Optical gas imaging of carbon dioxide at tracheal extubation: a novel technique for visualising exhaled breath

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Editor—There is strong evidence that the dominant route of spread of severe acute respiratory syndrome-related coronavirus-2 (SARS-CoV-2) is the airborne route and that the disease can be spread by both presymptomatic, symptomatic, and asymptomatic people.[1,2] The virus is carried in particles of various sizes that can travel considerable distances and remain suspended in the air.[3] Viral particles are released by all expiratory events (coughing, talking, and exhalation) and do not require an aerosol-generating procedure to be detectable in the local environment.[3,4]

In the setting of extubation of the trachea, neither the distribution of exhaled gases nor the capacity of these gases to carry virus in the peri-extubation period has been fully quantified. As a consequence of the assumed risk of disease transmission to healthcare workers present at extubation, there have been a multitude of barrier techniques proposed to reduce risk at this time, but the overwhelming majority have not been subject to any objective testing.[5] In the small number of studies where testing has occurred, the main focus was on intubation, not extubation, and static measurements of dye deposition (representative of large droplets) in simulated settings were used.[6] This methodology does not lend itself to assessment of environmental dispersal of smaller particles. Particle counting technology identifies aerosol in predetermined fixed loci and may miss less intuitive areas of exhalation (Fig. 1).

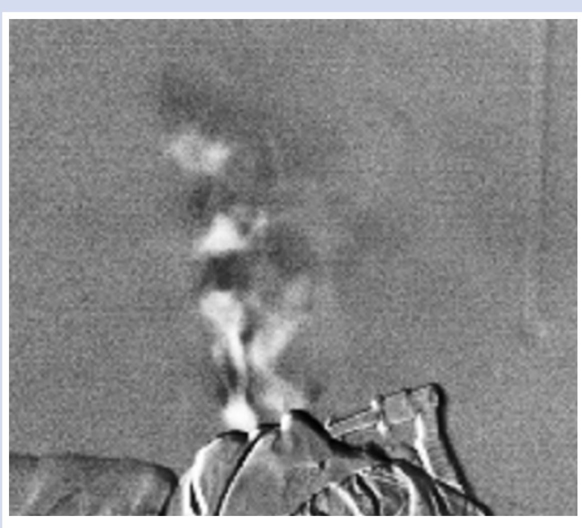

Fig 1. CO_2 optical gas imaging—exhalation around deflated cuff.

This study was performed to improve knowledge of the patterns of distribution of exhalation at the time of extubation which is considered an aerosol-generating procedure and therefore a potential risk to healthcare workers.[7] Knowledge regarding distribution of exhalation and the effect of barrier technologies may inform policies and procedures and reduce risk. The intended focus of the study is the perioperative period as opposed to the ICU. Although viral loads in the lung parenchyma and pharynx are higher in symptomatic individuals, the disease can be transmitted by those who are presymptomatic and asymptomatic.[8,9] This is of relevance to coronavirus disease 2019 (COVID-19) patients having intercurrent surgery and because screening tests used to risk stratify those coming for elective surgery are known to have false negative results.[10]

Optical gas imaging delivers real-time visualisation of exhaled breath air currents via a thermal camera designed for detection of carbon dioxide (CO_2) (Flir GF343, FLIR Systems Inc., Wilsonville, OR, USA). We report qualitative CO_2 optical gas imaging from a series of three SARS-CoV-2-negative subjects undergoing extubation in an operating theatre environment and subsequent breathing with a surgical facemask. Institutional ethical approval was obtained. All subjects were ASA physical status 1 or 2, and written informed consent was obtained before the observations.

In Sequence 1 (online video), extubation was performed without use of plastic covering. Exhalation around a deflated tracheal tube cuff led to a significant plume of unfiltered exhaled gases anteriorly to a distance of ~100 cm. Correct post-extubation positioning of an anaesthetic mask effectively inhibited exhaled air currents from anterior projection from the patient's mouth (Sequence 2, online video). A simple plastic sheeting in place over the subject's face was also sufficient to redirect exhaled breath away from the anaesthesiologist's face as seen in Sequences 2 and 3 (online videos). However, after placement of a paper surgical facemask after extubation, exhaled breath was redirected superiorly over the forehead of the patient in the direction of the attending anaesthesiologist, to face height (Sequence 4, online video). Minimal anterior displacement of exhaled air through the facemask was noted after surgical facemask placement (Sequences 2 and 4, online videos).

In view of these findings which show that the extubator remains closely exposed to unfiltered exhalation at the time of tracheal extubation and that a surgical facemask can divert flow towards the extubator, it is clear that wearing of appropriate personal protective equipment remains imperative. Whether this redirection allows for complete filtration of exhaled aerosol to the facemask material warrants further study. Deploying this imaging technology for evaluation of other airway techniques with potential for extensive droplet dispersal is warranted.

Declarations of interest

DB is a board member of the *British Journal of Anaesthesia*. The other 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.2020.11.016.

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