Airway Management Guidelines for Patients with Known or Suspected COVID-19 Infection

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Disclaimer:
Many of the publications upon which this document is based would be considered Level C (low quality, expert opinion and consensus) evidence. However, we feel that the benefit of providing this early guidance exceeds the risk. These recommendations should not be considered mandatory or standard of care in the management of the COVID-19 patient: the clinician's professional judgement must be applied to every situation.

Updates to this version (V 3.7 – April 28, 2020):

- Target oxygen saturations modified to be consistent with the Surviving Sepsis guidelines;
- Cardiac arrest and protected code blue sections updated;
- Addition of narrative and Figure re Rescuer®Emergency CPAP System 8700;
- Other minor changes to narrative throughout;
- Addition of multiple embedded links to instructional videos.

1. Background

As recently stated, 'the risk of respiratory failure requiring critical care support in patients infected with COVID-19 is significant'.[1] Acute care provider teams in prehospital and hospital settings should prepare for the arrival, transfer of care and management of these patients. Both the patient and provider teams are at risk during airway management of COVID-19 cases. While patient safety continues to be a goal, **what's different during a pandemic is that attention to the safety of the staff caring for the patient assumes equal or indeed, greater importance.** Caring for COVID-19 patient safely requires meticulous attention to detail using a common, standardized (and rehearsed) approach to airway management.

1.1 Context

In this document, recommendations for management of the COVID-19 patient relate to (a) efficacy of the recommended treatment modality; (b) its risk to staff safety and (c) resource availability. If a surge in the number of patients presenting with severe COVID-19 infections occurs and resources (e.g., ventilators) become scarce, recommendations may change.

1.2 Sources for the document

Material in this document is based on the following sources:

- Published recommendations – some peer reviewed, some not (e.g., society or other websites);
- Internal NSHA multi-disciplinary consensus conferences;
- Contact with clinicians working in 'hot zones' where surges have occurred;
- Expert opinion.

As such, these recommendations should be regarded as Level C evidence (limited evidence or expert opinion). This is a living document that will be updated as more information becomes available or as guidance needs to be altered.

2. Principles

General:

- When airway management of the COVID-19 patient is indicated, provider safety must be prioritized;
- When tracheal intubation is indicated, first attempt success should be rapidly and skillfully achieved.

Infection control:

- For any potentially aerosol-generating medical procedures (AGMPs), including tracheal intubation or positive pressure ventilation in the non-intubated patient, airborne/droplet/contact personal protective equipment (PPE) should be used by all providers, informed by local infection prevention and control recommendations (e.g., Appendix 4 & 5);
- Designate a 'ready bed' in a negative pressure, airborne infection isolation room (AIIR), with a separate preparatory space ('antechamber'). If unavailable, the intubation can occur in a normal pressure room with closed doors.

Airway Management Providers:

- While help may be available, all acute care physicians should train and prepare for intubating COVID-19 patients;
- The most skilled airway management provider available should perform tracheal intubation.

Team:

- Clinicians often feel a sense of urgency in managing hypoxemic patients. Airway providers and teams need to slow down to ensure their own safety as they prepare to manage known or suspected COVID-19 patients;
- The number of primary team members at the bedside should be limited (e.g., primary airway provider, airway support provider, clinical support provider);
- Providers and teams should engage in regular practice of the necessary procedures, including PPE donning and doffing and the approach to airway management.

Equipment:

- Required airway equipment and medications should be prepared prior to entry into the designated ready room;
- Indirect video laryngoscopy should be used as the primary approach for intubation.

Approach:

- Rapid sequence intubation should be used to facilitate first-pass intubation success and prevent patient coughing or gagging;
- An awake approach in general should be avoided. If considered necessary, this should only be done by an expert provider, trained to perform the approach in COVID-19 patients.

Communication:

- Team briefings should occur prior to entering the ready room and immediately prior to initiating airway management;

- Checklists and/or other visual aids should be used to facilitate preparation for and performance of the intubation procedure;
- No transports of potentially infected COVID-19 patients should occur without direct communication with the receiving providers/teams.

3. Suggested Management

3.1 Preamble:

COVID-19 is a novel virus presenting a new and unique constellation of symptoms and signs. Optimal management is not yet known. However, the following generalizations apply to these patients' respiratory support, including tracheal intubation:

- If possible, 'do-not-intubate' or 'do-not-resuscitate' status should be established prior to tracheal intubation of any, but especially the older and possibly co-morbid patient with COVID-19 related respiratory failure;
- Clinicians working in other countries' 'hot zones' indicate that with the use of CPAP or HFNO, some patients have avoided the need for intubation altogether, while others have been adequately temporized while a ventilator was sourced.
- **However,** in COVID-19 patients in hypoxemic respiratory failure with a worsening trajectory despite escalating oxygenation measures (e.g. use of HFNO or CPAP) early tracheal intubation has been advocated. This holds the advantage of intubation performed under controlled, non-emergency conditions. Also, once completed, it might help protect the health care worker by minimizing further droplet spread from the patient or by avoiding use of potentially aerosolizing non-invasive modalities such as continuous positive airway pressure (CPAP) or high-flow nasal oxygen (HFNO).
- Staff safety is paramount, so that use of oxygen delivery and ventilatory support modalities such as CPAP or HFNO that are considered to be at risk of aerosol generation should ideally occur in a negative pressure AIIR and staff should wear full airborne/droplet/contact precautions.
- Regardless of delivery modality, the patient requiring oxygen supplementation should be closely monitored for deterioration. If needed, escalation to the next level should occur in a timely fashion. When tracheal intubation is indicated, it should occur in a controlled manner with close attention to staff safety.
- Some COVID-19 patients with respiratory failure can present with a profound degree of hypoxemia, yet seemingly few symptoms (the 'silent' or 'happy' hypoxemic patient): speaking in full sentences, without significant dyspnea and with normal mentation. These patients may be candidates for a brief trial of supplemental oxygen that includes CPAP or HFNO.
- Others may have a more classic presentation of hypoxemia with tachypnea and high work of breathing, hypercarbia and tachycardia or with other signs such as confusion or hypotension. This population will likely require early tracheal intubation.
- Optimal oxygen goals are unknown, but a target SpO_2 of 92-96% should be considered if feasible[2]. If below 92%, escalation of oxygen therapy should be considered; if above 96%, reducing the oxygen flow rate can be considered, or de-escalation of the delivery modality to one with less potential for aerosol generation. Lower oxygen targets may be established for this disease going forward.
- The COVID-19 patient in hypoxemic respiratory failure appears to respond well to proning – both after intubation and before/without intubation, supplemented by modalities that range

from nasal prongs/cannulae to CPAP. However, on resumption of the supine position, the patient may again desaturate. The team should be ready for this eventuality.

- As few published studies currently address the degree of aerosol generation from CPAP or HFNO or the resulting extent of risk to staff, the term '*consider*' will be used when a recommendation is made for the use of these modalities. Risk vs. benefit should be considered.

3.2 Supplemental oxygenation before the need for tracheal intubation is identified.

3.2.1 For the known or suspected COVID-19 patient arriving by EMS:

Prior to offloading and in consultation with the receiving physician, hypoxemic patients should be remotely triaged (in the ambulance bay), with disposition as follows:

- Patients requiring nasal prongs/cannulae should have flows limited to ≤ 15 litres per minute (lpm) and should wear a procedure or surgical mask to help limit droplet spread;
- EMS may transport some patients requiring oxygen with a CPAP device strapped to the patient's face. These devices provide for hands-free oxygenation and flow dependent CPAP. Flows should be limited to ≤ 15 lpm and if not already in-situ, a viral filter should be placed between the mask and CPAP components (e.g., Figure 1).
- If a bag-valve mask (BVM) system is being used, a viral filter must be placed between the mask and self-inflating bag (e.g., Figure 2a).

