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Letters to the Editor

Novel Coronavirus Disease 2019 (COVID-19) Aerosolization Box: Design Modifications for Patient Safety



THE NOVEL CORONAVIRUS disease 2019 (COVID-19) is an unprecedented global pandemic that has shaken the healthcare community. The transmission of COVID-19 has not yet been fully elucidated, but we do know that the virus can be spread by respiratory droplets and aerosols, resulting in a severe lower respiratory tract infection and acute respiratory distress syndrome.¹ Along with other countries, the majority of the United States has issued “stay-at-home” orders to slow the spread of the disease. However, physicians and healthcare providers continue to go to work each day with great personal risk to themselves and their families. Furthermore, personal protective equipment (PPE) designed to protect healthcare workers has universally become short in supply.

During the peri-intubation period, aerosolization can occur during spontaneous ventilation through a facemask for denitrogenation, endotracheal tube insertion, endotracheal extubation, and anytime a patient is ventilated with a bag-valve mask (BVM). Attempts to prevent disease transmission during the peri-intubation period have included standardization of rapid-sequence intubations and the use of a video laryngoscope for all patients who are COVID-19 positive.

However, these unique challenges can inspire unique innovations. In an attempt to combat the shortage of PPE and protect healthcare providers, a Taiwanese physician (Lai Hsien-yung (Menonite Christian Hospital, Hualien, Taiwan, 2020) developed a simple, yet intuitive invention to reduce the spread of aerosols during endotracheal intubation.² Commonly referred to as the “aerosol box,” this invention encloses a patient’s head within an acrylic or polycarbonate rectangular barrier (Fig 1) in an attempt to reduce the direct spread of aerosols onto a provider during endotracheal intubation. A clear transparent box is rested on a mattress at the head of the bed. An opening along the caudal surface allows the patient’s head to be placed inside the box. Two small circular openings on the cephalad surface of the box are designed for a provider to place his or her arms through to perform the intubation. The original box design was featured in the *New England Journal of Medicine*, which demonstrated the effectiveness of droplet containment during a simulated cough.³

When attempting to use this design within our own institution, we quickly observed several pitfalls that could compromise patient safety. We found that the box was too wide and would not fit on a standard operating room table. The arm insertion holes were too small, making it difficult to maneuver inside the box. Obese patients cannot fit inside the box, and the roof of the box was too low, making maneuvering an endotracheal tube, double-lumen tube, or bougie difficult. The original box was heavy and unstable, and reverse Trendelenburg position could not be achieved. In addition, an assistant could not provide cricoid/laryngeal pressure without contaminating himself or herself, and a breathing circuit was challenging to use inside the box. Lastly, the several openings of the box made it unlikely that aerosols were maximally contained.

In a collaborative effort between anesthesiology and engineering at the University of California San Diego, modifications to the original box design were made to address each of these problems (Fig 2). The dimensions of the box and circular arm insertion holes were modified, allowing the box to fit on standard operating room tables and provide better maneuverability when a provider’s arms were inside the box. Shoulder cutouts were also created to accommodate obese patients. For stability, an adjustable L-bracket flange was designed to slide underneath any sized mattress, which also allowed for bed position changes and use in the intensive care unit. To improve the ease of BVM, a 3-cm slit was created on each side of the box to easily insert and remove a breathing circuit. An accessory arm hole was made on the right side of the box for an assistant to provide cricoid/laryngeal pressure while still providing maximal barrier protection. A switch from acrylic to polycarbonate (popularly known as LEXAN, its trade name) improved impact durability and relative ease of sterilization.⁴ Lastly, to better ensure the containment of aerosols, all arm insertion hole openings and slits have removable covers reinforced with a silicone-based sealant. A reusable clear drape was added to seal the back of the box for additional protection.

The box is constructed using a 3.175-mm clear polycarbonate sheet, precut to shape using a table router (Fig 3). A thermo-bender was used to apply heat along bending lines on the polycarbonate sheet forming the 3D shell. The edges were sealed with 90°-angled polycarbonate strips and a plastic adhesive (Weld-On 16, Compton, CA). Polycarbonate hinges and circular polycarbonate discs were used to provide the shutters for the arm access holes at the front and on the sides. A flexible

