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Guidelines

Consensus guidelines for managing the airway in patients with COVID-19

Guidelines from the Difficult Airway Society, the Association of Anaesthetists the Intensive Care Society, the Faculty of Intensive Care Medicine and the Royal College of Anaesthetists

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Summary

Severe acute respiratory syndrome-corona virus-2, which causes coronavirus disease 2019 (COVID-19), is highly contagious. Airway management of patients with COVID-19 is high risk to staff and patients. We aimed to develop principles for airway management of patients with COVID-19 to encourage safe, accurate and swift performance. This consensus statement has been brought together at short notice to advise on airway management for patients with COVID-19, drawing on published literature and immediately available information from clinicians and experts. Recommendations on the prevention of contamination of healthcare workers, the choice of staff involved in airway management, the training required and the selection of equipment are discussed. The fundamental principles of airway management in these settings are described for: emergency tracheal intubation; predicted or unexpected difficult tracheal intubation; cardiac arrest; anaesthetic care; and tracheal extubation. We provide figures to support clinicians in safe airway management of patients with COVID-19. The advice in this document is designed to be adapted in line with local workplace policies.

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Introduction

This consensus statement has been brought together at short notice to advise on airway management for patients with coronavirus disease 2019 (COVID-19). It applies to all those who manage the airway ('airway managers'). It draws on several sources including relevant literature but more immediately from information from clinicians practicing in China, Italy and airway experts in the UK. It is probably incomplete but aims to provide an overview of principles. It does not aim to propose or promote individual devices. The advice in this document is designed to be adapted in line with local workplace policies. This document does not discuss when to intubate patients, the ethics of complex decision-making around escalation of care or indemnity for staff necessarily working outside their normal areas of expertise. It does not discuss treatment of COVID-19 nor intensive care ventilatory strategies but rather it focuses on airway management in patients with COVID-19.

The one-page summary (Fig. 1) may be useful as a stand-alone resource, and the principles of safe, accurate and swift management must always be considered (Fig. 2). The full paper is likely to be of greater value as a reference when planning local services. The advice is based on available evidence and consensus at the time of writing, in what is a fast-moving arena. Some references refer to English or UK governmental sites for up-to-date advice. Those practicing in other countries should be aware that advice in their country may differ and is regularly updated, so they should also refer to their own national guidance.

COVID-19: the need for airway interventions and risks to airway managers

Severe acute respiratory syndrome-corona virus-2 (SARS-CoV-2), which causes COVID-19, is a single-stranded ribonucleic acid -encapsulated corona virus and is highly contagious. Transmission is thought to be predominantly by droplet spread (i.e. relatively large particles that settle from the air), and direct contact with the patient or contaminated surfaces (fomites), rather than airborne spread, in which smaller particles remain in the air longer [1, 2]. Procedures during initial airway management and in the intensive care unit (ICU) may generate aerosols which will increase risk of transmission [1]. Healthcare workers (HCW) treating patients with COVID-19 are at increased risk of contracting the illness [3–6].

The predominant COVID-19 illness is a viral pneumonia. Airway interventions are mainly required for tracheal intubation and establishing controlled ventilation. However, as the epidemic increases, there will be many

patients in the community with COVID-19 who are asymptomatic or have mild disease. These patients may present for emergency surgery for unrelated conditions.

Staff safety

The highest viral load of SARS-CoV-2 appears in the sputum and upper airway secretions [1]. Tracheal intubation is a potentially high-risk procedure for the airway manager, particularly as it risks exposure to a high viral load and if transmission occurs to HCWs, this may be associated with more severe illness [4]. For this reason, airway managers should take appropriate precautions.

This is clearly an area of great importance [7]. Whereas this article focuses predominantly on management of the airway, staff protection is too important not to include. We discuss in brief: aerosol-generating procedures and personal protective equipment are only one part of a system to reduce viral exposure. There is extensive advice which is updated regularly on infection prevention and control related to COVID-19 [8].

Aerosol-generating procedures

Severe acute respiratory syndrome-corona virus-2 is spread by inhalation of infected matter containing live virus (which can travel up to 2 m) or by exposure from contaminated surfaces. Aerosol-generating procedures create an increased risk of transmission of infection.

A systematic review of infection risk to HCWs [9], based on limited literature, ranked airway procedures in descending order of risk as: (1), tracheal intubation; (2), tracheostomy (and presumed for emergency front-of-neck airway (FONA)); (3), non-invasive ventilation (NIV); and (4), mask ventilation. Other potentially aerosol-generating procedures include: disconnection of ventilatory circuits during use; tracheal extubation; cardiopulmonary resuscitation (before tracheal intubation); bronchoscopy; and tracheal suction without a 'closed in-line system.' Transmission of infection is also likely to be possible from faeces and blood although detection of virus in the blood is relatively infrequent [1].

High-flow and low-flow nasal oxygen

There is much debate about the degree to which high-flow nasal oxygen is aerosol-generating and the associated risk of pathogen transmission [10]. Older machines may expose staff to greater risk. The risk of bacterial transmission has been assessed as low [11], but the risk of viral spread has not been studied. There are other reasons not to use high-flow nasal oxygen in a situation of mass illness and mass mechanical ventilation. First, it may simply delay tracheal

