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Improved polyethylene terephthalate shield and the mitigation of COVID-19 aerosols during airway manipulation

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Abstract

We continue to encounter on a daily basis, a significant number of patients with, or suspected of having a COVID-19 infection. It is important therefore to take proper steps to avoid viral transmission during airway manipulation. During this pandemic, different types of protective devices have been introduced to mitigate exposure to droplets and aerosols from a patient's airway. In this paper, we describe an intubation shield made from polyethylene terephthalate, which was inspired by the Wake Forest Type acrylic shield. Compared to the original shield, our shield is sturdier, has higher disinfectant resistance and is recyclable. Our device also enables clear visualization through the shield and easy access to airway management tools under disposable drapes. In addition to using personal protective equipment, this shield may further reduce the chance of viral transmission and room contamination.

Keywords: Barrier device; COVID-19; Intubation; Personal protective equipment.

Case report

As of August 2021, we are in the second year with Coronavirus disease 2019 (COVID-19). Our institution has been performing elective surgeries on non-COVID-19 patients as well as emergency surgeries on patients regardless of their COVID-19 status. In the first phase of the pandemic, there were critical shortages of personal protective equipment (PPE). At that time, we developed a barrier device for intubation to protect medical professionals from viral transmission. Our device is a modified version of the shield created by Dr. Douglas Ririe at Wake Forest University [1]. The original shield consists of an acrylic shield and disposable plastic cover.

Demand for acrylic plates (made from polymethyl methacrylate: PMMA) was extremely high at the beginning of pandemic. Therefore, we produced a revised model of the shield using readily available polyethylene terephthalate (PET) panels (PET-6010, Takiron-CI, Osaka, Japan). The size of the PET shield is as follows; the base has a depth of 300 mm, shield width is 300 mm, the first vertical rise is 200 mm, and the angled panel has a length of 400 mm. The thickness of the PET plates is 4 mm, and the angle of the shield is 30 degrees (Figure 1A). The total weight is 1200 grams. The material cost is approximately 50 US dollars.

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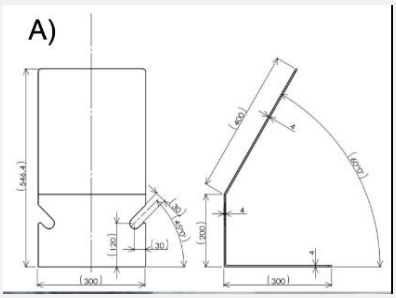

Figure 1: Details of the polyethylene terephthalate (PET) shield. **(A)**. The blue print of the PET shield. All measurements are in mm.

We chose PET to construct the shield because of the following advantages: 1) The impact strength of PET is higher than that of PMMA (Notched Izod Impact test under 23°C; PET:140 J/m^2, PMMA: 20 J/m^2) [2]. This means the PET shield is sturdier and more impact resistant than a PMMA shield, for example, when a laryngoscope or other instrument hits the shield or if the shield is dropped to the floor. 2) The PET panel is more flexible, so that the transparent panel can be more easily curved during fabrication. 3) PET has a high resistance to common disinfectants, including ethanol, isopropanol, and sodium hypochlorite. PMMA is sometimes damaged by highly concentrated ethanol or isopropanol [3]. 4) PET is a recyclable material.

A recent crossover study showed that the box-type shield made the use of bougies more difficult compared with using no shield [4]. We have observed similar results. Eight board-certified anesthesiologists in our institution participated in intubation simulation sessions using either our new PET or the original box-type shield. The time required for intubation was not clinically different between the two shields. However, all anesthesiologists struck a stylet against the top plate of the box-type shield, while no anesthesiologist hit it using the PET shield. Our modified PET shield has a larger vertical space above the patient's face. Therefore, it may reduce the risk of damaging the shield and provide greater access during intubation procedures.

Since our shield's caudal end and sides are covered by a plastic tent, the spread of aerosolized secretions toothers is likely reduced compared to the box-type shield,which has open arm holes and an open caudal end. In addition to improved accessibility, our shield is easier to clean and disinfect since it is an open design and the tentis thrown away.

Figure 1B shows a laryngoscopist during intubation using a training mannequin. The shield provides clear visualization of the airway during intubation. A disposable plastic cover is taped on the PET shield, creating a tent (Figure 1C).

The supplementary movie shows the use of our PET shield for a COVID-19 non-confirmed patient undergoing intubation/extubation for an elective surgery. Written consent was obtained from the patient for publication and video recordings. After the induction of anesthesia, we used a video laryngoscope (McGRATH^{TM}) to verify correct placement, and intubation was completed smoothly. We kept the PET shield in place during surgery until extubation. After surgery, while the patient was deeply anesthetized, mouth and pharynx were suctioned. A nasal canula was applied and then, a surgical mask was placed on the patient's face prior to extubation. The mask was left on the patient after extubation to further minimize the shedding of aerosols as described by Kristensen et al [5].

Figure 2: Details of the polyethylene terephthalate (PET) shield. **(B)**. Intubation view of laryngoscopist. A video laryngoscope (McGRATHTM) was used for tracheal intubation on a training mannequin.

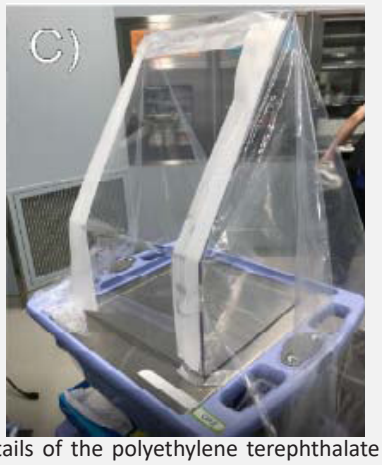

Figure 3: Details of the polyethylene terephthalate (PET) shield. **(C)**. Sideview of the draped PET shield.

Discussion

Various barrier devices for tracheal intubation have been created and used in clinical settings [6]. The recent study by Fidler et al. [7] reported aerosol retention characteristics in 6 different types of barrier devices. In their report, an early aerosol box design showed that compared to no barrier, aerosol counts at the operator's month were reduced 20-fold, and there was a 3-fold decrease at the operator's chest. The drape tent device which is similar to our device showed that particle counts were at least 50% lower at all measurement locations compared with measurements taken without a barrier device. If a barrier device was not used, particle counts at the operator's month were elevated compared to most of the barrier devices. Their drape removal experiments showed a high number of aerosolized particles can be released into the environment when the barrier is removed. Therefore, they recommend a strong suctioning of the contained air prior to removing the drape and barrier.

Conclusion

In summary, in addition to using standard PPE, use of our PET shield may further mitigate the chance of viral transmission and room contamination while performing airway manipulation for COVID-19 positive or presumed/non-confirmed cases. Our revised version has some advantages over the original Wake Forest shield. It is stronger, durable, recyclable, and has higher disinfectant resistance. In addition, compared to a conventional

intubation box, it may be easier to use and therefore provide superior viral containment.

Declarations

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Appendix: Supplementary Movie https://youtu.be/uem-9K0IVD1g

Limited access only for those who know this link. The patients have given consent for the video presentation.

Conflict of Interest: All authors declare that they have no conflict of interest.

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