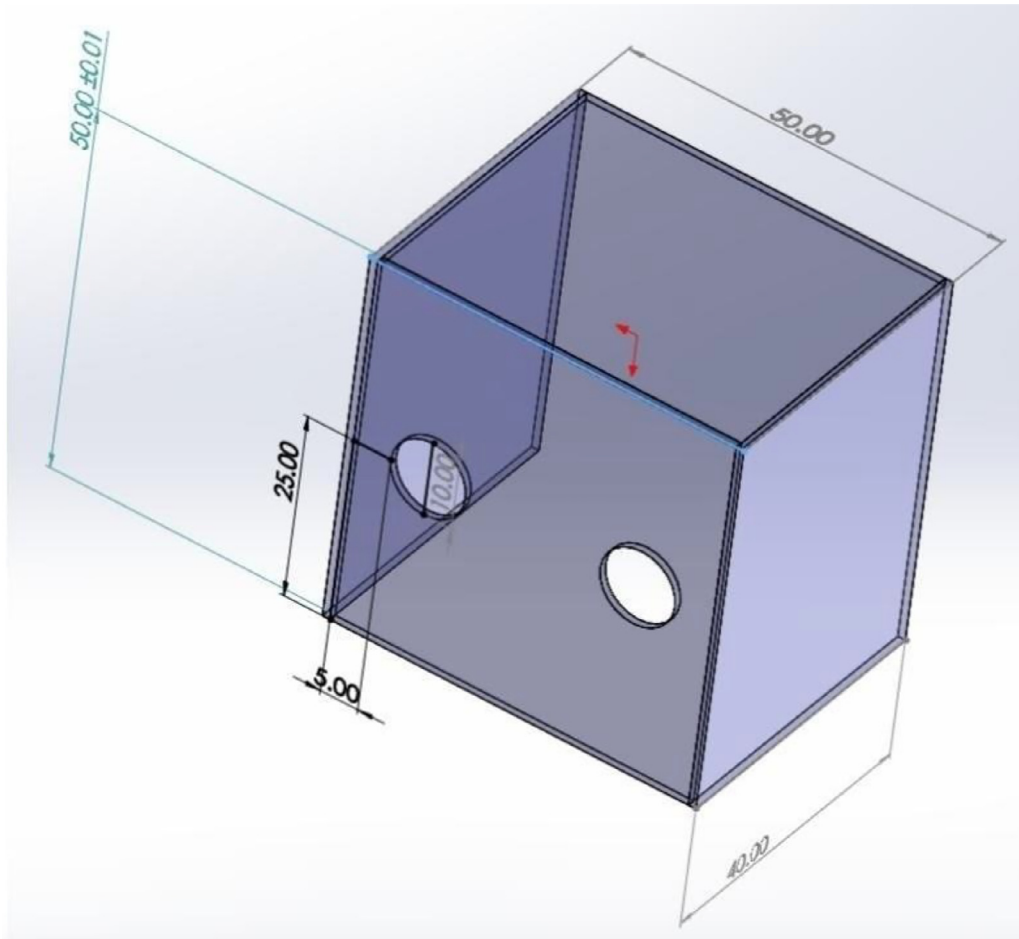


Fig. 1. Original aerosol box design created by Lai Hsien-yung (Mennonite Christian Hospital, Hua Lian, 2020) with dimensions in the metric system.³

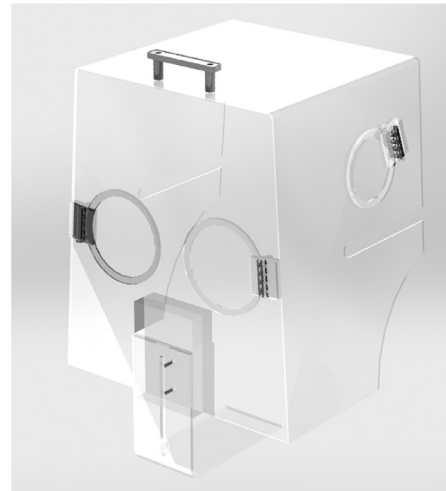
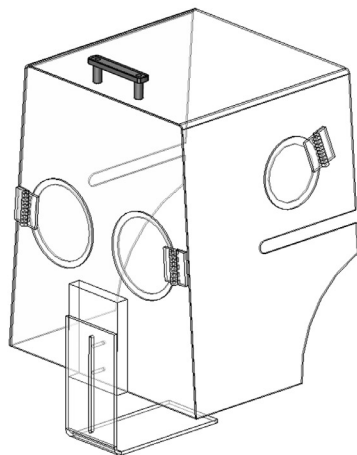


Fig. 2. Computer-generated rendering showing modified aerosolization box.