A SUMMARY FOR EMERGENCY TRACHEAL INTUBATION OF THE ADULT COVID-19 PATIENT

- Tracheal intubation of the patient with COVID-19 is a high-risk procedure for staff, irrespective of the clinical severity of disease.
- In severe COVID-19 it is also a high-risk procedure for the patient.
- Limit staff present at tracheal intubation: one intubator; one assistant; and one to administer drugs and monitor the patient. A runner should be outside the room.
- Create a COVID-19 tracheal intubation trolley or pack that can be used in ICU or elsewhere.
- Wear full personal protective equipment (PPE) at all times. Consider double gloving. Defog goggles and/or eye wear if possible. Touch as little as possible in the room to avoid fomites.
- Intubate in a negative pressure room with > 12 air changes per hour whenever possible.
- Know and communicate the plan before entering the room; use a checklist to achieve this.
- Take the algorithm or cognitive aid you plan to use into the room or display it there.
- Prepare airway equipment and drugs outside the room as much as possible. Use a kit dump mat if available.
- Plan how to communicate before entering the room.
- The best skilled airway manager present should manage the airway to maximise first-pass success.
- Be safe, accurate and swift. Aim to succeed at the first attempt because multiple attempts increase risk to sick patients and staff. Do not rush but make each attempt the best it can be.
- Use reliable techniques that work, including when difficulty is encountered. The chosen technique may differ according to local practices and equipment. With prior training and availability this is likely to include:
 - Pre-oxygenation with a well-fitting mask and a Mapleson C ('Waters') or anaesthetic circuit, for 3–5 minutes.
 - Videolaryngoscopy for tracheal intubation;
 - 2-person, 2-handed mask ventilation with a VE-grip to improve seal;
 - A second generation supraglottic airway device for airway rescue, also to improve seal.
- Place a HME filter between the catheter mount and the circuit at all times. Keep it dry to avoid blocking.
- Avoid aerosol-generating procedures, including high-flow nasal oxygen, non-invasive ventilation, bronchoscopy and tracheal suction without an in-line suction system in place.
- Establish full monitoring: including continuous waveform capnography before, during and after tracheal intubation.
- Use RSI with cricoid force where a trained assistant can apply it. Take it off if it causes difficulty.
- To avoid cardiovascular collapse consider ketamine 1–2 mg.kg⁻¹
- Paralyse early with rocuronium 1.2 mg.kg⁻¹ or suxamethonium 1.5 mg.kg⁻¹. Ensure full neuromuscular blockade before attempting tracheal intubation
- Have a vasopressor for bolus or infusion immediately available for managing hypotension.
- Do not face mask ventilate unless needed, and use a 2-person, low flow, low pressure technique if needed.
- Intubate with a 7.0–8.0 mm ID (women) or 8.0–9.0 mm ID (men) tracheal tube with a subglottic suction port.
- Pass the cuff 1–2 cm below the cords to avoid bronchial placement. Confirming position is difficult wearing PPE.
- Inflate the tracheal tube cuff to seal the airway before starting ventilation. Note and record depth.
- Confirm tracheal intubation with continuous waveform capnography – which is present even during cardiac arrest.
- Avoid circuit disconnection - push twist all connections.
- Clamp tube and pause ventilator for airway manoeuvres or disconnections.
- Use a standard failed tracheal intubation algorithm with a cognitive aid if difficulty arises.
- Communicate clearly: simple instructions; closed-loop communication (repeat instructions back); adequate volume without shouting.
- Place a nasogastric tube after tracheal intubation is completed and ventilation established safely.
- If COVID-19 status not already confirmed take a deep tracheal aspirate for virology using closed suction.
- Discard disposable equipment safely after use. Decontaminate reusable equipment fully and according to manufacturer's instructions.
- After leaving the room ensure doffing of PPE is meticulous.
- Clean the room 20 minutes after tracheal intubation (or last aerosol-generating procedure).
- A visual record of ease of tracheal intubation should be prominently visible in the patient's room.
- If airway difficulty occurs the subsequent plan should be displayed in the room and communicated between shifts.

Figure 1 One-page summary for emergency tracheal intubation of the coronavirus disease 2019 patient.

COVID-19 airway management: SAS	
Safe	for staff and patient
Accurate	avoiding unreliable, unfamiliar, or repeated techniques
Swift	timely, without rush or delay

Figure 2 Principles of coronavirus disease 2019 airway management.

intubation in those for whom treatment escalation is appropriate [12]. Second, the very high oxygen usage risks depleting oxygen stores, which is a risk as a hospital's oxygen usage may increase many-fold during an epidemic. For all these reasons, high-flow nasal oxygen is not currently recommended for these patients around the time of tracheal intubation.

Low-flow nasal oxygen (i.e. $< 5 \text{ l}\cdot\text{min}^{-1}$ via normal nasal cannula) may provide some oxygenation during apnoea and might therefore delay or reduce the extent of hypoxaemia during tracheal intubation. There is no evidence we are aware of regarding its ability to generate viral aerosols, but on balance of likelihood, considering the evidence with high-flow nasal oxygen, this appears unlikely. It is neither recommended nor recommended against during emergency tracheal intubation of patients who are likely to have a short safe apnoea time. In patients who are not hypoxaemic, without risk factors for a short safe apnoea time, and who are predicted to be easy to intubate, it is not recommended.

Systems to prevent contamination of healthcare workers, including personal protective equipment

Personal protective equipment (PPE) forms only one part of a system to prevent contamination and infection of HCWs during patient care. In addition to PPE, procedures such as decontamination of surfaces and equipment, minimising unnecessary patient and surface contact and careful waste management are essential for risk reduction. The virus can remain viable in the air for a prolonged period and on non-absorbent surfaces for many hours or even days [2]. The

importance of cleaning, equipment decontamination and correct use of PPE use cannot be overstated. In the SARS epidemic, which was also caused by a corona virus, HCW were at very high risk for infection, but reliable use of PPE significantly reduced this risk [13, 14].

Personal protective equipment is not discussed here in detail. General principles are that it should be simple to remove after use without contaminating the user and complex systems should be avoided. It should cover the whole upper body. It should be disposable whenever possible. It should be disposed of appropriately, immediately after removal ('doffing'). A 'buddy system' (observer), including checklists, is recommended to ensure donning and doffing is performed correctly. Personal protective equipment should be used when managing all COVID-19 patients. Airborne precaution PPE is the minimal appropriate for all airway management of patients with known COVID-19 or those being managed as if they are infected. The Intensive Care Society has made a statement on PPE, describing minimal requirements and noting that PPE needs to be safe, sufficient and used in a manner that ensures supplies are sustainable [15].

It has been suggested that double-gloving for tracheal intubation might provide extra protection and minimise spread by fomite contamination of equipment and surrounds [16]. Fogging of goggles and/or eyewear when using PPE is a practical problem for tracheal intubation in up to 80% of cases (personal communication Huafeng Wei, USA); anti-fog measures and iodophor or liquid soap may improve this. Training and practising PPE use before patient management is essential for staff and patient safety.

