjectively easier to use but presents further challenges in transportation and decontamination, which were not examined in our study. Our results contribute to the literature in this area and provide novel data describing droplet and contact contamination during simulated intubation. As a result of our study, we are re-evaluating the benefits of using barrier techniques.

The risk of contact contamination during intubation is significant as the aerosol and droplet particles settle on surfaces and may be concentrated around the head of the patient. In addition, our simulated model may underestimate the degree of contamination present if the patient has been in the environment for a long duration. The plastic sheet may act as a medium to transfer contaminants to HCWs and although it may reduce aerosol and droplet spread in coughing patients[6], the benefit during intubation in an apneic patient not receiving BMV is unclear.

Our study has several limitations and our results should be interpreted cautiously. We enrolled a small sample size and our results may not be generalizable to subjects of different sizes, levels of training or intubation techniques. In addition, we used a simulated airway protocol using a manikin which may not reflect clinical practice or actual droplet contamination. The assessment scale we utilized was practical but not validated, and the significance of the total score is not established. Finally, the intubators could not be blinded to group allocation which could have inadvertently introduced bias.

Overall, our study results provide preliminary and limited data to suggest that the benefits of barrier techniques on droplet contamination such as a plastic drape or box require further study and validation before they are introduced into widespread practice. Not only are the benefits unclear, subjective feedback in our study suggests that these barriers may impede intubation. Further study is urgently required to evaluate the use of novel devices for their risk modification of aerosol, droplet, and contact contamination as well as the need for additional steps that may delay airway securement and prolong healthcare worker exposure. Large multicentre registries such as IntubateCOVID where different barriers are used may help inform us better in the future[15].

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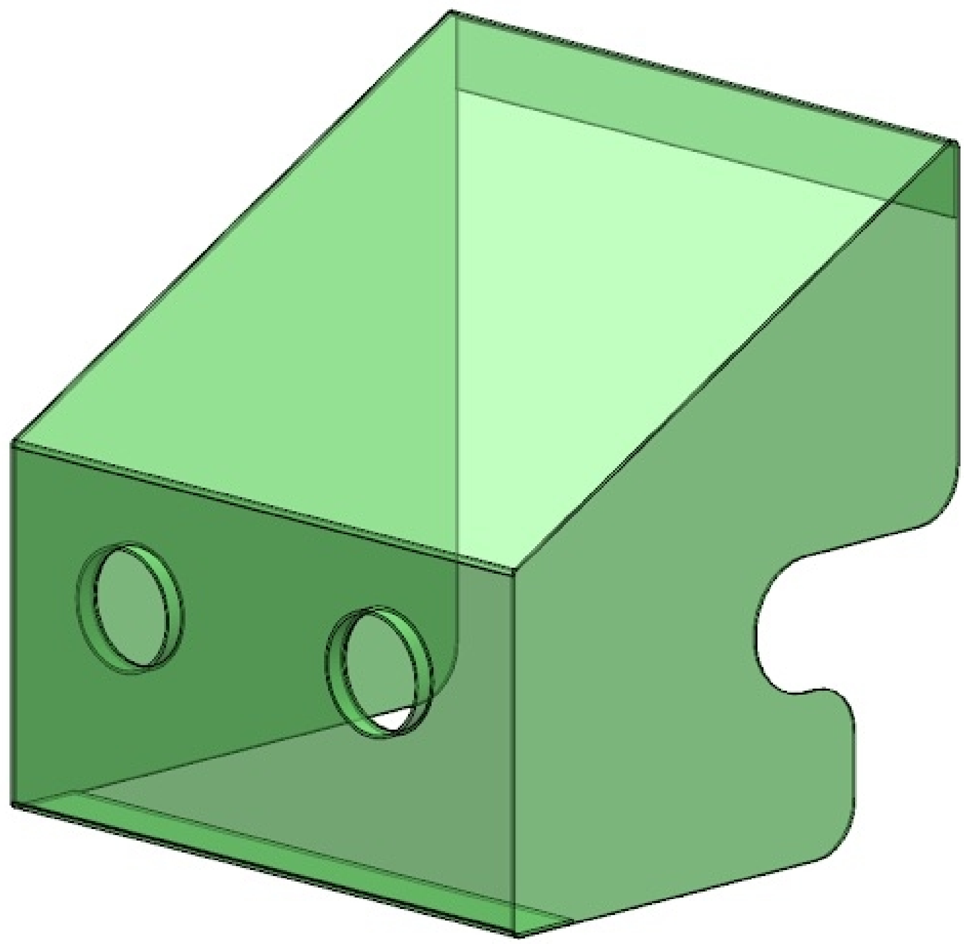

Figure 1. Plexiglass intubation box CovidBox V 2.3, (CovidBox, Canada). The intubator performs the intubation through the two holes while the assistant helps using their arm along the notch on the right.

180x172mm (72 x 72 DPI)

Figure 2. Intubator contaminated with fluorescein on hand, forearm and body highlighted with UV light after intubation using plastic sheet.

559x530mm (72 x 72 DPI)

Location	Intubator			Assistant		
	Control	Sheet	Box	Control	Sheet	Box
Right hand	5 (5-5)	7 (7-7)	7 (7-7)	2 (2-2)	5 (4-6)	3 (3-6)
Left hand	6 (6-7)	7 (7-8)	8 (7-8)	3 (2-4)	6 (5-7)	4 (3-5)
Right forearm	0 (0-0)	5 (5-5)	1 (0-3)	0 (0-0)	0 (0-3)	0 (0-0)
Left forearm	3 (2-4)	5 (4-6)	2 (0-3)	0 (0-0)	0 (0-2)	0 (0-0)
Right upper arm	0 (0-0)	0 (0-2)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Left upper arm	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Chest	0 (0-2)	3 (2-4)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Head & neck	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Lower body	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Total Score	18 (13-21)	29 (25-34)	17 (15-22)	4 (4-6)	11 (10-16)	8 (7-9)