plastic sheet (Worbla, ePlastics, San Diego, CA) was cut to shape forming the side panels. Slits were made in the side panels to accommodate access and provide smooth passage for

ventilator circuit tubing. An L-bracket measuring 15 cm × 27 cm on each side was attached to the enclosure using 50-mm polycarbonate screws and hex nuts. A 25-mm thick acrylic

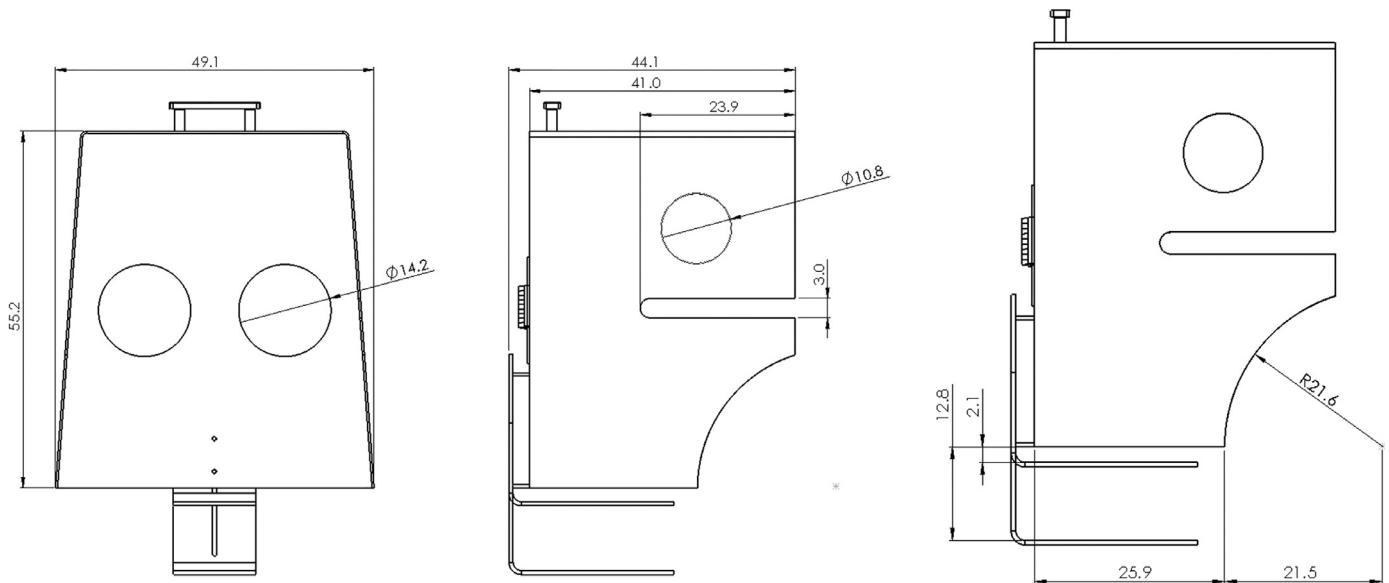


Fig. 3. Modified box dimensions in the metric system.

plate measuring 15 cm × 21 cm was used to provide a space between the enclosure and the L-bracket. This facilitated a stop gap between the enclosure and the top of the mattress.

These modifications, the use of the adjustable flange, and a full demonstration of how to use the box are shown in the supplemental video (Video 1).

This modified aerosol box also has the unique advantage of being used to care for cardiac patients. In addition to providing a barrier during the intubation of a cardiac patient, the box can be used while transporting intubated cardiac patients with BVM from the operating room to the intensive care unit, reducing aerosol spread and exposure. This would also free up transport ventilators, which have become standard to use while transporting patients who are COVID-19 positive. Furthermore, the increased height and larger arm holes also allow for more favorable conditions while intubating and extubating patients with double-lumen tubes for thoracic procedures. Compared with other barrier devices, the aerosol box has the advantage of being reusable if properly maintained and cleaned, which is becoming increasingly important with the shortage in PPE. Simulated training before clinical use is recommended. The box should be removed immediately in an emergency and not used in known or suspected difficult airways.

COVID-19 has already claimed the lives of hundreds of healthcare providers. Anesthesiologists are particularly vulnerable given their unique skills in critical care and respiratory management. Continuing to create, innovate, and share medical devices such as the aerosol box can help protect health care providers during this global pandemic.

Conflict of Interest

None.

Appendix A. Supplementary materials

Supplementary data associated with this article can be found in the online version at <http://doi.org/10.1053/j.vca.2020.05.001>.

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