Ideally, patients are managed in single, negative pressure rooms with good rates of air exchange (> 12 exchanges per hour) to minimise risk of airborne exposure [17]. In reality, many ICU side rooms do not meet this standard and, when critical care is expanded to areas outside of ICU, airway management may take place in rooms with positive pressure (e.g. operating theatres) or those with reduced air exchanges. Most operating theatres are positive pressure with high rates of air exchange. These factors may have implications for transmission risk, retention of aerosols and therefore what constitutes appropriate PPE [18]. Guidance on PPE requirements after tracheal intubation is beyond the scope of this document [8].

Tracheal intubation of the critically ill

This is a high-risk procedure with physiological difficulty: around 10% of patients in this setting develop severe hypoxaemia ($S_pO_2 < 80\%$) and approximately 2% experience cardiac arrest [19, 20]. These figures are likely to

be higher for patients with severe COVID-19 and drive some of the principles below. The first-pass success rate of tracheal intubation in the critically ill is often < 80% with up to 20% of tracheal intubations taking > two attempts [19]. The increased risk of HCW infection during multiple airway manipulations necessitates the use of airway techniques which are reliable and maximise first-time success. This applies equally to rescue techniques if tracheal intubation fails at first attempt.

Delivering care in non-standard environments and by or with staff less trained in critical care

It is likely that management in expanded critical care services will involve working in areas other than standard critical care units. This creates logistical difficulty in airway management.

Monitoring should adhere to Association of Anaesthetists standards and in particular, continuous waveform capnography should be used for every tracheal intubation and in all patients dependent on mechanical ventilation unless this is impossible. Note that even in cardiac arrest during lung ventilation there will be a capnograph trace – a flat trace indicates and should be managed as oesophageal intubation until proven otherwise ('no trace = wrong place')[21, 22].

Caring for COVID-19 patients may also involve recruitment of staff to the critical care team who do not normally work in that setting and have received emergency training to enable them to deliver care alongside fully trained staff. In severe escalation, even these standards might become difficult to maintain. The Chief Medical Officer has written to all UK doctors to explain regulatory support for this [23]. At its extreme peak, care may also be delivered by retired staff and medical students. Due to the high consequence nature of airway management in these patients, both for the patient and staff, it is recommended that these staff do not routinely take part in airway management of COVID-19 patients.

In some circumstances, the development of a specific tracheal intubation team may be an appropriate solution where case load is sufficient.

The most appropriate airway manager

We recommend that the 'most appropriate' clinician manages the airway. This is to enable successful airway management that is safe, accurate and swift. Deciding who is the most appropriate airway manager requires consideration of factors such as the available clinicians' airway experience and expertise, whether they fall into any of the groups of

clinicians who would be wise to avoid tracheal intubation, the predicted difficulty of airway management, its urgency and whether a tracheal intubation team is available. On occasion, this may necessitate senior anaesthetists managing airways in lieu of junior anaesthetists or intensivists who do not have an anaesthesia background. However, it is unlikely and unnecessary that tracheal intubation will be the exclusive preserve of one specialty. Judgement will be required.

Staff who should avoid involvement in airway management

This is a problematic area and there is no national guidance. In some locations, healthcare providers are excluding staff who are themselves considered high risk. Current evidence would include in this group: older staff (the mortality curve rises significantly > 60 years of age); cardiac disease; chronic respiratory disease; diabetes; recent cancer; and perhaps hypertension [4, 6]. Whereas no clear evidence exists, it is logical to also not include staff who are immunosuppressed or pregnant from airway management of COVID-19 patients.

Simulation

Due to the uncertainties inherent in the new processes to be adopted, we recommend regular and full in-situ simulation of planned processes, to facilitate familiarity and identification of otherwise unidentified problems, before these processes are used in urgent and emergent patient care situations.

Single vs. reusable equipment

Where practical, single-use equipment should be used [24]. However, where single-use equipment is not of the same quality as re-usable equipment this creates a conflict. It is also possible that supplies of single-use equipment may run short. The balance of risk to patients and staff (frontline and those involved in transport and decontamination of equipment) should be considered if a decision is made to use reusable airway equipment. We recommend use of the equipment most likely to be successful, while balancing the above factors. Reusable equipment will need appropriate decontamination. It is important to precisely follow manufacturer's instructions for decontamination of reusable equipment.

When to intubate the critically ill COVID-19 patient

This document does not consider when patients' tracheas should be intubated. However, in order to avoid aerosol-generating procedures, it is likely that patients' tracheas

may be intubated earlier in the course of their illness than in other settings.

Fundamentals of airway management for a patient with suspected or confirmed COVID-19

Airway management for patients who are suspected or confirmed to have COVID-19 follows similar principles in both emergency and non-emergency settings (Fig. 1).

1 Prepare.

- a Institutional preparation (equipment for routine management and for managing difficulty; adequate numbers of appropriately trained staff; availability of tracheal intubation checklists; PPE etc.) should be in place well before airway management occurs. If this does not already exist, it is strongly recommended it is put in place urgently. Resources from this guideline may form part of that preparation.
- b Team and individual preparation require knowledge of the institutional preparation, the skills required, how to use PPE correctly and assessment of the patient’s airway to predict difficulty and prepare the airway strategy (Fig. 3). It is accepted that MACOCHA (Malampatti, obstructive sleep apnoea, c-spine movement, mouth opening, coma, hypoxaemia, non-anaesthetist intubator [25]) is not widely used but it is validated and recommended.

2 Create a COVID-19 tracheal intubation trolley or pack. Critically ill patients may need to be intubated in a location other than ICU. On ICU, tracheal intubation will likely take place in single rooms. Prepare a tracheal intubation trolley or pack that can be taken to the patient and decontaminated after use. The Supporting Information (Appendix S1) in the online supplementary material illustrates and provides some guidance on its contents.

3 Have a strategy. The airway strategy (the primary plan and the rescue plans, and when they are transitioned

to) should be in place and the airway team briefed before any part of airway management takes place.

4 Involve the smallest number of staff necessary.

This is not an argument for solo operators but staff who have no direct role in the airway procedure should not unnecessarily be in the room where airway management is taking pace. Three individuals are likely required: an intubator; an assistant; and a third person to give drugs and watch monitors. A runner should be watching from outside and be able to summon help rapidly if needed (Fig. 4).

