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Design and Implementation of Low-cost Flexible Intubation Box

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ABSTRACT: Intubation is the process by which healthcare workers connect a flexible tube called endotracheal tube to patients' airway through mouth. This will be applied to patients who are unable to breath or need assistance in breathing or airway management. During this process healthcare professionals are at high risk of contracting disease transmitted through air and aerosol, and the best example is the current coronavirus pandemic as most healthcare professionals contracted COVID-19 while they were helping patients in critical cases. Therefore the need of a protective shield such as an intubation box is necessary to prevent professionals from high risk disease such as corona virus. Intubation box is a transparent box placed on top of the patient with access port to insert healthcare professionals' hands for intubation. The main challenges with the existing intubation system is its inaccessibility in all areas and its rigid nature to freely in tubate the patient. The aim of this research is therefore to design and build a low cost flexible intubation box using easily accessible materials for protection of healthcare workers in resource limited areas from COVID-19. Final prototype was implemented using materials accessible everywhere. Instead of acrylic plastic, flexible transparent plastic was attached on the light wood frame assembled having the shape of a designed intubation box by tightly securing it to prevent leakage of aerosol. The box was built for a total cost less than $7.5. The developed intubation box helps to protect healthcare professionals from contracting corona virus while they perform intubation. Having simple design and low cost gives advantage for areas where the existing intubation box is not easily accessible.

Keywords: Corona Virus, Healthcare professionals, Intubation, Low-cost intubation box, Protective shield.

Abbreviations: ET, endotrac heal tube; BiCPAP, bi-level continuous positive airway pressure; CPAP, continuous positive airway pressure.

I. INTRODUCTION

Intubation is the procedure of inserting a tube, called an Endotracheal Tube (ET), through the mouth and then into the airway. This is done so that a patient can be placed on a ventilator to assist with breathing during anesthesia, sedation, or severe illness. The tube is then connected to a ventilator, which pushes air into the lungs to deliver a breath to the patient. This process is done because the patient cannot maintain their airway, cannot breathe on their own without assistance, or both [1]. COVID-19 patients in critical condition need intubation to assist them through mechanical ventilation [2]. Intubation of COVID-19 patient falls under high risk aerosolizing procedures including positive pressure ventilation with bi-level positive airway pressure (BiPAP) or continuous positive airway pressure (CPAP), high flow nasal cannula, bronchoscopy and nebulizer treatment and regarded as high risk for COVID-19 transmission to healthcare workers [3]. While intubating the patient for ventilation, healthcare staff could contract the virus due to the droplets coming out of the patient's mouth or the patient could suddenly cough while the process is going on. The data from highly infected countries indicates that, large number of healthcare staff contracted the virus while helping the patient. This is due to lack of complete personal protection equipment. Intubation box is used to contain aerosols to prevent healthcare professionals from risk of corona virus transmission during airway management by acting as a barrier between the patient and caregiver during intubation procedure [4]. The use of specialized personal protective equipment such as N95 masks and powered air-purifying respirators can protect health workers but the need for special personal protective equipment such as an intubation box is high in most areas [5]. In advanced settings, an intubation box made of transparent acrylic plastic is being used to protect the healthcare workers but it is not easily accessible everywhere especially in resource limited areas. In addition to this the procedure of intubation with rigid aerosol box is time consuming and has potential impact on first pass test of healthcare workers. The aim of this research is to design and implement a low cost flexible intubation box using materials easily accessible in resource limited areas so that everyone can assemble the prototype easily to use it for protection of healthcare staffs from contracting the current corona virus pandemic and other diseases from the patient. One of the disadvantage of rigid intubation box is that it increases the time required for intubation resulting in hypoxia and infection [6, 7] and suitable modification is needed to improve the efficiency [8]. The proposed solution reduces the time of intubation so that the patient does not risk hypoxia and infection. It also plays vital role in first pass test of healthcare workers.

