CORRESPONDENCE

A simple negative-pressure protective barrier for extubation of COVID-19 patients

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To the Editor,

We read with interest the creative article recently published in the *Journal* by Matava *et al.* on how “Clear plastic drapes may be effective at limiting aerosolization and droplet spray during extubation”.¹ Recently, others have also suggested innovative barriers such as the “Aerosol Box”,² and the carton-made protective shield³ for tracheal intubation and extubation. While we appreciate these suggestions for protecting healthcare workers when they are managing the airway of patients with coronavirus disease (COVID-19), these barriers have limitations. Coughing during airway intervention, particularly during extubation, can generate droplets of various sizes.⁴ Although the barriers suggested by Matava and others^{1–3} may block the large droplets projected by coughing from landing on the airway practitioner’s face or body, the “smaller” droplet nuclei ($< 5 \mu\text{m}$; i.e., “aerosols”) will likely be suspended, drifting about in the air inside the barrier device. It is also likely that the water content of the small droplets will evaporate, making the droplets even smaller and allowing them to drift farther,⁴ and possibly escaping into the surrounding environment when the barrier is removed. Every effort should be made to

mitigate this risk during airway intervention. Because availability of negative-pressure rooms is limited, and to reduce the risk of aerosol exposure during extubation in a non-negative-pressure environment, we have developed the following procedure, which is practical, simple, and affordable.

Before extubation, and while the patient remains paralyzed, we place a clear plastic bag split along one side of its seam over the patient’s head so that the bag naturally forms a “tent” (Figure A). We then cut a small hole at its apex (Figure B). To prevent droplets from being exhaled from the lungs, the endotracheal tube (ETT) is clamped momentarily to allow its disconnection from the ventilation circuit and its end is inserted through the barrier tent’s hole. The bag is then sealed around the ETT (with tape or an elastic band) before being reconnected to the circuit (Figure C). The ETT clamp is then released. After anesthesia is terminated and paralysis reversed, the patient is fully awakened with the return of airway reflexes, the tape securing the ETT is loosened (Figure C), and the ETT cuff is deflated through the plastic cover. During tracheal extubation, a continuous suction (at 200 mmHg from the anesthesia machine) is applied at the connector near the filter at the ETT (Figure D); slowly lifting the plastic cover from the patient’s mouth and face creates a negative pressure within the “tent” (Figure E). The “tent” is quickly closed, wrapped around the ETT, and a tightly fitted mask with filter is quickly applied over the patient’s face until any coughing subsides. During extubation, the large droplets associated with coughing will likely settle inside the tent. We simulated aerosols (see video available at <https://youtu.be/CxDD2YY70VI>) using an AirLife® Misty Max 10® Nebulizer (Carefusion, Yorba Linda, CA, USA) to generate droplet nuclei of sterile water with a median aerodynamic diameter of $1.30 \pm 0.07 \mu\text{m}$ (91.5% droplets

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are $< 4.7 \mu\text{m}$ at $10 \text{ L}\cdot\text{min}^{-1}$ of oxygen flow).⁵ These are seen visibly suspended and drifting about in the air but are being directed to the tip of the ETT (that is connected to suction) inside the negative-pressure tent (Figure F). Thus, this tent has the potential to serve as a barrier to contain

both the larger droplets, while the tent's negative-pressure environment reduces the smaller aerosols ($< 5 \mu\text{m}$), most of which will likely be removed through the tip of the ETT and into an attached filter.

FIGURE A) One side of a clear plastic bag is split along the seam and the bag is then placed over the intubated patient's head and chest, forming a "tent". B) A hole is cut in the "apex" of the tent to accommodate the endotracheal tube (ETT) for connection to the filter and ventilator. C) The bag is then sealed around the ETT with an elastic band (arrow) prior to being reconnected to the circuit; the tape securing the ETT can be loosened through the plastic "tent". D) During tracheal extubation, a continuous suction is applied at the filter connector (arrow). The insert shows the suction tubing connected to the filter using a three-dimensional (3D) printed tapered connector. The 3D printer STL file is available from the co-author (chris.r.hung@gmail.com). E) During tracheal extubation, the plastic cover is slowly lifted from the patient's head and neck, and

combined with the continuous suction, creates a negative pressure within the "tent." Following removal of the tent, a tightly fitted mask with filter can be quickly applied to the patient's face. F) Small aerosol droplets projected during coughing are illustrated visibly suspended in the environment and are being removed by the suction at the tip of the ETT within the negative-pressure "tent." These processes can also be seen in a video available at <https://youtu.be/CxDD2YY70VI>. The video shows the steps involved in building the negative-pressure tent as well as the extubation procedure. In addition to serving as a barrier to contain the large droplets, it also shows that this tent has the potential to remove the smaller aerosol droplets ($< 5 \mu\text{m}$) using suction applied through the ETT

Although we recognize there are limitations to this negative-pressure “tent”, we have been safely using this method of extubation in the operating room for presumed COVID-19 patients.

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