5 Wear appropriate, checked PPE (see above).

Even in an emergency and including cardiac arrest, PPE should be in worn and checked before all airway management and staff should not expose themselves to risk in any circumstance.

6 Avoid aerosol-generating procedures wherever possible.

If a suitable alternative is available, use it. If aerosol generation takes place, the room is considered contaminated, airborne precaution PPE should be used and the room should be deep cleaned after 20 min [24].

7 Focus on promptness and reliability.

The aim is to achieve airway management successfully at the first attempt. Do not rush but make each attempt the best it can be. Multiple attempts are likely to increase risk to multiple staff and to patients.

8 Use techniques that are known to work reliably across a range of patients, including when difficulty is encountered.

The actual technique may differ according to local practices and equipment. Where training and availability is in place this is likely to include:

- a Use of a kit dump mat (Fig. 5);
- b Videolaryngoscopy for tracheal intubation;
- c A 2-person 2-handed mask ventilation with a VE-grip (Fig. 6);
- d A second-generation supraglottic airway device (SGA) for airway rescue (e.g. i-gel, Ambu Aura Gain, LMA ProSeal, LMA Protector)

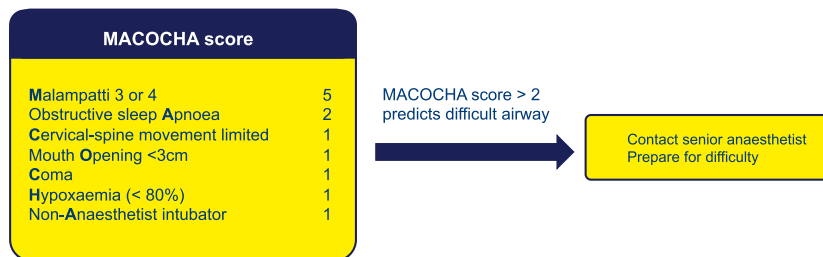


Figure 3 MACOCHA score and prediction of difficult intubation. Adapted from [23].

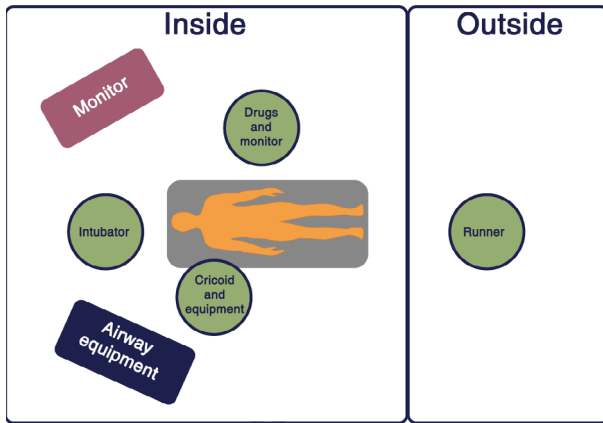


Figure 4 Personnel plan for tracheal intubation of a patient with coronavirus disease 2019. Adapted from [20].

- 9** *The most appropriate airway manager should manage the airway.* See above.
- 10** *Do not use techniques you have not used before or are not trained in.* Again, for the reasons stated above, this is not a time to test new techniques.
- 11** *Ensure all necessary airway kit is present in the room before tracheal intubation takes place.* This includes the airway trolley and a cognitive aid consistent with the rescue strategy.

- a** Monitoring including working continuous waveform capnography
- b** Working suction
- c** Ventilator set up
- d** Working, checked intravenous (i.v.) access
- 12** *Use a tracheal intubation checklist* (Fig. 7 and also see Supporting Information, Appendix S2). This is designed to aid preparedness and should be checked before entering the patient's room as part of preparation.
- 13** *Use a cognitive aid if difficulty arises* (Fig. 8). Airway difficulty leads to cognitive overload and failure to perform optimally. A cognitive aid will help focus the team and enhance transitioning through the algorithm. Two algorithms are provided: that derived from the Difficult Airway Society (DAS) 2018 guidelines for tracheal intubation of the critically ill [20] has intentionally been reduced in scope and choices removed to accommodate the current setting and encourage reliable and prompt decision-making and actions.
- 14** *Use clear language and closed loop communication.* It may be hard to communicate when wearing PPE and staff may be working outside normal areas of practice. Give simple instructions. Speak clearly and loudly, without shouting. When receiving instructions repeat what you have understood to the person speaking. If team members do not know each other

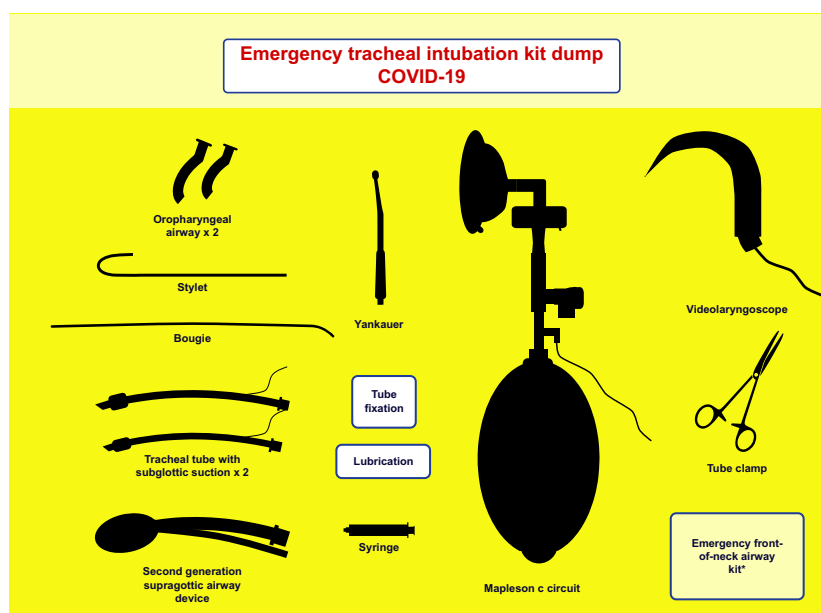


Figure 5 Exemplar of kit dump mat. The emergency front-of-neck airway kit may be excluded from the airway kit dump due to the risk of contamination and could be placed outside of the room with immediate access if required.