II. MATERIALS AND METHODS

The proposed design was based on the standard size to accommodate any size of patient. The box will be

placed on the chest of the patient and behind the head. The bottom part of the intubation box is open while two circular holes on the front side are used to insert hands to access the patient during intubation. The base dimension of the proposed intubation box was 50cm × 40cm while the height from the back side was 50cm and front side 40cm. The difference in height was to make the top side inclined for a better view for caregivers. The Fig. 1 below shows the software design of the proposed low cost flexible intubation box on Solid Works software.

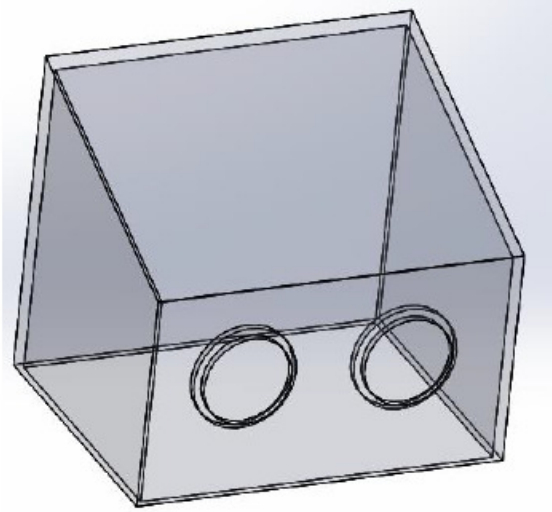

Fig. 1. 3D Design of Proposed Intubation Box.

The above design was confirmed after consulting anesthesiologists working on mechanical ventilators and having the experience of intubation. The slanted part on top of the box, with an angle of 105°, is considered for better view of healthcare professionals during intubation.

III. RESULTS AND DISCUSSION

The final implementation was made using materials easily available in any environment. Instead of using rigid acrylic plastic, low-cost flexible transparent plastic was fixed on a box frame made of light wood. Sealing of the box was carefully made to prevent leakage from the box. The figure below shows the final implementation of a low cost flexible intubation box.

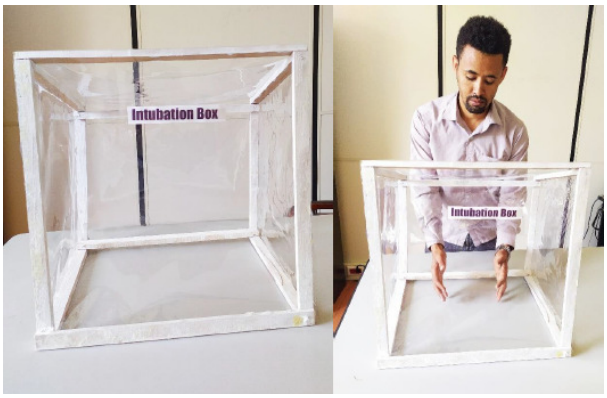

Fig. 2. Final Prototype of Low-Cost Flexible Intubation box (Own Image).

This prototype has two mechanisms of accessing the patient airway during intubation. The first mechanism is by inserting hands through access hole while the second mechanism is by partly dragging the rectangular area having the access holes. The implemented prototype of a low-cost flexible intubation box opens the door for healthcare facilities to assemble and use this vital protective equipment at a very low cost. The use of this kind of easily implementable protective device is highly appreciated to reduce occupational hazard on healthcare workers during the corona virus pandemic [9]. Beside this the flexibility feature added from the front side of the box makes it comfortable for healthcare professionals to perform intubation as compared with rigid aerosol boxes. The slanted part at the top provide better view and ergonomics for healthcare worker involved in intubation [10].

IV. CONCLUSION

Intubation box plays a vital role in protecting healthcare Workers involved in aerosol generating activities from contracting corona virus and other air borne diseases by acting as an extra shield in the hospital intensive care unit. Implementation of this device from easily accessible materials at low cost gives advantage for resource limited areas to assemble their own prototype easily. Making the patient accessing the port area flexible made the intubation procedure easier for healthcare professionals compared to the rigid intubation box. The use of intubation box should be as an additional protection together with gloves, masks and face shields.

V. FUTURE SCOPE

Since the role of intubation box is not limited by the current pandemic, low income countries should adapt this technology in simple possible way.

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Conflict of Interest. No.

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