


Aerosol containment box to the rescue: extra protection for the front line

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ABSTRACT

As the COVID-19 pandemic has created shortages of vital personal protective equipment that threatens healthcare workers' risk of exposure, a need for innovative new ways to protect healthcare workers has emerged. An aerosol containment box that covers the patient's head and neck in bed provides a solution to protect clinicians during aerosol-generating procedures such as intubation. We collaborated with original designer HYL and modified the size to adapt to larger patients and operator mobility. We expand its applicability by allowing the use of different instruments. The container is outfitted with an ultra-low particulate air-equipped filtration vacuum device to create negative pressure within the chamber and actively remove floating droplet nuclei generated during a procedure. This barrier method will be a valuable and economical option to protect healthcare workers on the front line globally during this pandemic and beyond.

As the COVID-19 pandemic has developed, the reported percentage of patients who develop respiratory failure and require mechanical ventilation has ranged from 3% to 15%.^{1,2} Aerosol-generating procedures including intubation pose the greatest exposure risk for healthcare workers. During an airway procedure, there is a risk of exposure to aerosolised droplets on the operator's hair, neck, ears and shoes and on the surroundings in the patient's room.³ Meanwhile, shortages of personal protective equipment may place healthcare personnel at greater risk.

In response to the need to further protect our healthcare providers, we collaborated with HYL to adapt the design of his 'aerosol box,' a clear plastic barrier device to shield clinicians from aerosolised particles during airway procedures.⁴ Hospitals around the world have begun manufacturing these



Figure 1 Use of the aerosol containment device for a simulated intubation procedure.

boxes and testing their ability to protect against aerosol spread during intubation.³⁻⁵ We first tested the original design in the emergency department and intensive care unit for intubation and bronchoscopy. Clinicians found that the 50cm width of the prototype did not fit obese patients, the 10cm arm holes limited manoeuvrability for some operators, and the 50cm height was too low for insertion or removal of certain types of stylet. Our modified aerosol containment device (**figure 1**) addresses these issues with increased height (60cm at the open end), width (60cm) and armhole width (15cm). The top of the box is slanted towards the operator at an 8° angle to eliminate visual blockage by the upper joint for operators of various heights.

We added two side ports to accommodate the hose of an ultra-low particulate air (ULPA) device (Atrix Omega Plus H14). Adding a vacuum creates partial negative pressure within the container to facilitate the removal of droplet nuclei and capture them with the ULPA filter to significantly reduce the risk of exposure. The device ports can be cut to different sizes to fit another vacuum or suctioning apparatus, allowing healthcare workers to make use of what is readily available in their hospital setting. The ULPA device used in our study has a filter installed within the vacuum that captures particles of 0.12µm or higher at

an efficiency of 99.97%. In settings without such equipment, a bacterial/viral filter can be attached to the port before connecting to a suction or vacuum apparatus. The two-sided design allows the dexterity of the vacuum placement depending on room configuration. The vacuum effectively removed air inside the box as demonstrated by a smoke test (online supplementary video 1). This bottled powdered smoke (Regin FP-201) is used to confirm negative pressure in isolation rooms. The turbulent smoke generated has a particle size of 0.3–2.5µm, which simulates aerosol particles that are less than 10µm, which are considered 'airborne transmission' and able to penetrate below the glottis to the alveolar space.⁶

The test was conducted using a disposable, flexible material to cover the open end of the box, which allows a negative pressure seal with the vacuum and further contains droplet dispersion. We also plugged vacuum ports that were not in use with a rubber stopper. The vacuum device should remain active for at least 30s after completion of the procedure to remove floating particles, based on the vacuum strength and container size described. This will prevent particles from re-aerosolising when removing the container from the patient. After this waiting period, the vacuum device should be turned off and the box removed off the patient carefully without creating excessive air turbulence within the chamber. The container can be cleaned with a disinfectant spray or wipe recommended for the material used in its construction. In the future, we plan to add rubber seals to the armholes for additional protection of the operator and to use an antifog coating to ensure visibility. The container can also be used to insert other instruments through side port or armholes, expanding its use for nasopharyngeal or oropharyngeal samplings, bronchoscopy or even gastroduodenoscopy.

There are several limitations with this device. Operators should be familiar with and practice manoeuvres within the confined space. The box may not fit all body habitus, and short neck length will increase the distance to the operator's arms. During difficult intubation or emergency, the box may pose as a barrier and should be readily removed with careful handling to avoid injury.

The design and intermediate iterations are available online.⁷ The use of the box is a simple way which might reduce aerosolisation during aerosol-generating procedures. It may provide additional protection to front-line healthcare workers. We suspect that the aerosol box will be instrumental beyond the current COVID-19 pandemic

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to protect clinicians from highly contagious droplet or airborne infections.

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Competing interests FM is a consultant for Portola Company outside of the submitted work.

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Author note The information on the aerosol containment device has been previously published on the internet to share with all healthcare providers during this COVID-19 pandemic. 1. <https://www.houstonmethodist.org/-/media/pdf/Research/covid19/HM-Aerosol-Container-User-Guide-final.ashx>. 2. "Aerosol Container Smoke Test" (April 2, 2020). <https://aerosolblock.org>.

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REFERENCES

- Meng L, Qiu H, Wan L, *et al.* Intubation and ventilation amid the COVID-19 outbreak: Wuhan's experience. *Anesthesiology* 2020;132:1317–32.
- Poston JT, Patel BK, Davis AM. Management of critically ill adults with COVID-19. *JAMA* 2020. doi:10.1001/jama.2020.4914
- Canelli R, Connor CW, Gonzalez M, *et al.* Barrier Enclosure during endotracheal intubation. *N Engl J Med Overseas Ed* 2020;382:1957–8.
- Lai HY, Chang D. Aerosol box protects healthcare providers during endotracheal intubation. Available: <https://sites.google.com/view/aerosolbox/home> [Accessed 31 Mar 2020].
- Lai HY, Chang D. Aerosol block. Available: <https://www.aerosolblock.org/> [Accessed 31 Mar 2020].
- Tellier R, Li Y, Cowling BJ, *et al.* Recognition of aerosol transmission of infectious agents: a commentary. *BMC Infect Dis* 2019;19:101.
- Houston Methodist Research Institute. Aerosol container user guide. Available: <https://www.houstonmethodist.org/-/media/pdf/Research/covid19/HM-Aerosol-Container-User-Guide-final.ashx> [Accessed 20 May 2020].