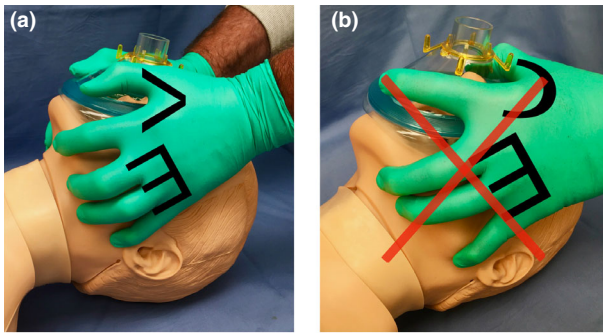


Figure 6 (a). Two-handed two-person bag-mask technique with the VE hand position; the second person squeezes the bag. (b). The C hand position, which should be avoided. Reproduced with permission of Dr A. Maticoc.

well, a sticker with the individual's name can be placed on the top of the visor to aid communication with other staff.

Anaesthetic and airway technique for emergency tracheal intubation

- 1 A rapid sequence induction (RSI) approach is likely to be adopted. Use of cricoid force is controversial [28], so use it where a trained assistant can apply it but promptly remove it if it contributes to tracheal intubation difficulty.
- 2 Meticulous pre-oxygenation should be with a well-fitting mask for 3–5 min. A closed circuit is optimal (e.g. anaesthetic circle breathing circuit) and a rebreathing circuit (e.g. Mapleson's C ('Waters') circuit) is preferable to a bag-mask which expels virus-containing exhaled gas into the room.
- 3 Place a heat and moisture exchange (HME) filter between the catheter mount and the circuit. Non-invasive ventilation should be avoided. High-flow nasal oxygen is not recommended.
- 4 Patient positioning, including ramping in the obese and reverse Trendelenburg positioning, should be adopted to maximise safe apnoea time.
- 5 In agitated patients, a delayed sequence tracheal intubation technique may be appropriate.
- 6 If there is increased risk of cardiovascular instability, ketamine $1\text{--}2\text{ mg}\cdot\text{kg}^{-1}$ is recommended for induction of anaesthesia. Rocuronium $1.2\text{ mg}\cdot\text{kg}^{-1}$ for neuromuscular blockade, should be given as early as practical. These measures minimise apnoea time and risk of patient coughing. If suxamethonium is used the dose should be $1.5\text{ mg}\cdot\text{kg}^{-1}$.
- 7 Ensure full neuromuscular blockade before tracheal intubation is attempted. A peripheral nerve stimulator maybe used or wait 1 minute.
- 8 Ensure a vasopressor for bolus or infusion is immediately available for managing hypotension.
- 9 Only after reliable loss of consciousness – to avoid coughing – gentle continuous positive airway pressure (CPAP) may be applied, if the seal is good, to minimise the need for mask ventilation. Bag-mask ventilation may be used to assist ventilation and prevent hypoxia if indicated. Use a Guedel airway to maintain airway patency. Use the 2-handed, 2-person technique with a VE-grip to improve seal particularly in the obese patient [29]. When bag-mask ventilation is applied, minimal oxygen flows and airway pressures consistent with achieving this goal should be used.
- 10 Alternatively, a second-generation SGA may be inserted, after loss of consciousness and before tracheal intubation, to replace the role of bag-mask ventilation or if this is difficult [7, 30].
- 11 Laryngoscopy should be undertaken with the device most likely to achieve prompt first-pass tracheal intubation in all circumstances in that operator's hands – in most fully trained airway managers this is likely to be a videolaryngoscope.
 - a Stay as distant from the airway as is practical to enable optimal technique, whatever device is used
 - b Using a videolaryngoscope with a separate screen enables the operator to stay further from the airway and this technique is recommended for those trained in their use.
 - c If using a videolaryngoscope with a Macintosh blade, a bougie may be used.
 - d If using a videolaryngoscope with a hyperangulated blade, a stylet is required.
 - e Where a videolaryngoscope is not used, a standard Macintosh blade and a bougie (either pre-loaded within the tracheal tube or immediately available) is likely the best option
 - f If using a bougie or stylet, be careful when removing it so as not to spray secretions on the intubating team
- 12 Intubate with a tracheal tube size 7.0–8.0 mm internal diameter (ID) in women or 8.0–9.0 mm ID in mens, in line with local practice. Use a tracheal tube with a subglottic suction port where possible.
- 13 At tracheal intubation, place the tracheal tube without losing sight of it on the screen and pass the cuff 1–2 cm below the cords, to avoid bronchial intubation.