3.2.2. For the known or suspected COVID-19 patient in a secondary assessment unit, Emergency Department (ED) or inpatient unit – initial oxygen supplementation options:

- **O_2 nasal prongs/cannulae** at flows ≤ 10-15 lpm
  - Standard nasal cannulae are particularly well-tolerated at flows ≤ 5 lpm;
  - These or design specific (non-humidified) higher flow nasal cannulae featuring larger diameter tubing can be used with flow rates up to 10-15 lpm:
    - ***Note :*** this does NOT refer to delivery of humidified high-flow nasal oxygenation by devices such as Airvo®. See discussion of this modality in section 3.3.2 below.
  - The patient should wear a standard procedure or surgical mask applied over the nasal cannulae to help limit droplet spread;
  - Negative pressure AIIR is not required;
  - Staff should be protected by droplet/contact PPE;
  - A trial of lateral positioning or self-proning can occur with the patient wearing nasal prongs/cannulae;
  - If the target SpO_2 of 92-96% is not achieved with nasal cannulae up to 15 lpm, escalation to a non-rebreathing face mask (NRM) should be considered.

- **O_2 by simple, venturi or non-rebreathing facemask** at ≤ 15 lpm:
  - Filtered non-rebreathing masks such as the Tavish® (Figure 3) or Hi-Ox™ (with an attached filter - Figure 4) can be considered, as they may offer some additional staff protection due to viral filters over the expiratory ports;
  - Negative pressure AIIR is not required;
  - Staff should be protected by droplet/contact PPE;
  - Flow rates of supplemental oxygen should be limited to the least needed to achieve the target oxygen goal (e.g., SpO_2 92-96%);

- A trial of lateral positioning or self-proning can occur with the patient wearing a simple or non-rebreathing mask.

- Regardless of which of the foregoing devices is used (nasal prongs, design-specific higher flow nasal cannulae, simple, venturi or non-rebreathing face mask, or some combination thereof), total flow rates $\leq$ 15 lpm are NOT considered to be aerosol-generating. This means they can be used in a regular (non-AIIR) environment and with staff using droplet-precaution PPE. Again, a procedure or surgical mask should be worn by the patient over nasal prong/cannulae options.

3.3 Further escalation required.

For the known or suspected COVID-19 patient with ongoing hypoxemia despite a trial of the foregoing, or as initial management due to profound hypoxemia and/or distress, options are as follows:

3.3.1 Early tracheal intubation may be indicated for the following indications:

- Significant hypoxemia refractory to non-rebreathing mask at flows $\leq$ 15 lpm in conjunction with one or more of the following:
  - Clinical signs of the patient tiring:
    - Dyspnea;
    - Tachypnea with RR > 30-35 (adult);
    - Tachycardia;
    - Agitation;
    - Accessory muscle use; paradoxical chest/abdomen movement;
  - Worsening PaO_2/FiO_2;
  - Increasing $PaCO_2$;
  - Rapidly progressive disease trajectory or other clinical judgement.
- Other standard indications for tracheal indication, e.g., failure to protect the airway or obstructing airway pathology, hemodynamic instability, sepsis, multi-organ failure.

3.3.2. **Tracheal intubation after a failed trial of CPAP or HFNO:**

- See the next section for discussion on the use of CPAP or HFNO.
- With availability of a negative pressure AIIR and availability of airborne/droplet/contact PPE for staff protection, some patients may be candidates for a 30-60 minute trial of CPAP or HFNO so support oxygenation;
- Failure to respond to a 30-60 minute trial of CPAP or HFNO would be an indication for tracheal intubation.

3.3.3. Continuous positive airway pressure (CPAP) or high-flow nasal oxygenation (HFNO) are acknowledged as being potentially aerosol-generating[3]. However, reports from countries with significant surges of COVID-19 patients report extensive use of both CPAP and HFNO, for the following indications:

- To help prevent the need for intubation in some cases. This would most often relate to the 'silent/happy' hypoxemic population requiring more oxygen support than non-rebreathing mask or nasal prongs at < 10-15 lpm provides – patients who are hypoxemic without displaying other signs of physiologic compromise.
- To defer the need for intubation temporarily while arranging for a ventilator to become available, e.g., in a 'surge' situation.

CPAP and HFNO are preferentially used in a negative pressure, airborne infection isolation room environment and certainly with staff wearing full airborne/droplet/contact PPE. Furthermore, the patient must be closely monitored for deterioration so that if needed, timely tracheal intubation can occur in a controlled fashion.

CPAP. CPAP can be delivered by a variety of devices, e.g.:

- By a non-invasive ventilation device;
- By a commercial flow-dependent CPAP mask with integrated viral filters such as the Rescuer® Emergency CPAP System 8700 (Figure 6/Video) . These devices have been distributed around the province as a potential resource for empiric use when escalation of oxygen therapy is required but local resources do not include traditional CPAP or HFNO devices. It can be *considered* for use to temporize, for example, pending the arrival of a transport crew able to perform tracheal intubation. Discussion with the EHS LifeFlight Critical Care Medical Control Physician is encouraged when considering this escalation.
- CPAP can be 'rigged' by applying nasal prongs at 5-10 lpm and applying an overlying cuffed mask attached to viral filter, catheter mount, bag-valve mask device with PEEP valve (10 cm H_20) with oxygen running at a flow of 15 lpm (Video);
- All CPAP generating options should be considered as potentially aerosol-generating and ideally used in a negative pressure AIIR;
- To help reduce aerosolization potential, consider starting with the least supporting pressure (e.g., CPAP 8-10 cm H_20) consistent with adequate SpO_2 (e.g., 92-96%).
- Staff caring for the patient using CPAP should be protected by full airborne/ droplet/contact PPE;
- A trial of CPAP in the prone position can be considered in the cooperative awake, spontaneously breathing patient.
- If CPAP is used, the patient should be closely monitored for deterioration, and if not responding favourably within a 30-60 minute trial period, should proceed to tracheal intubation.

