- A discussion on the thought process of choosing appropriate PPE for different clinical scenarios.
- OR or ward preparation with focus on infection prevention and control measures.
- Checking and donning of PAPR.
- Conduct of GA in OR or urgent intubation in the general ward.
- Capabilities to counter drawbacks of PAPR use:
  - o Safe doffing and decontamination of PAPR.
  - o PAPR failure drill.

Thought processes and step-by-step instructions are detailed in Fig 1, which includes practical pointers to achieve maximal protection. Figure 1 is tailored to the use of Jupiter™ PAPR in the OR, but the same principles can be applied to the use of any PAPR in a variety of clinical settings.

Training—team level

To validate and improve our processes, a multidisciplinary OR drill was organised for an elective tracheostomy, which is a high-risk AGP requiring robust infection prevention and control measures for staff protection. Participants' proficiency in PAPR use was supervised and evaluated by our infection prevention and control team. An inter-professional debrief was conducted to refine our processes further. For example, we observed that our standard isolation gown with back ties may inadvertently expose one's back and risk contamination of the PAPR; hence the wrap-around surgical gown is now recommended when a PAPR is used.

Training—hospital level

Workflow for use of PAPR in an EAMR and for emergency OR cases was tested in the broader context of a hospital-level drill, where a manikin-simulated COVID-19 patient was intubated in the general ward and subsequently transferred for scans and procedures. This drill led to further improvements to the EAMR logistical support by providing a trained OR nurse to bring the Jupiter™ PAPR to the anaesthetist at the EAMR location, assist in safe donning and doffing, and set up of a doffing area.

With rigorous infection prevention and control measures and PAPR training, we managed to keep patient-to-doctor transmission at 0% from January to March 2020, while providing seamless care for the majority of COVID-19 patients in Singapore.

Declarations of interests

The authors declare that they have no conflicts of interest.

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Reducing droplet spread during airway manipulation: lessons from the COVID-19 pandemic in Singapore

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Keywords: airway management; COVID-19; extubation; infection control; intubation; operating room; prevention

Editor—Coronavirus disease 2019 (COVID-19) was declared a pandemic by the World Health Organization[1] on March 11, 2020 because of its rapid worldwide spread. In the operating theatre (OT), anaesthetists are taking precautions for every patient to minimise perioperative viral transmission as infected patients can be asymptomatic.[2] Airway manipulation poses a high risk of viral transmission to humans within close contact because of the proximity of the respiratory secretions that can aerosolise from coughing and gagging.[3] Supplementary Fig 1 from Chan and colleagues[4] shows the dispersion of respiratory particles: the dispersion distance of exhaled air can range from 42 to 99 mm, and from coughing bouts after intubation up to 460 mm.

The Singapore General Hospital instituted guidelines for airborne and contact precautions, including (i) environmental, reducing staff during airway manipulation, regular disinfection and sterilisation, sufficient air exchange time; and (ii) personal protective equipment (PPE). We identified a potential

shortcoming in that none of these measures reduced the production and spread of respiratory secretions, which contain the bulk of the viral burden. Decontamination of the OT depends on adequate cleaning of OT equipment and reduction of viral load by high-frequency air changes. There is a long period between intubation and extubation, in which respiratory droplets remain on surfaces before cleaning. We describe some practical innovations that anaesthetists can consider integrating into their workflow. These innovations are not meant to replace PPE, but aim to reduce the cumulative risk of perioperative viral transmission to all the personnel in the OT. In countries where doctors are advised to reuse PPE because of shortages, these may afford an extra degree of protection.

Plastic tent or screen for intubation

Supplementary Figs 2 and 3 were taken from a simulation run for proof of concept. All volunteers gave their consent. The appropriate PPE for intubation was not worn in this simulation to conserve supplies.

The main aim of constructing a tent or screen is that, if the patient coughs/gags during intubation, secretions will land under the sheet. Making the tent involves combining two transparent plastic bags into a single bag large enough to be draped over the patient's head to chest. Two drip stands are used to hold the tent up. A videolaryngoscope and tracheal tube can be passed under the plastic tent for intubation. The C-MAC® (KARL STORZ Endoscopy (UK) Ltd) videolaryngoscope is shown because it has an external screen outside the tent that would provide a clear laryngoscopy view. The tent is disposed and the drip stands wiped down.

Alternatively, Supplementary Fig 4 shows the use of a large plastic screen for intubation. The same plastic sheet is draped over the patient's head and chest after inducing unconsciousness, and taped down at the sides to minimise leak. Intubation is performed with the aid of the McGRATH™ (Medtronic, USA) videolaryngoscope because of ease of cleaning compared with the C-MAC®. The plastic sheet can be left in the same position for the duration of the operation. If the patient needs to be in a lateral or beach chair position, the sheet is shifted correspondingly over the face.