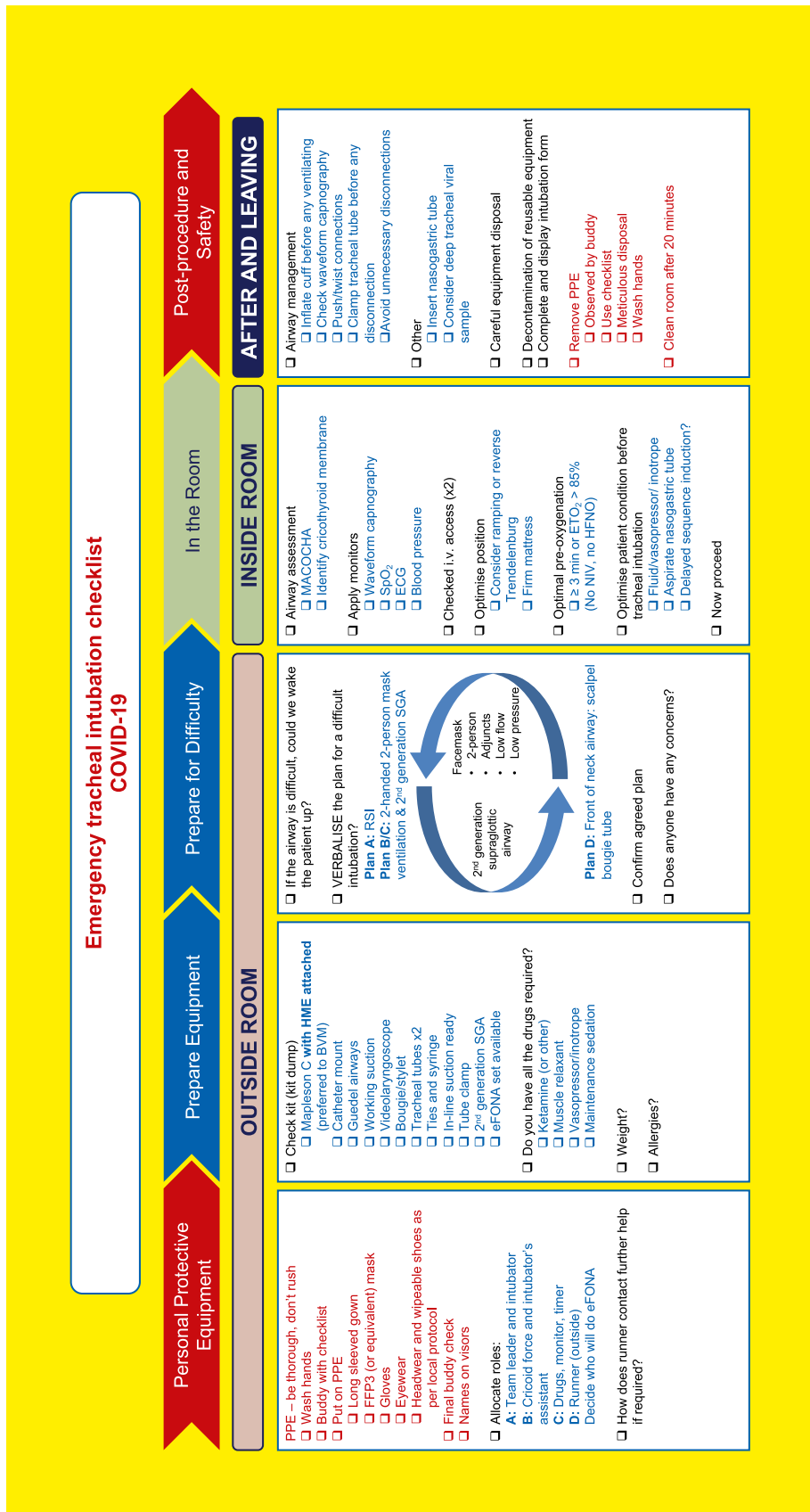
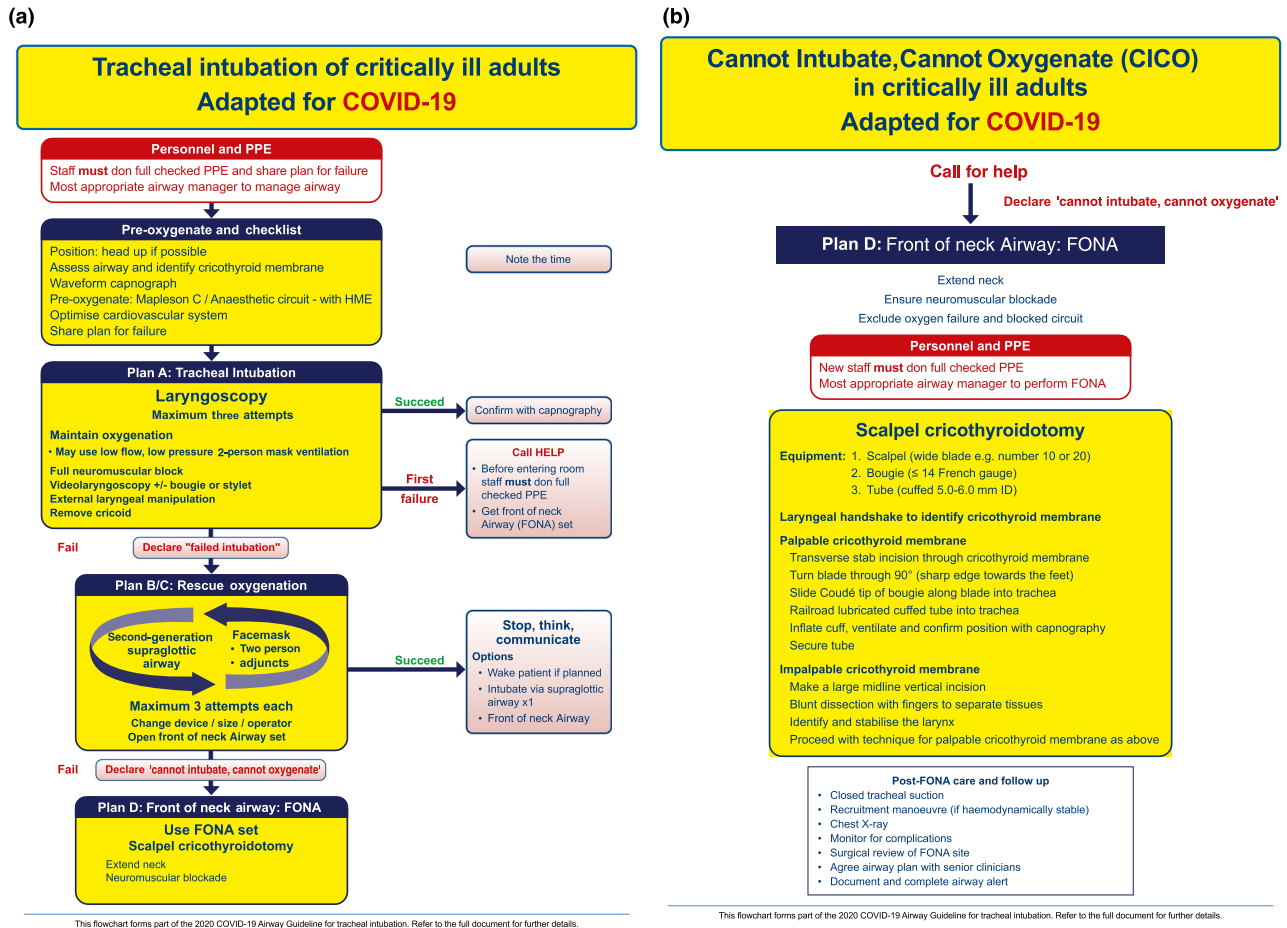
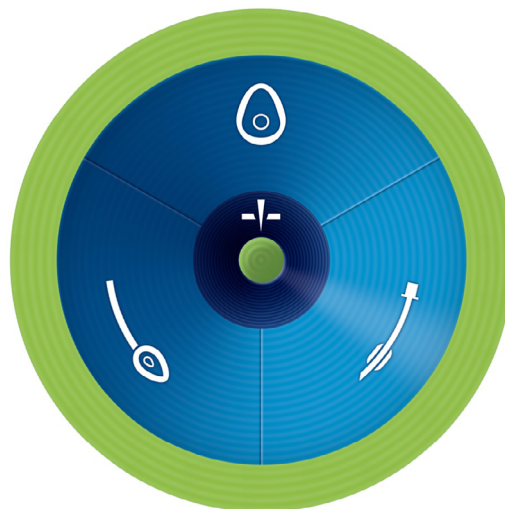