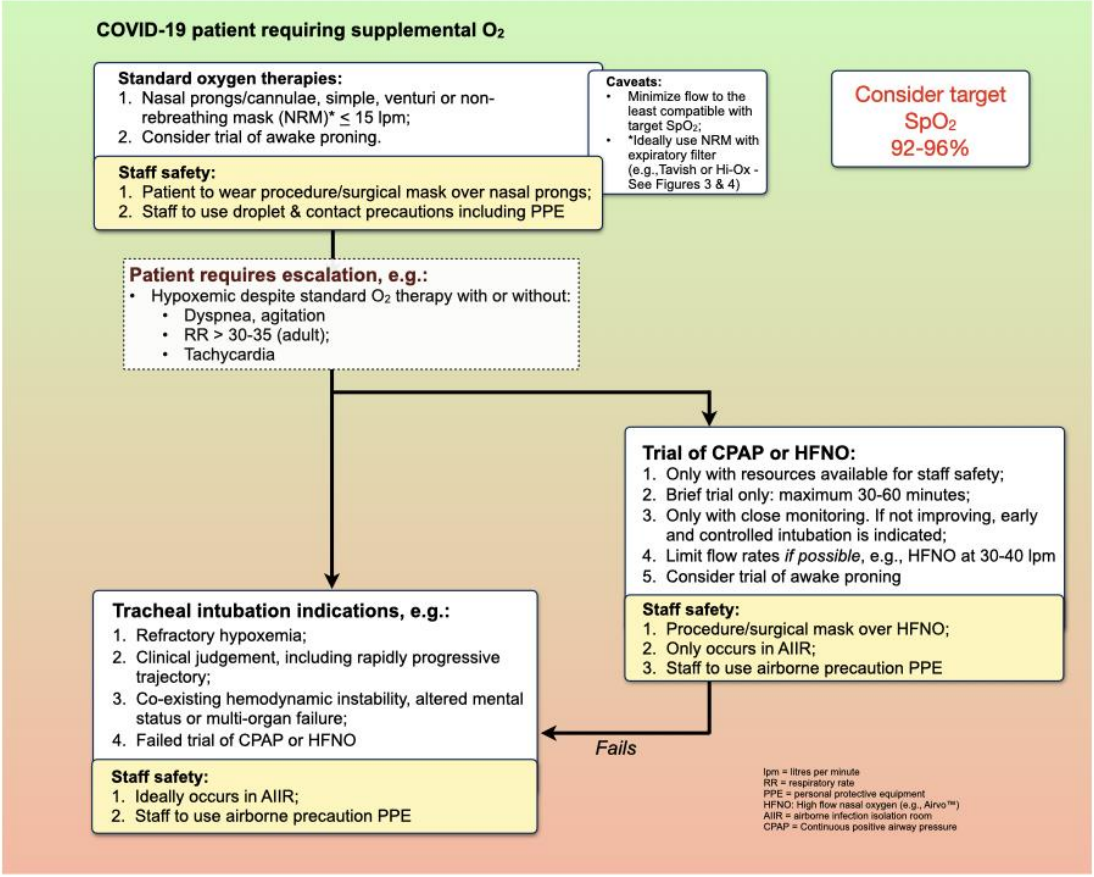
HFNO including Airvo™; Optiflow™; Vapotherm™, deliver humidified oxygen at flow rates of 40-70 lpm:

- Should be considered as potentially aerosol-generating and ideally used in a negative pressure AIIR;
- Staff caring for the patient using HFNO should be protected by full airborne/droplet/contact PPE;
- To help reduce aerosolization potential, consider using FiO_2 1.0 and reducing flows to the least needed to achieve target oxygen goal (e.g., SpO_2 92-96%);
- A trial of HFNO in the prone position can be considered in the cooperative awake, spontaneously breathing patient.
- If HFNO is used, the patient should be closely monitored for deterioration, and if not responding favourably within a 30-60 minute trial period, should proceed to tracheal intubation;

Bi-level positive airway pressure (BiPAP) is not generally recommended for support of the COVID-19 patient in hypoxemic respiratory failure.[4, 5]

If the patient responds well to support with HFNO or CPAP, that modality can be continued with ongoing close observation for tiring or deterioration. Small doses of analgesic may be helpful,

e.g., ketorolac, acetaminophen or low-dose ketamine. With or without a trial of CPAP or HFNO, when required, tracheal intubation should occur before it is an emergency. Controlled tracheal intubation before the patient decompensates will minimize the potential for risk to staff due to breaches of PPE donning protocols.



4. Tracheal intubation of the COVID-19 patient: recommendations

4.1 Location:

Tracheal intubation of the COVID-19 patient should ideally occur in a negative pressure airborne infection isolation room (AIIR).[1, 6, 7] However, the benefit of intubation in a negative pressure environment must be weighed against the risks of transporting a critically ill patient to another location for tracheal intubation. Regardless of location, ideally, the chosen area should have a mock-up diagram of where equipment and personnel are best positioned for that room, as it may be in a location that is unfamiliar to the providers (e.g. Appendix 1). Providers should strive to perform in-situ simulation in these areas.

4.2 Approach:

Rapid sequence intubation (RSI) is the default approach for managing these patients, so that the risk of aerosolized droplet production by coughing or gagging can be minimized. Use of a checklist and visual aid with which the team is familiar and has trained using is strongly encouraged (e.g. Appendix 6) For every case, a 'double set-up' RSI is recommended, with use of a video laryngoscope as the primary approach and the location of the cricothyroid membrane marked and prepped for rescue

cricothyrotomy. Awake intubation should almost never occur, and only be elected as a measure of last resort if none of the standard techniques of face mask ventilation, videolaryngoscopic-aided tracheal intubation or supraglottic airway ventilation are predicted to succeed. If used, awake intubation should only be performed by a provider very familiar with the procedure and who is additionally trained in airway management of the COVID-19 patient.

4.3 Equipment Preparation:

Providers are encouraged to create compact kits that can be taken into the room (e.g., Appendix 3) to avoid contamination of other equipment. It is assumed that clinicians using the airway equipment described below are experienced and have practiced the chosen procedure wearing PPE individually and with their teams in simulations. Core equipment should include:

- Suction: open rigid (e.g., Yankauer, +/- high flow suction-Ducanto) and closed in-line tracheal suction setups;
- BVM with PEEP valve, cuffed face mask, viral filter and waveform CO_2 (Figure 2b). Adding a flexible catheter mount provides an easier range of motion for BVM setup to help minimize the risk of accidental disconnection (Figure 2c). Connections must be secure.
- Oropharyngeal airway (with alternative sizes);
- Regular nasal prongs;
- Intubation devices:
    - We recommend use of a video laryngoscope that supports use of single-use (disposable) blades. For a first attempt, we recommend use of a Macintosh-shaped blade, used in conjunction with a tracheal tube introducer ('bougie'). Examples of video laryngoscope include:
        - Storz C-MAC® S with single-use Macintosh 3 or 4 blades;
        - GlideScope ® Spectrum™ with single use [Macintosh-shaped] DVM 3 or 4 blades;
        - McGrath Mac with single-use Mac size 3 or 4 blades.
    - Hyper-angulated video laryngoscope blade options are available for all of the foregoing. These can be used for the patient with anticipated difficult Macintosh laryngoscopy, for a second intubation attempt after proven difficult Macintosh laryngoscopy (if the patient is still oxygenated), or alternatively, for first attempt use due to clinician preference if skilled with the device. Examples include:
        - Storz C-MAC® S with single-use D-blade;
        - GlideScope ® Spectrum™ with single-use LoPro S3 or S4 blade;
        - McGrath™ Mac with X blade.
    - Other Options:
        - A high quality single-use direct laryngoscope should ideally be available in case the VL system fails.
        - If available, a single-use flexible intubation endoscope may be valuable in experienced hands, for example, used through a supraglottic device.

- Tracheal tubes:
    - Evac (i.e., including a subglottic suction port) tubes should be considered for primary use unless a difficult tracheal intubation is predicted. If an Evac tube is chosen, for an average sized adult, decrease the size by 0.5 mm internal diameter (ID).
    - If difficult intubation is predicted, a conventional tracheal tube or a Parker Flex-tip tracheal tube is recommended: size 7.0-7.5 mm ID for an adult female; 7.5-8.0 for an adult male.
    - 10 ml syringe for cuff inflation.

- Use a familiar commercial TT securing device (no tape).

- Tracheal tube adjuncts:
  - It is recommended that a bougie be used routinely for all tracheal intubations facilitated by a video-enabled or traditional direct Macintosh blade.
  - If a hyper-angulated blade video laryngoscope blade is chosen for use, a conventional or Parker Flex-tip TT tube is suggested, appropriately styleted to a 60 to 70-degree distal bend.
  - In experienced hands, a bougie that maintains a pre-shaped curve or is steerable may be used with a hyper-angulated video laryngoscope.

- Tracheal tube confirmation:
  - Waveform CO_2 is strongly recommended and should be attached proximal to the viral filter. Seeing six complete breaths with sustained amplitude confirms correct tracheal tube placement.
  - A colorimetric CO_2 detection device is an alternate if waveform capnography is not available.
  - A complete absence of CO_2 must not be ascribed to peri-intubation arrest or low-flow state: rather, esophageal intubation must be excluded.

