Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

home-made aids, however well intentioned. We must protect our staff during high-risk procedures, but not when this confers a threat to patient safety. Whilst both the safety and efficacy of barrier enclosures in airway management remain unproved, our focus should continue to be on the use of appropriate and well-fitted personal protective equipment, worn and disposed of effectively.

Declarations of interest

CS is a former member of the editorial board of *BJA Education*. The other authors declare no conflicts of interest.

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Evaluating intubation boxes for airway management

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Keywords: aerosol-generating procedures; airway management; barrier enclosure; COVID-19; SARS-CoV-2; schlieren analysis; tracheal intubation

Editor—The concept of an intubation box to contain aerosols has been proposed to address the risk of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission to healthcare professionals during airway management.[1–4] This barrier enclosure method has been widely promoted in the popular media.[5,6] Although there is a need for innovation, it remains important to fully assess new concepts to ensure their fitness for purpose. To date, the intubation box has only been tested using a vertical cough model using a Simman[1] mannikin (Laerdal Medical, Stavenger, Norway). We subjected such a box to objective airflow analysis of its performance with a human volunteer (more relevant to how it would be clinically deployed). We also collated perspectives from potential users in anaesthesia.

For airflow dynamic analysis, a barrier enclosure box of similar dimension and design to that proposed was placed over the head and upper torso of a healthy volunteer laying on an operating table in our simulation theatre (see Supplementary Fig. S1).[1] Schlieren imaging (a passive imaging method for direct visualisation of refractive index changes) was performed around the box during both normal and deep exhalation and during coughing. The imaging focused on both the user side of the box (where there are two apertures for insertion of the healthcare professional's hands) and on the opposite side (which is open to allow positioning over the patient). A high-speed monochromatic camera (Phantom version 311 capable of 10,000 image s^{-1} frame rate with 1920×1080 pixel resolution; Bell Labs, Wayne, NJ, USA) was used to capture images and allow analysis. Testing was repeated three times.

This assessment showed that substantial amounts of air moved out of the box and into the operating room during coughing (Fig. 1). This could be eliminated by placing a drape over this open side of the box such that, on repeat assessment, no airflow escaped the enclosure on that side. The analysis also identified some movement of air out of the box via the

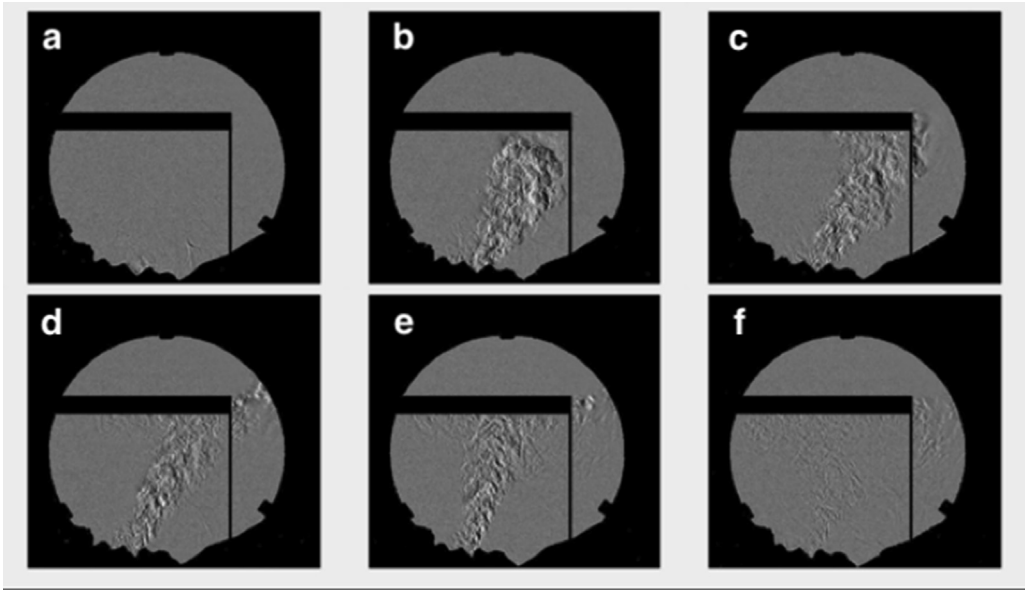

Fig. 1. Composite figure composed of stills from high-speed videography of schlieren imaging of a cough from a healthy volunteer lying on operating table with head within a barrier enclosure. (a) Still image immediately before cough with further images taken in series at (b) 5%, (c) 10%, (d) 40%, and (e) 75% of total cough duration, and (f) immediately upon cessation of air expiration as air continues to move around and out of the box.

holes on the user side during deep exhalation by the volunteer but not during coughing.