Figure 7 Emergency tracheal intubation checklist in a patient with coronavirus disease 2019. Adapted from [20] with permission.



(c) T h e v o r t e x



For each lifeline consider:

- Manipulations:**
 - Head and neck
 - Larynx
 - Device
- Adjuncts**
- Size/type**
- Suction/O₂ flow**
- Muscle tone**

Maximum three attempts at each lifeline (unless gamechanger)
at least one attempt should be by most experienced clinician
Cannot Intubate, Cannot Oxygenate status escalates with unsuccessful best effort at any lifeline or with unsuccessful attempts at any two consecutive lifelines

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Figure 8 Cognitive aids for use when managing unexpected difficulty when intubating a patient with coronavirus disease 2019. (a) Unexpected difficult tracheal intubation. (b) Cannot intubate, cannot oxygenate. Adapted from [20] with permission. (c) Vortex approach cognitive aid. From [27] with permission.

- 14** Inflate the cuff with air to a measured cuff pressure of 20–30 cmH₂O immediately after tracheal intubation.
- 15** Secure the tracheal tube as normal.
- 16** Start mechanical ventilation only after cuff inflation. Ensure there is no leak.
- 17** Confirm tracheal intubation with continuous waveform capnography.
- 18** Confirming correct depth of insertion may be difficult.
 - a** Auscultation of the chest is difficult when wearing airborne precaution PPE and is likely to risk contamination of the stethoscope and staff, so is not recommended.
 - b** Watching for equal bilateral chest wall expansion with ventilation is recommended.
 - c** Lung ultrasound or chest x-ray may be needed if there is doubt about bilateral lung ventilation.
- 19** Once correct position is established record depth of tracheal tube insertion prominently.
- 20** Pass a nasogastric tube after tracheal intubation is complete and ventilation established to minimise the need for later interventions.
- 21** If the patient has not yet been confirmed as COVID-19 positive collect a deep tracheal sample using closed suction for COVID-19 testing. Some upper airway samples are false negatives.
- 22** A visual record of tracheal intubation should be prominently visible on the patient's room (see also Supporting Information, Appendix S3).

Unexpected difficulty

- The basic algorithm for tracheal intubation can usefully adhere to the simplified DAS 2018 guideline for tracheal intubation of the critically ill patient (Figs. 8a and 8b) or the Vortex approach (Fig. 8c). If there is difficulty with tracheal intubation this should be managed according to standard rescue algorithms with attention to the following:
 - a** Transition through the algorithm promptly, consider minimising number of attempts at each technique.
 - b** Declare difficulty or failure to the team at each stage.
 - c** Mask ventilation may be deferred initially and a second-generation SGA used as an alternative between attempts at laryngoscopy. This may reduce aerosol generation due to improved airway seal
 - d** If an emergency FONA is required, the simplified DAS 2018 guidance should be followed (Fig. 8b). The scalpel-bougie-tube technique is particularly preferred in COVID-19 patients due to the risk of aerosolisation with the oxygen insufflation associated with cannula techniques.

To improve simplicity, we have only provided the option of the scalpel-bougie-tube technique. If a different technique is specifically adopted and trained for in your department, this may also be appropriate.

- Where there is problem, a difficult airway plan should be recorded, prominently displayed and communicated to staff at shift change overs (an example of an ICU airway alert form is shown in Supplementary Appendix S4).

Predicted difficult airway

- The choice of airway technique in a predicted difficult airway will be specific to the patient's needs and is therefore beyond the scope of this guideline.
- Many techniques for managing the difficult airway will include potentially aerosol-generating procedures – see above. While there are reports from other countries of use of awake tracheal intubation note:
 - a** Topicalisation of the airway will need to be considered carefully to minimise aerosol-generating procedures and coughing.
 - b** Flexible bronchoscopy techniques (whether alone, via a SGA conduit or with a videolaryngoscope, so called video-assisted flexible intubation) are likely to be aerosol-generating and therefore unlikely to be first choice.
 - c** Alternative difficult tracheal intubation techniques include tracheal intubation via an SGA including the intubating laryngeal mask airway (blind or flexible bronchoscope-assisted), or with (video guidance and an Aintree intubation catheter).

Airway management after tracheal intubation and trouble shooting

- Use an HME filter close to the patient, instead of a heated humidified circuit (wet circuit) but take care this does not become wet and blocked.
- Monitor airway cuff pressure carefully to avoid airway leak. If using high airway pressures, ensure the tracheal tube cuff pressure is at least 5 cmH₂O above peak inspiratory pressure. Cuff pressure may need to be increased before any recruitment manoeuvres to ensure there is no cuff leak.
- Monitor and record tracheal tube depth at every shift to minimise risk of displacement.
- Managing risk of tracheal tube displacement. This is a risk during patient repositioning including: prone positioning; turning patients; nasogastric tube aspiration or positioning; tracheal suction; and oral toilet. Cuff pressure and tracheal tube depth should be checked and

corrected both before and after these procedures. There is a risk of tracheal tube displacement during sedation holds and this should be considered when planning these (e.g. timing, nursing presence etc.).