- Supraglottic airway device:
  - A supraglottic airway device (SGD) should be selected based on the patient's weight. A second SGD, one size smaller or a different type should also be available.
  - The type of device should be based on provider familiarity and ease of placement and should ideally support endoscopically guided (with flexible intubation endoscope) tracheal intubation if needed. A 'second generation' device that also features an esophageal drainage port and is designed to obtain a better seal is ideal.
  - The EMS i-gel® with a passive oxygenation port is the currently recommended device for use in our Provincial emergency departments; other devices may be more familiar in other areas.

- Cricothyrotomy equipment:
  - Bougie, #10 scalpel blade and a 5.5 and 6.0 tracheal tube; pack of sterile gauze.

- Vascular access with two IVs should be in place. If not yet established, supplies for IV and intra-osseous (I-O) access should be available.

4.4 Pharmacologic preparation:

Drugs should be drawn up outside the room:

- Ketamine 1.0-1.5 mg/kg. Providers may choose to decrease the dose of ketamine for patients with a shock index of >1 (HR/SBP) by 25-50%.
- An induction sedative-hypnotic other than ketamine can be used, guided by provider familiarity and preference;
- Rocuronium 1.5 mg/kg;
- Succinylcholine 1.5 mg/kg can be used as an alternative to rocuronium.
- IM ketamine in the 50 mg/ml concentration should be available for behavior control, if needed.
- Push dose pressors should be drawn up in advance, labelled and ready to administer (e.g., norepinephrine, epinephrine or phenylephrine).

- A norepinephrine drip should be available before RSI, to be started at a dose of 0.1mcg/kg/min as necessary.
- Post intubation sedation and analgesia (bolus and infusion) should be readied. Choice of sedative should be governed chiefly by provider familiarity.
- 20-cc syringe of saline flush solution.

4.5 Personal Protective Equipment (PPE):
Provider PPE for all team members involved in tracheal intubation of the COVID-19 patient should be for airborne/droplet/contact precautions. Please consult with your local infection control authorities regarding exact PPE recommendations, as these may change subject to equipment availability. A checklist should be used for PPE donning and doffing (e.g., Appendix 4 & 5, respectively).

- SLOW DOWN: Regardless of the urgency to proceed with the intubation, take the time to don (and later doff) PPE safely. Designate one team member to be a 'checker' or coach. A 360-degree review of each team member should occur before entering the room.
- Peripheral vision, fogging and glare from PPE visors may cause challenges. Be prepared for this by having practiced with the equipment during simulation exercises beforehand.

4.6 Team Briefing outside room:
No matter their experience level, providers will be anxious about airway management for COVID-19 patients. These patients are critically ill and are physiologically compromised. Based on physiologically similar cohorts, post-intubation cardiac arrest may occur in up to 3% of critically ill patients.[8, 9] Regardless, the team must be reminded that their safety is the foremost priority (Video).

- Outside the room, the team leader should be identified. This individual may or may not be the primary airway provider.
- Primary team identified:
    - Primary airway provider;
    - Airway support provider (e.g., RT, medic);
    - Clinical support provider (e.g., nurse)
- Support team (if available) is identified with PPE donned in anteroom after the primary team has entered the patient's room:
    - Second provider as intubation support/cardiac arrest lead;
    - Airway support provider (e.g., RT, medic or nurse) as a 'runner' who can easily identify the requested equipment and pass it into the room.
- Articulate the plan to the team:
    - RSI as the default approach;
    - Preoxygenation strategy;
    - Review your plan for difficulty if encountered using the RSI visual aid (e.g., Appendix 2);
    - Assign specific airway roles for those inside the room (e.g., timing, bougie assistant, two-handed BVM ventilation);
    - The plan for confirmation of tracheal intubation using waveform CO_2. If unavailable, colorimetric CO_2 can be used;
    - The plan for transfer to mechanical ventilation, including how to do planned circuit disconnections, if required;
    - The plan for cardiac arrest;
    - Invite questions from the team.

4.7 Inside the room:
Preparation should be guided by a checklist with which the team has trained and become familiar (e.g., Appendix 6):

- Monitors applied to patient:
  - Standard SpO_2, ECG, non-invasive blood pressure (on the opposite arm to that to be used for medication administration, cycled at intervals of no less than 2 minutes);
  - Waveform CO_2 monitoring should begin with preoxygenation;
- Patient positioning:
  - The patient should be positioned in a back up (close to sitting or position of comfort) if hemodynamics permit. The bed can be transitioned to a flatter (but still somewhat back up or reverse Trendelenburg) position as the patient loses consciousness with RSI.
  - The head and neck should be positioned in the standard 'sniff' position;
  - Obese patients should be ramped (using blankets or a dedicated positioning insert) to also achieve ear-to-sternum 'sniff' positioning.
- Good free-flowing vascular access confirmed.
- Airway exam: evaluation of the patient's airway anatomy should occur. Dentures removed.
- Final briefing and review of cognitive aid (e.g., algorithm, Appendix 2) with any changes to the plan based on airway exam findings.

4.8 Pre-oxygenation:
COVID-19 patients being intubated for respiratory failure can be expected to desaturate rapidly with the onset of apnea during RSI. Thus, optimized pre-oxygenation is important. Once again recognizing the need to minimize the potential for aerosol generation during the process, options for pre-oxygenation include:

4.8.1 Continue the existing oxygen delivery modality for the pre-oxygenation phase:

- The patient requiring tracheal intubation shortly after arrival by EMS may already be receiving CPAP by cuffed facemask (with flows $\leq$ 15 lpm) system with viral filter and straps.
- Or, EMS may have used a standard BVM system applied to the patient with straps: facemask-viral filter-BVM with PEEP valve (Figure 2a). This may also be continued into the pre-oxygenation phase;
- The inpatient may have been receiving CPAP, HFNO or in rare cases, BiPAP: any of these modalities can simply be continued for the pre-oxygenation phase prior to RSI.
  - Notwithstanding, transferring the patient on CPAP or HFNO to standard cuffed mask and BVM device for pre-oxygenation provides the opportunity to confirm the size of mask is that needed for a good seal, before the potential need for positive pressure ventilation. Providers should consider both effectiveness and familiarity in choosing a pre-oxygenation setup, recognizing the same device may be needed to re-oxygenate the patient between attempts;
  - As previously indicated, these modalities should ideally be administered in a negative pressure, AIIR with staff wearing full airborne/droplet/contact PPE.

4.8.2 Change from nasal prongs or non-rebreathing mask to a more effective pre-oxygenation modality:

- The patient currently receiving oxygen supplementation by standard nasal prongs or NRFM proceeding directly to RSI will need to be transitioned to a more effective means of pre-oxygenation (Video);
- In some cases, ketamine administration may be required to facilitate tolerance of pre-oxygenation techniques;
- One option (e.g., Figure 2c) to provide some CPAP during pre-oxygenation is a bag-valve mask (BVM) flowing at 15 lpm with PEEP valve (10cm H_20) and viral filter, placed over nasal prongs flowing at 5-10 lpm. The need for additional flow administered by nasal prongs follows from the significant degradation of flow (often by 50% or more) through many disposable BVMs.
- Providers should additionally pay attention to the reservoir bag of the BVM to ensure it remains well inflated and is not collapsing. Should collapse occur, additional flow through the BVM (>15 lpm) may be necessary (see video).
- It is important that the BVM set-up has an integrated connector to enable monitoring of waveform CO_2. A good seal during pre-oxygenation should ideally be confirmed by the presence of a square waveform capnographic trace in the spontaneously breathing patient.
- Providing gentle manually assisted ventilations (pressure support) in tachypneic spontaneously breathing patients poses an additional risk of aerosolization when asynchronous breaths are delivered with a poor mask seal. This is not recommended.
- If available (e.g., in the operating room), end-tidal oxygen readings can be used to monitor efficacy of pre-oxygenation efforts.
- Regardless of the setting or pre-oxygenation technique, the goal in the pre-oxygenation phase is to achieve an SpO_2 > 90%, if feasible.

