

The qualitative evaluation of the limitation of aerosol spread by a transparent intubation box

Dear Editor,

During the current coronavirus disease of 2019 (COVID-19) pandemic personal protective equipment (PPE) and the value of able and healthy healthcare workers (HCWs) has strongly come to the fore. In support of these efforts, as many others have done, the Department of Anaesthesiology at the University of the Free State has developed a prototype transparent intubation box in collaboration with Divine Studios. Canelli et al. effectively demonstrated the protection of HCWs from droplet contamination by the use of a similar intubation box.¹ Feldman et al. also showed that despite the current PPE recommendations, HCWs are still contaminated on exposed skin and other areas, thus additional layers of protection may still be warranted.²

We did not have access to equipment that could test the efficacy of the intubation box quantitatively thus resorted to qualitative methods which included the creation of visible smoke that was also detectable by smell. As aerosol is defined as either liquid or solid particles suspended in a gas, we felt this method would be comparable. The smoke generation source was a 25 ml volume of a simple homemade mixture of five parts of potassium nitrate, four parts of refined sugar and one part of sodium bicarbonate. This mixture was combined with melted oil crayons to increase visibility.³ This mixture has not been quantitatively evaluated for aerosol particle size, but previous studies have shown that monodisperse sucrose aerosols can be generated with particle diameters from 20–100 nm as a vapour and studies on cigarette smoke have shown particle size dispersions (PSDs) of 140–185 nm (which often contain anhydrous sugars).⁴ Aerosol PSD is determined by many factors, chief of which being airflow velocity.⁵ Common respiratory aerosols range from below 1 µm to 2 µm in some fungi and the COVID-19 pathogen has a PSD of 60–140 nm and we concluded that our smoke generation source would be an adequate comparison as a result.^{6,7} These smoke generation sources were first tested outside to evaluate for flame size, smoke volume and tolerability. After gaining approval by our head of department, we proceeded to use them to test the aerosol limitation capabilities of the intubation box.

The allocated COVID-19 theatre at Universitas Academic Hospital was used (as there were no patients booked on that list for the day and we wanted to simulate actual air flows in a working theatre). Prior to the testing we also acquired the permission of the theatre operational manager and asked that all piped gas flows to that theatre be arrested. The correct fire extinguishers were available as backup, but as the ignition of the smoke generation sources produced minimal open flame, we did not deem it a high risk for propagation of fire. The smoke generation sources were contained in tin cans and placed on a cold

15 mm thick granite slab to prevent conduction of the heat to the theatre beds.

Our intubation box was a simple 500 mm x 500 mm x 500 mm design with two 150 mm diameter arm holes at the cranial end for the intubator, a simple arm hole at the side of identical size with a 15 mm aperture below the arm hole on the side for suction tubing placement. The suction tubing was placed through the smaller aperture with an HME filter connected to the tubing on the inside of the box. The intubation box was evaluated in four steps. The first step was with a transparent plastic cover in place and theatre suction apparatus connected to an HME filter. The suction apparatus was set to maximum and registered 30 cm H₂O on the Bourdon gauge. As the filter could be a point of resistance, we attached another Bourdon gauge distal to the filter in series with the suction apparatus to measure suction strength after the filter and this gauge registered 10 cm H₂O negative pressure. After 27 minutes 40 seconds the visual field in the intubation box became clear again. No smoke could be visualised escaping the box by two video cameras placed at adjacent walls monitoring the box continuously. The smoke could, however, be detected by smell, thus indicating minimal seepage of the aerosol.

This setup was repeated without suction in a second step. After thirty minutes no visible aerosol leak could be detected, but the visual field inside the box did not clear. Our third step included placing plastic arm sleeves through the plastic drape to mimic continuous access to the patient, as a seal with plastic covering will not realistically be maintained throughout a surgical procedure. At this time minimal smoke could be visualised escaping through the sleeves, but with negative pressure suction in place, the box's visual field cleared by 27 minutes again. The fourth step was a control measure, whereby we did not use the intubation box at all. The smoke filled the theatre and was still visible in theatre after 30 minutes, despite the usual negative pressure environment in that theatre.

In conclusion, we found that an intubation box effectively limits aerosol spread qualitatively. In contrast to the findings of Cubillos et al., we could not conclusively state that an intubation box with negative pressure suction and transparent plastic covering prevents the escape of aerosol, especially when the internal volume is accessed through arm holes.⁸ More high quality quantitative research is required on these boxes, but with HCWs still at high risk for infection and with the fallibility of recommended PPE practices, other avenues to protect HCWs need to be explored. The level to which a covered or uncovered intubation box impedes visualisation of the airway/performance of intubation is also an area of concern and provides room for future study.