- *Suction.* Closed tracheal suction is mandatory wherever available.
- *Tracheal tube cuff leak.* If a cuff leak develops to avoid aerosol-generation pack the pharynx while administering 100% oxygen and setting up for re-intubation. Immediately before re-intubation, pause the ventilator.
- *Airway interventions.* Physiotherapy and bagging, transfers, prone positioning, turning the patient, tube repositioning. If the intervention requires a disconnection of the ventilator from the tracheal tube before the airway intervention:
 - a Ensure adequate sedation.
 - b Consider administering neuromuscular blockade.
 - c Pause the ventilator so that both ventilation and gas flows stop
 - d Clamp the tracheal tube
 - e Separate the circuit with the HME still attached to the patient
 - f Reverse this procedure after reconnection
- *Avoid disconnections.* push-twist all connections to avoid risk of accidental disconnections.
- *Accidental disconnection.* Pause the ventilator. Clamp the tracheal tube. Reconnect promptly and unclamp the tracheal tube.
- *Accidental extubation.* This should be managed as usual, but management should be preceded by full careful donning of PPE before attending to the patient, irrespective of clinical urgency.
- *Tracheostomy.* This is a high-risk procedure due to aerosol-generation, and this should be taken into account if it is considered. It may be prudent to delay tracheostomy until active COVID-19 disease is resolved.

Risk of blockage of heat and moisture exchange filters

Actively heated and humidified 'wet circuits' may be avoided after tracheal intubation to avoid viral load being present in the ventilator circuit. This will theoretically reduce risks of contamination of the room if there is an unexpected circuit disconnection. There is a risk of the filter becoming blocked if it becomes wet. This will cause blockage of the filter and may be mistaken for patient deterioration, which it also may then cause. Consider

whether the HME filter is wet and blocked if there is patient deterioration or difficulty in ventilation. If the HME filter is below the tracheal tube or the catheter mount, condensed liquid may saturate the HME. This is particularly likely to occur if both an HME and a wet circuit are used simultaneously [31].

Tracheal extubation

- Many ICUs routinely extubate patients' tracheas and then use high-flow nasal oxygen immediately for up to 24 h. This is unlikely to be desirable or feasible in patients with COVID-19. Consequently, tracheal extubation may be delayed, unless the pressure of beds demands otherwise.
- Efforts should be made to minimise coughing and exposure to infected secretions at this time.
 - a Undertake appropriate physiotherapy and tracheal and oral suction as normal before extubation.
 - b Prepare and check all necessary equipment for mask or low flow ($< 5 \text{ l.min}^{-1}$) nasal cannula oxygen delivery before extubation.
 - c After extubation, ensure the patient immediately wears a facemask as well as their oxygen mask or nasal cannulae where this is practical.
 - d During anaesthesia, drugs to minimise coughing at emergence include dexmedetomidine, lidocaine and opioids [32]. The value of these is unproven in critical care and needs to be balanced against adverse impact on respiratory drive, neuromuscular function and blood pressure. For these reasons, routine use is currently unlikely.
 - e While an SGA may be considered as a bridge to extubation to minimise coughing this involves a second procedure and the possibility of airway difficulty after SGA placement so is unlikely to be a first-line procedure [33, 34].
 - f Likewise, the use of an airway exchange catheter is relatively contra-indicated in a patient with COVID-19 due to potential coughing etc.

Airway management during cardiac arrest

- The UK Resuscitation Council has published statements on the management of cardiac arrest in patients with COVID-19 [35].
- Airway procedures undertaken during management of cardiac arrest are likely to expose the rescuer to a risk of viral transmission. *"The minimum PPE requirements to assess a patient, start chest compressions and establish monitoring of the cardiac*

arrest rhythm are an FFP3 facemask, eye protection, plastic apron, and gloves.”[35].

- Avoid listening or feeling for breathing by placing your ear and cheek close to the patient’s mouth.
- In the presence of a trained airway manager early tracheal intubation with a cuffed tracheal tube should be the aim.
- Before this, insertion of an SGA may enable ventilation of the lungs with less aerosol generation than facemask ventilation.
- In the absence of a trained airway manager, rescuers should use those airway techniques they are trained in. Insertion of an SGA should take priority over facemask ventilation to minimise aerosol generation.
- An SGA with a high seal pressure should be used in preference to one with a low seal. This will usually be a second-generation SGA where available.

Airway management for anaesthesia

- While it is beyond the scope of this document to define which patients need precautions, it is worth noting that patients may be asymptomatic with COVID-19 but infective [36–39], though symptomatic patients are more likely to pose a risk of transmission. During an epidemic, there should be a very low threshold for considering a patient at risk of being infective and it may become necessary to treat all airway interventions as high risk.
- Decisions around airway management should be undertaken using the fundamental principles described above.
- Airway management should be safe, accurate and swift.
- There is likely to be a lower threshold for use of an SGA over facemask ventilation and also a lower threshold for tracheal intubation.
- If using an SGA, spontaneous ventilation may be preferred to controlled ventilation, to avoid airway leak.
- Drug choices may differ from when intubating a patient with critical illness and, in particular if the patient is not systemically unwell, ketamine may not be chosen as the induction agent.
- Note that tracheal intubation is associated with more coughing at extubation than when an SGA is used. Avoiding this may be by
 - a Use of an SGA instead of tracheal intubation
 - b Changing a tracheal tube to an SGA before emergence
 - c Use of i.v. or intracuff lidocaine; i.v. dexmedetomidine; opioids (e.g. fentanyl, remifentanyl) before extubation.

Conclusions

The management of patients with known or suspected COVID-19 requires specific considerations to safety for staff and patients. Accuracy is critical, and clinicians should avoid unreliable, unfamiliar or repeated techniques during airway management, thus enabling it to be safe, accurate and swift. Swift care means that it is timely, without rush and similarly without delay. We have highlighted principles that may achieve these goals, but the details of these principles may be subject to change as new evidence emerges.

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Supporting Information

Additional supporting information may be found online via the journal website.

Appendix S1. A COVID-19 airway trolley and sample contents.

Appendix S2. Principles of airway management in a COVID-19 patient. Reproduced with permission of Dr A. Chan. Department of anaesthesia and Intensive Care, Chinese University Hong Kong [26].

Appendix S3. Tracheal intubation details to be displayed in or at entrance to the patient's room. (Courtesy Royal United Hospital, Bath)

Appendix S4. Difficult tracheal intubation plan for communication between staff. (Courtesy Royal United Hospital, Bath)