4.9 RSI and tracheal intubation should follow:

- Rapidly and safely performing an RSI to achieve high first pass success requires a team that has a shared plan (mental model) (Video)
- The team should be aware that these patients will often be apnea intolerant and that rapid oxygen desaturation should be expected.
- Adequate time (e.g., 50-60 seconds) must be given for the complete onset of neuromuscular blockade to minimize the possibility of coughing or gagging with airway instrumentation.
- Pre-oxygenation as described above can be continued after loss of consciousness while awaiting the onset of neuromuscular blockade. Here, CPAP transitions to apneic CPAP and requires an open airway with appropriate flows to maintain passive lung recruitment (Video).[3]
- Positive pressure bag-mask ventilation while awaiting the onset of neuromuscular blockade is ideally avoided but if elected, should be done with use of an oral airway, keeping insufflation pressures well below 20 cm H_20 and with attention to maintaining a good seal;
- Apneic oxygenation can be considered during laryngoscopy and intubation by continuing nasal prong oxygen flow at no more than 10 lpm;
- The clinician should stand straight during laryngoscopy, using indirect viewing via the video screen for both laryngoscopy and intubation (Videos).
- Despite these devices being used ‘indirectly’ it is critical that the user maintain awareness of what is happening when the blade, bougie or tracheal tube enter the mouth.

- Use of a bougie should be considered to facilitate all tracheal intubations using Macintosh videolaryngoscopy[10] (VL). If used, it must be extracted carefully and discarded in a trash bin next to the bed;
- The tube should be advanced until the cuff has just disappeared below the cords: auscultation to rule out endobronchial intubation will be difficult and is not advised;
- The cuff of the tracheal tube must be inflated prior to initiation of positive pressure ventilation;
- The BVM or ventilator circuit with viral filter should be attached to the proximal end of the tracheal tube;
- Sustained waveform capnography should be confirmed;
- Blood pressure should be reassessed;
- The tube should be firmly secured using a commercial securing device.

5. Failed first attempt at tracheal intubation (refer to algorithm, Appendix 2; Video).

5.1 Re-oxygenation:

If the first attempt at laryngoscopy and intubation fails, these patients will very likely desaturate before a second attempt. If needed, attempts to reoxygenate the patient must occur in a controlled manner. Options include:

- Gentle face mask ventilation with OPA, 2-handed mask hold/jaw thrust for a good seal and low tidal volumes (Fig 5., Video);
- Placing a second-generation SGD can be considered for both re-oxygenation and as a potential exit strategy (preferably one that support flexible endoscopic intubation).
- Apneic CPAP: Place an OPA. Re-apply the filtered BVM system, again with PEEP of 10 cm H_20 at a flow of 15 lpm over nasal prongs (e.g., at 5-10 lpm) without manual assistance (Video);

Recovery from a state of potentially low SpO_2 on the monitor will be delayed ('pulse-ox lag'). However, waveform capnography will provide true breath-to-breath feedback on the effectiveness of gentle positive pressure ventilation (PPV) by BVM or SGD. Monitoring this will help overcome the natural tendency to over-ventilate in response to low SpO_2 (e.g., with increased pressure, volume or rate) which risks mask seal leaks.

5.2 Further attempts at tracheal intubation after a failed first attempt:

- A further attempt at tracheal intubation can occur in the still-adequately oxygenated patient.
- A second attempt can occur with an optimized technique with the original device, use of a different device (e.g., hyper-angulated videolaryngoscope), or use of a different operator (Video). .
- Flexible endoscopic intubation through an intubating SGD is an option for the clinician skilled in the technique in the still-adequately oxygenated patient.

5.3 Failed tracheal intubation in the still-oxygenated patient

- Even if still adequately oxygenated, failure to intubate the COVID-19 patient in respiratory failure after a maximum of three attempts should prompt consideration to perform a surgical airway, as awakening the patient is unlikely to be a viable option.
- If not done to this point, an SGD should be placed while equipment and/or personnel to perform surgical airway are obtained, with attention to minimizing insufflation pressure and leak.
- The 'exit strategy' surgical airway should be performed in a timely fashion in the still-oxygenated patient to help minimize how long positive pressure ventilation must occur by face mask ventilation

or a SGD. It will ideally occur by an open surgical technique (e.g., scalpel/bougie cricothyrotomy) by the most available clinician able to perform the procedure.

- Any ongoing attempts at positive pressure ventilation by face mask or SGD ventilation during cricothyrotomy should be discontinued just before the cricothyroid membrane is incised, to avoid risk of aerosolization via the incision.

5.4 'Can't intubate, can't oxygenate'

- Distinct from the foregoing 'exit strategy' situation whereby surgical airway must occur in a timely fashion, emergency cricothyrotomy must be performed immediately if a 'can't intubate, can't oxygenate' (CICO) situation occurs (Video).
- The CICO situation is defined by the failure of at least one attempt at all of tracheal intubation, optimized face mask ventilation and SGD ventilation, with current or imminent hypoxemia.
- If CICO occurs, scalpel/bougie-assisted cricothyrotomy should proceed immediately by the most qualified individual already present (Video).

6. Post-intubation management:

- Ongoing sedation and analgesia should be addressed given the expected duration of pharmacologic paralysis with high-dose rocuronium;
- If intubated outside an intensive care setting, consideration should be given to maintaining pharmacologic paralysis with ongoing sedation during transportation to the setting of the patient's final disposition. This may help avoid accidental extubation or coughing and bucking during transfer.
- Initial ventilator settings should be consistent with a lung protection ventilation strategy, e.g., tidal volume 6 ml/kg predicted body weight; plateau pressure $\leq$ 30 cm H_2O; RR 25/minute; PEEP 8-10 cm H_2O; FiO_2 1.0, titrated down rapidly as permitted to maintain SpO_2 92-96% thereafter. Tidal volume should be reassessed and adjusted to keep the driving pressure (difference between PEEP and plateau pressure) below 15 cmH_20.[11]
- Ongoing hypoxemia post intubation can be addressed with options that include increasing FiO_2 if not already at 1.0; recruitment maneuver to re-recruit alveoli collapsed during the intubation process (e.g. inspiratory hold at 40cm H_2O x 10-15 seconds), maintaining pharmacologic paralysis and sedation and proning the patient;
- Consideration should be given to placing invasive vascular access in the same setting, e.g., arterial line and central venous access;
- Consideration should be given to placing a nasogastric tube;
- **Circuit disconnects** should be minimized:
  - If needed, they should ideally occur proximal to the viral filter.
  - If occurring distal to the filter (i.e., between tube and filter), first clamp the tube and also ensure that positive pressure ventilation from the ventilator or BVM has temporarily been suspended. After reconnection and tube de-clamping, confirm successful resumption of ventilation with waveform capnography.
  - The tracheal tube of a spontaneously breathing patient should be clamped only VERY briefly, for fear of development of negative pressure pulmonary edema.