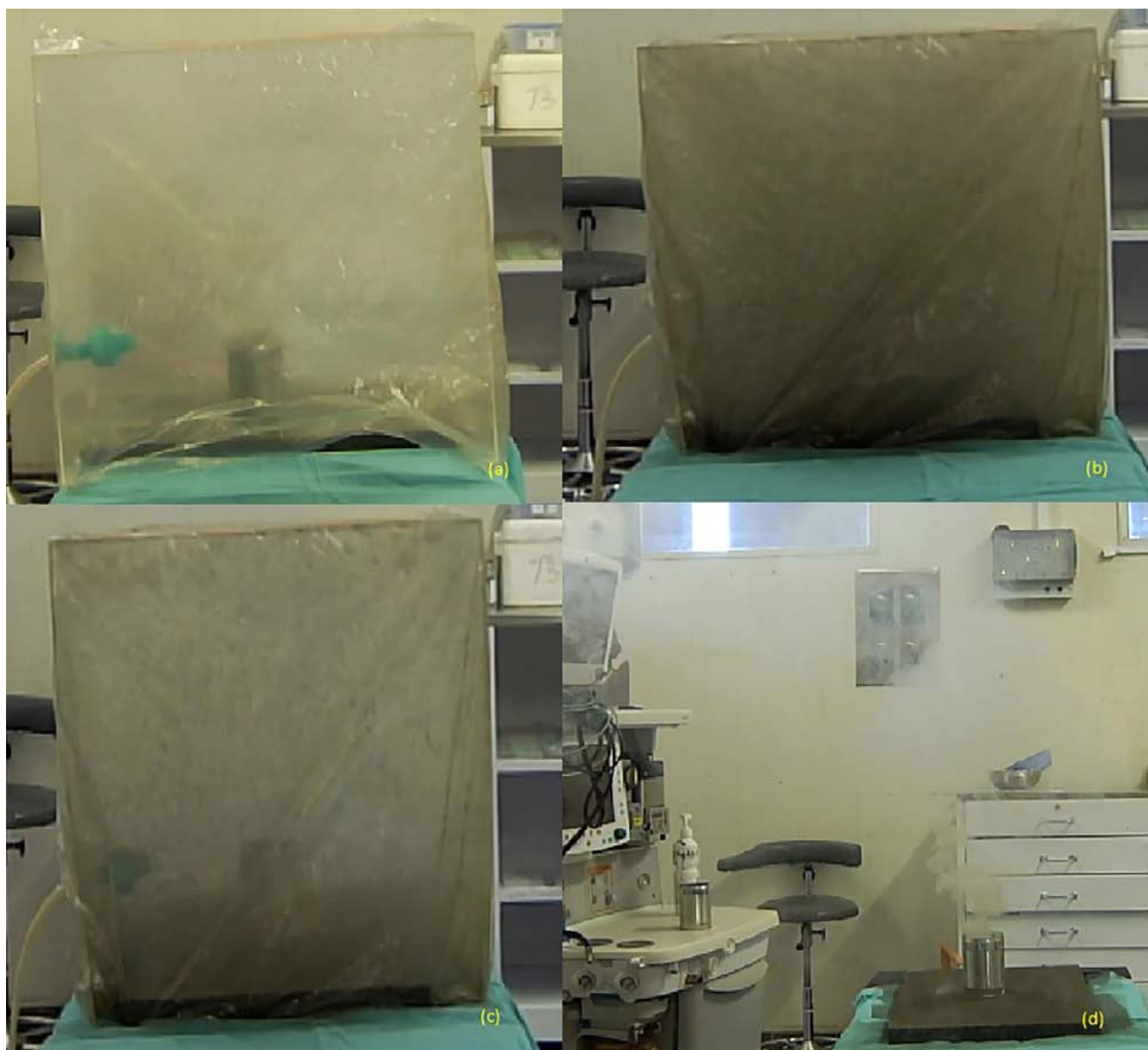


Figure 1: The maximal clarity of the box and drape can be seen in (a) and after 2 minutes the contents of the box become obstructed by aerosol (b) and remain so without suction. After 27 minutes and 40 seconds the contents can be visualised again with the aerosol largely eliminated (c). Without the use of an intubation box, the aerosol can be seen to contaminate the anaesthetic workstation (d).

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Conflict of interest

The authors have no conflict of interest and the requirements for submission, including permission from the head of department, have been fulfilled.

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