User feedback from anaesthesiologists resulted in a clear consensus that the box, even with modification, did not add advantage over our current practice. Since the onset of the pandemic in Ireland, we have performed intubation only on patients under full neuromuscular blockade such that coughing is prevented at tracheal intubation. Tracheal extubation is done slowly and carefully under a simple plastic covering placed over the patient's face. The box was considered to create new complexity around procedures that ideally should be done quickly. There was also some concern that the box would concentrate infectious material confined within the box bringing added risk at the time of glove doffing and box cleaning.

There are differences in opinion regarding the use of rigid box constructs for airway management.[7] Our analysis identified an easily implemented modification to the original design that might better protect the operating room and other staff from contamination. Although our imaging method does not measure droplet movement *per se*, it does show the air currents that carry particles. Our test method is closer to real-world conditions compared with previous methods used. The airflow dynamics associated with airway interventions (especially with infected patients and with positioning involving greater neck flexion[8]) are likely to be greater in magnitude and more variable in direction than with our healthy volunteer. Aside from rigid boxes and other solutions, there are other barrier constructs available commercially that more fully enclose the patient's head and upper torso (e.g. AerosolShield; Campbell Hill Ltd, Melksham, Wiltshire, UK). Disposable systems eliminate the need for cleaning and storage for reuse, an advantage for contagious patients. However, all designs compromise the movements of the healthcare provider such that specific training is likely necessary.[9–11]

Declarations of interest

The authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bja.2020.05.006.

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Effectiveness of a negative-pressure patient isolation hood shown using particle count

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Keywords: aerosol-generating procedure; aerosolisation; COVID-19; negative pressure; particle count; personal protective equipment

Editor—The critical shortage of medical supplies, including personal protective equipment, during the coronavirus disease 2019 (COVID-19) pandemic has compelled clinicians to look for additional ways to protect themselves from aerosolised particles during airway management. Although a few devices with a similar goal have been described,[1,2] limitations remain, including lack of containment and effective removal of aerosols and the need for sterilisation. We developed a negative-pressure patient isolation hood that is disposable to reduce sterilisation risks and is coupled to negative pressure generated by smoke evacuators to achieve coronavirus source control during aerosol-generating procedures (Supplementary video 1).

A humidifier generating supraphysiological amounts of aerosolised particles was used for testing to ensure efficacy even at extreme conditions (Supplementary Fig. 1). Most particles generated from human respiratory sources during coughing, sneezing, and talking are droplet nuclei 0.5–5.0 μm in diameter.[3] A particle counter with a size detection range of 0.3–10 μm was placed inside the hood, and a second counter was placed outside of the hood at approximately the height of the clinician's head. With continuous aerosolisation, particle counts inside the hood were more than 100-fold greater than that generated by a cough.[4] With the humidifier running continuously, the particle counter at the height of the clinician's head detected 700 (inter-quartile range: 570–800) L^{-1} aerosolised particles without the protection of a negative-pressure patient isolation hood. In contrast, the particle count was 18 (0–30) L^{-1} with the hood (Fig. 1). Particle count from inside the hood decreased by 63% when the smoke evacuator was generating 230 L min^{-1} of airflow, showing effective aerosol removal.

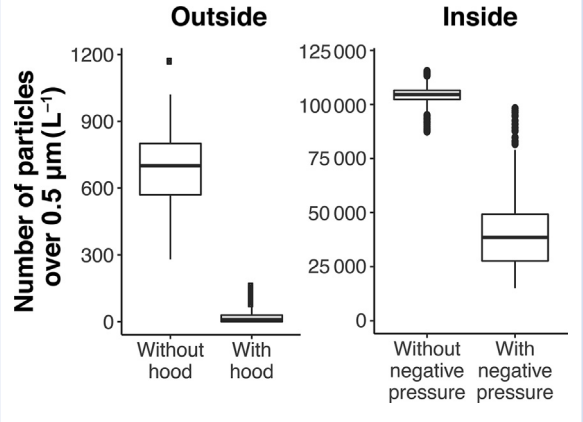

Fig 1. Particle count outside (left-side panel) and inside (right-side panel) of the negative-pressure patient isolation hood during continuous aerosol generation. The middle horizontal line represents the median; the upper and lower borders of the box represent the upper and lower quartiles. The top and bottom horizontal lines indicate the range. Dots represent values outside of the 97.5 and 2.5 quantiles.