7. Extubation of the trachea

Extubation of the COVID-19 patient may not occur for some days but may have to be addressed by ICU staff. Similarly, Anesthesia staff caring for COVID-19 positive patients undergoing urgent or emergency surgical procedures will need to extubate the patient. This is a similarly high-risk time with the potential for aerosolization of patient secretions due to cough. The following precautions should occur:

- Full airborne/droplet/contact PPE should be worn;
- Minimize staff in the room;
- Consideration can be given to transfer of the patient to a negative pressure AIIR environment for extubation;
- A clear plastic sheet can be transiently placed in front of the patient's face during extubation, to help limit droplet spread with any coughing that occurs immediately after extubation;
- Further efforts to avoid droplet/aerosol spread with cough after extubation might include:
    - Early application of the mask used for preoxygenation, reattached to the circuit distal to the filter;
    - Early application of a simple or non-rebreathing face mask (flow $\leq$ 15 lpm);
    - Nasal prongs/cannulae (flow $\leq$ 10-15 lpm) with application of a procedure or surgical mask.
- Use of an airway exchange catheter as a placeholder, (as may be done for the patient who was difficult to intubate) should not occur, to minimize the possibility of cough.

8. Cardiac arrest and **Protected Code Blue**[1, 8]

8.1 Peri-intubation cardiac arrest in the COVID-19 patient may relate to the combination of profound hypoxemia, medications and reduction in venous return from the onset of positive pressure ventilation after intubation. COVID-19 patients requiring tracheal intubation are at increased risk of peri-intubation cardiac arrest given their degree of hypoxemia and apnea intolerance during RSI. Return of spontaneous circulation (ROSC) in these patients can generally be accomplished with re-oxygenation, together with measures to support blood pressure and cardiac output. Resuscitation from arrest occurring in the context of tracheal intubation for the COVID-19 patient would involve staff already wearing airborne/droplet/contact precautions. Beyond this, standard resuscitation considerations apply, with the exception of ensuring that the cuff of the endotracheal tube is well-inflated, so that the intra-thoracic pressure generated with chest compressions (if needed) does not allow air to escape past an underinflated cuff.

8.2 Cardiac arrest occurring in the non-intubated patient on the ward or in the ICU unfortunately has a poor outcome[12]. Both chest compressions and positive pressure ventilation delivered to the non-intubated patient are both considered AGMPs and thus pose risk to the provider. The following are some additional considerations required for the 'protected code blue'[13].

- Limit resuscitation team numbers in the room;
- Pulse check and initial defibrillation (if indicated) can be done by a staff member in only droplet/contact PPE precautions; this staff member would exit the room immediately a staff member wearing full airborne/droplet/contact precautions enters to take over;
- Chest compressions are considered potential aerosol-generating: thus, compressions would only be initiated by staff wearing full airborne/droplet/contact precautions;
- Tracheal intubation is indicated as soon as a staff member with the skills and with airborne/droplet/contact PPE donned becomes available;
- Chest compressions should be discontinued during tracheal intubation, if performed, and only resumed once the tube's cuff is inflated and its correct position has been confirmed by CO_2 detection;
- The absence of any CO_2 return must be taken as an indication of esophageal intubation until proven otherwise ('no trace = wrong place');

- If used, BVM or supraglottic airway ventilation should occur with attention to a good seal, low insufflation pressures and with a viral filter attached;
- Consideration should be given to leaving the resuscitation cart outside the room and taking in specially prepared modular packs and the defibrillator[1].
- For further details, please see the NSHA document on protected code blue.

9. Other recommended resources:

1. Consensus statement: Safe airway Society principles of airway management and tracheal intubation specific to the COVID-19 adult patient group. Medical Journal of Australia pre-print (open access). Available at: https://www.mja.com.au/journal/2020/212/10/consensus-statement-safe-airway-society-principles-airway-management-and

2. Royal College of Anaesthetists COVID-19 Airway Management Principles https://icmanaesthesiacovid-19.org

3. Training and airway management videos related to management of the COVID-19 patient will be available at https://AIMEairway.ca and should be considered non-proprietary open access materials.

4. Coronavirus disease 2019 (COVI-19) from Life In The Fastlane (LITFL): updated weekly

10. References:

1. *Wax RS, Christian MD*. Practical recommendations for critical care and anesthesiology teams caring for novel coronavirus (2019-nCoV) patients. Can J Anaesth. 2020.
2. *Alhazzani W, Moller MH, Arabi YM, Loeb M, Gong MN, Fan E, et al.* Surviving Sepsis Campaign: guidelines on the management of critically ill adults with Coronavirus Disease 2019 (COVID-19). Intensive Care Med. 2020.
3. *Hui DS, Chow BK, Lo T, Tsang OTY, Ko FW, Ng SS, et al.* Exhaled air dispersion during high-flow nasal cannula therapy versus CPAP via different masks. Eur Respir J. 2019; 53(4).
4. NHS England. Guidance for the role and use of non-invasive respiratory support in adult patients with coronavirus (confirmed or suspected). 2020 [updated March 26, 2020March 31, 2020]; Version 2:[Available from: https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/03/CLEARED_Specialty-guide_-NIV-respiratory-support-and-coronavirus-v2-26-March-003.pdf.
5. *Alraddadi BM, Qushmaq I, Al-Hameed FM, Mandourah Y, Almekhlafi GA, Jose J, et al.* Noninvasive ventilation in critically ill patients with the Middle East respiratory syndrome. Influenza Other Respir Viruses. 2019; 13(4): 382-90.
6. *Murthy S, Gomersall CD, Fowler RA*. Care for Critically Ill Patients With COVID-19. JAMA. 2020.

7. *Brewster DJ, Chrimes NC, Do T*. Consensus statement: Safe Airway Society principles of airway management and tracheal intubation specific to the COVID-19 adult patient group. The Medical Journal of Australia. 2020; ((preprint)).
8. *Wardi G, Villar J, Nguyen T, Vyas A, Pokrajac N, Minokadeh A, et al.* Factors and outcomes associated with inpatient cardiac arrest following emergent endotracheal intubation. Resuscitation. 2017; 121: 76-80.
9. *Janz DR, Semler MW, Joffe AM, Casey JD, Lentz RJ, deBoisblanc BP, et al.* A Multicenter Randomized Trial of a Checklist for Endotracheal Intubation of Critically Ill Adults. Chest. 2018; 153(4): 816-24.
10. *Driver BE, Prekker ME, Klein LR, Reardon RF, Miner JR, Fagerstrom ET, et al.* Effect of Use of a Bougie vs Endotracheal Tube and Stylet on First-Attempt Intubation Success Among Patients With Difficult Airways Undergoing Emergency Intubation: A Randomized Clinical Trial. JAMA. 2018; 319(21): 2179-89.
11. *Amato MB, Meade MO, Slutsky AS, Brochard L, Costa EL, Schoenfeld DA, et al.* Driving pressure and survival in the acute respiratory distress syndrome. N Engl J Med. 2015; 372(8): 747-55.
12. *Shao F, Xu S, Ma X, Xu Z, Lyu J, Ng M, et al.* In-hospital cardiac arrest outcomes among patients with COVID-19 pneumonia in Wuhan, China. Resuscitation. 2020.
13. Couper Kea. COVID-19 infection risk to rescuers from patients in cardiac arrest. Consensus on science with treatment recommendations. . Brussels, Belgium: International Liason Committee on Resuscitation (ILCOR) [cited 2020 March 30]; Available from: http://ilcor.org.