The advantage of the tent is its low cost, easy availability, and disposability. It allows room for manoeuvring the tube and is tall enough to allow a bougie in. The length of the tent is sufficient to fall past the patient's pillow so that there is no contact between the intubating personnel and the patient. This protective tent can be modified for use in ICUs during suctioning, bronchoscopy, and other aerosol-generating procedures. The screen is similar to the tent and provides a tighter seal. We suggest leaving adequate holes at the sides and the head end for the airway team to access the patient.

There are reports of using acrylic boxes with preformed armholes for intubation.[5,6] However, that requires time and cost for manufacturing and delivery before it is available. The armholes, being of fixed shape and size, limit dexterity in manipulating the tracheal tube, especially in difficult airways. The bottom panel of the box is left open, which runs the risk of the assistant standing there being exposed to aerosolised respiratory secretions.

Plastic screen for extubation

Supplementary Fig 5 shows use of a plastic screen for extubation. A small hole is cut distally to allow the ventilator tubing to pass through. If the patient coughs, secretions will land on the plastic sheet. A potential window of infection exists when the tracheal tube is removed with secretions at the cuff before it is thrown into the bin. We suggest for the tracheal tube to be wrapped with a plastic bag and immediately disposed.

Hudson mask for extubation

Supplementary Fig 6 shows the two holes at the sides of a Hudson mask (Teleflex, USA) being taped up using a transparent dressing. The Hudson mask is placed over the patient's face following intubation, and the tracheal tube passes under the Hudson mask. At extubation, the Hudson mask is connected to oxygen, and a suction catheter is passed under the Hudson mask into the patient's mouth. Once the patient is ready for extubation, the tracheal tube and the suction catheter are removed from under the mask and discarded immediately. Should the patient cough post-extubation, secretions are contained within the mask. The patient can then be transferred out of the OT with the Hudson mask for oxygen supplementation.

In summary, these low-cost, accessible, and disposable methods can reduce contamination by respiratory secretions at the source. They may add another layer of protection from perioperative viral transmission during outbreaks of highly infectious diseases, such as COVID-19, especially in the context of acute shortages of PPE.

Authors' contributions

Study design: both authors
Drafting of article: PSAY
Reviewing of article: both authors

Declarations of interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bja.2020.04.007.

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Reducing droplet spread during airway manipulation. Reply to Au Yong and colleagues (*Br J Anaesth* 2020; 125: e176–e178)

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Keywords: aerosolisation; airway management; COVID-19; infection prevention; tracheal intubation

Editor—The coronavirus 2019 (COVID-19) pandemic has sparked innovation in infection control, drawing focus to the management of aerosol-generating procedures for the anaesthetist.[1] We read with interest Yong and colleagues'[2] use of a plastic tent or sheet to reduce droplet spread during airway manipulation. The authors state that the main aim of a plastic tent or sheet is related to the patient coughing or gagging on intubation, and therefore possible viral spread. All recent COVID-19 guidelines recommend rapid sequence induction and intubation for securing the airway.[3–6] If a patient is fully paralysed, the patient will not cough or gag; to do so would reflect poor anaesthetic technique.

The tent method also has various limitations. The tent creates a reservoir of droplets. With the raised poles supporting the structure, the process of dismounting and disposal of the plastic sheet may risk contamination and viral transmission. It may not be applicable for children and patients who are anxious or claustrophobic. They mention that the tent is tall enough to allow a bougie in. If the initial laryngoscopy with a stylet-loaded tracheal tube fails, then switching to the use of a bougie may entail lifting up of the tent cover which may cause air currents that spread viral aerosol. The plastic sheet method (taped down at the sides) also compounds airway management by limiting the space available to both the intubator and assistant. Any barrier, whether a plastic sheet or one of the many intubating boxes proposed, may interfere with crisis management such as difficult intubation, crash Caesarean section, cardiopulmonary resuscitation, etc. The authors have also not provided any evidence that their technique minimises contamination, as presented by other authors including using fluorescent resin powder viewed under ultraviolet light during simulated aerosol production.[7]

We do not recommend leaving the plastic sheet *in situ* for the entire duration of the operation because of the risk of viral transmission via fomites. The plastic sheet can be easily and safely disposed of by simply folding down, keeping the contaminated surfaces opposed, into a smaller size, rolling into a bundle, or both. It should be discarded immediately after intubation as per local infection control measures.

Emergence and extubation should be undertaken with great caution because of the risk of coughing and of aerosolisation. The authors' plastic sheet technique is intended to protect the operator, but it fails to prevent patient and work surface contamination including the patient's chest and overlying gown or surgical drapes. The use of a three-layered plastic drape configuration by Matava and colleages[7] during a simulated cough is more successful in this respect. The authors also use a small hole cut into the plastic sheet to allow passage of the tracheal tube and breathing circuit tubing. However, the hole remains open, allowing virus transmission. Patino Montoya and colleagues[8] proposed taping and sealing the hole to the tracheal tube. At extubation, both the tube and plastic sheet can be lifted away as a unit and discarded. However, other

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