Procedural Video Support Materials:

1. 2-handed mask application/ventilation: Use the V-E grip as part of an aggressive jaw thrust

2. Optimized video laryngoscopy using either a Mac blade and Hyperangulated blade

4. Pre-oxygenation CPAP and Apneic CPAP

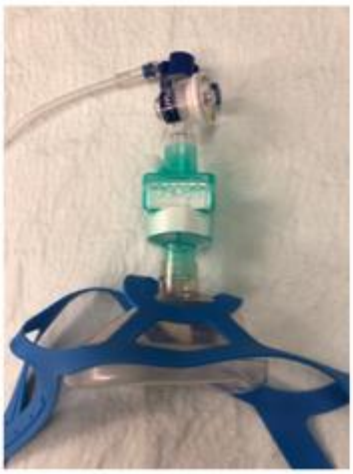
5. Emergency Cricothyrotomy (emergency Front of Neck Airway)

Approach Videos and Support Materials

1. Five approach videos and a summary video can be found (here)

2. Full resolution downloadable support materials are updated in a folder (here)

11. Figures and Appendices



Flow dependent CPAP mask with added viral filter

Low flow CPAP mask wit integrated viral filters

Figure 1: Flow dependent CPAP masks with viral filter

Figure 2a: BVM/PEEP/manometer, viral filter, mask

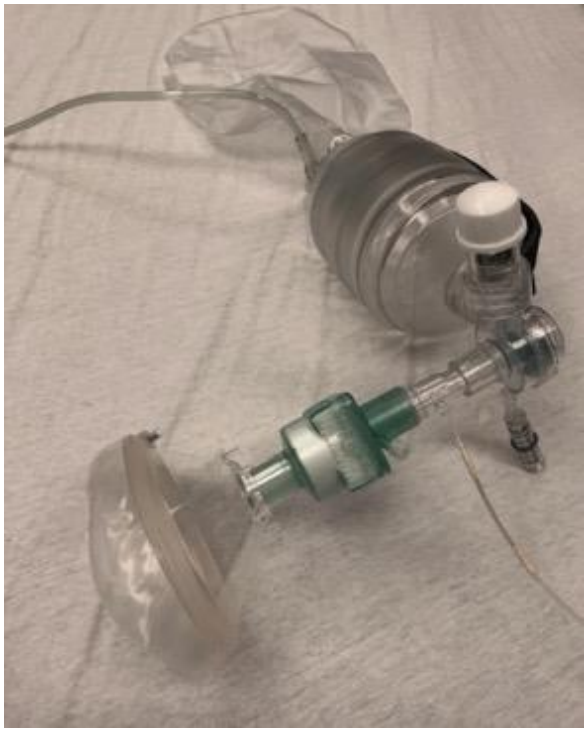


Figure 2b: BVM/PEEP/manometer, waveform CO_2 connector, viral filter, mask

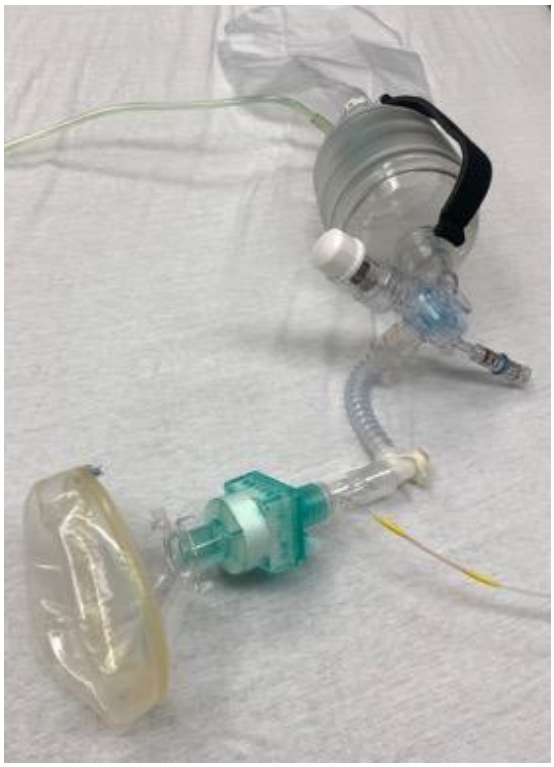


Figure 2c: BVM/PEEP/manometer, flexible mount, waveform CO_2 connector, viral filter, mask

Figure 3: Tavish® filtered non-rebreather mask. Photo source: https://www.respan.com/pages/covid-19-and-respan-filter-masks

Figure 4: HiOx™ non-rebreather mask with attached viral filter on expiratory port. Photo source: https://www.novusmedical.ca/covid19-the-hiox

Figure 5: Two-handed mask hold with a thumbs forward / thenar eminence ('V-E') grip and jaw thrust (video)

Rescuer Emergency CPAP System

Quick Instructions

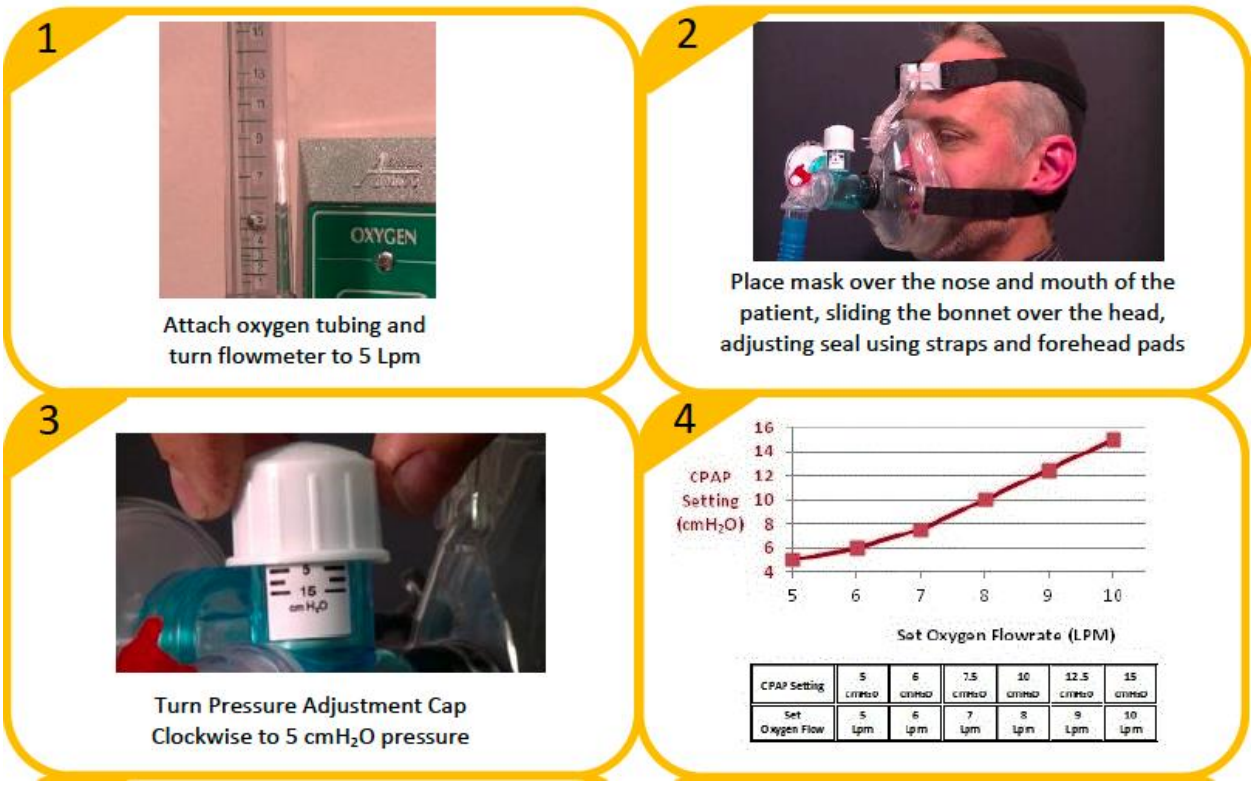
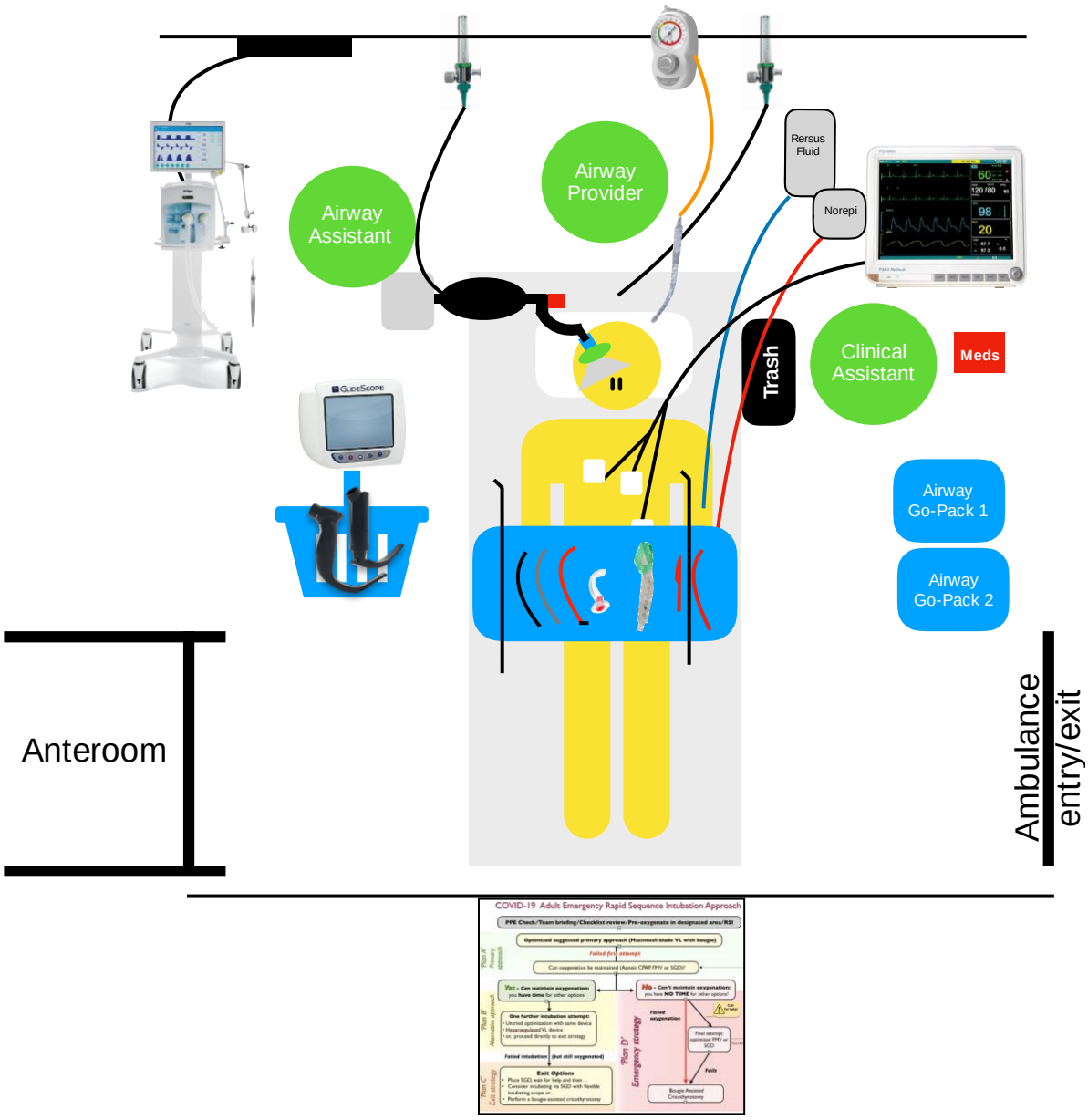


Figure 6: Rescuer Emergency CPAP System (e.g., 8700)

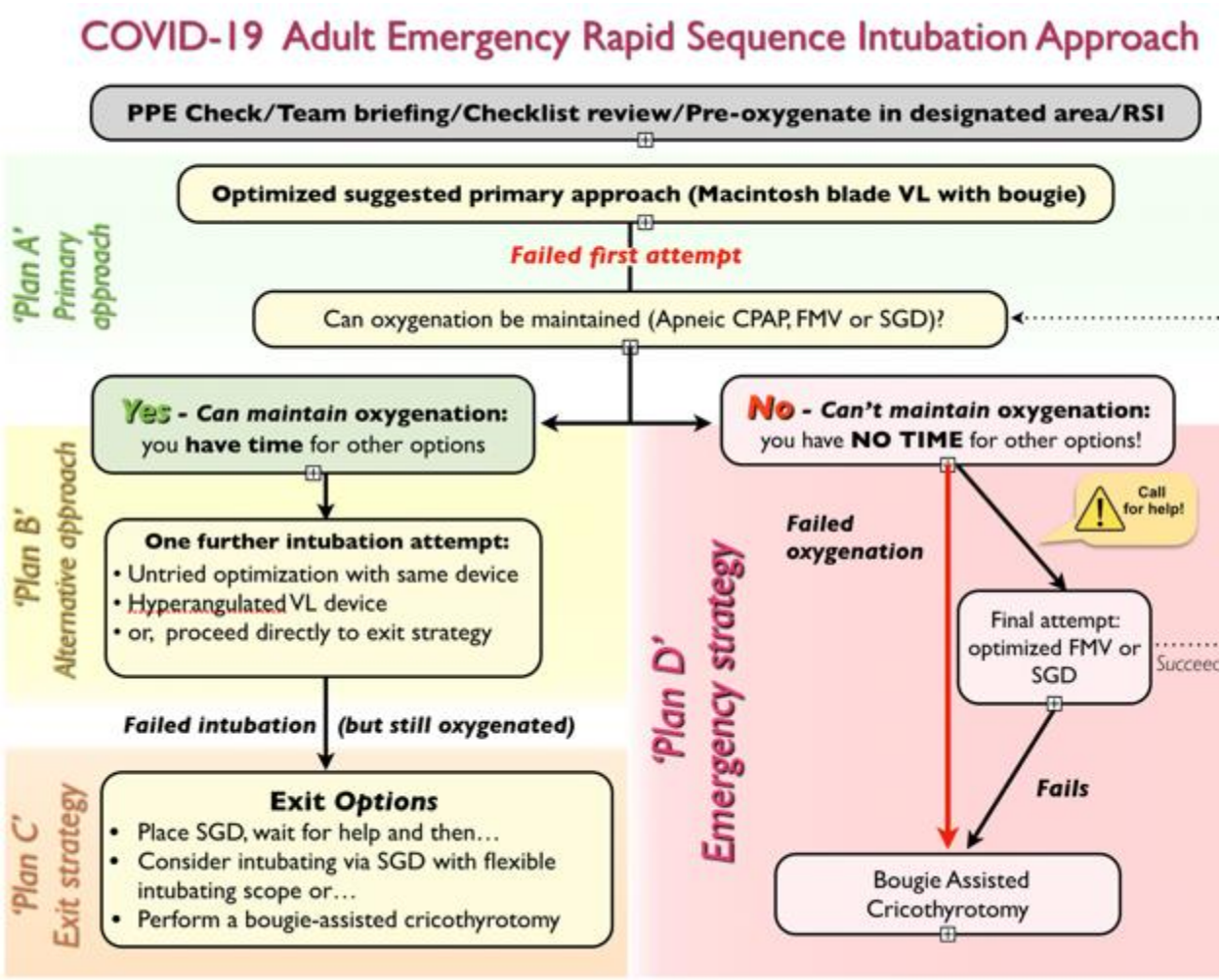
Appendices:

Appendix 1: Room mock-up

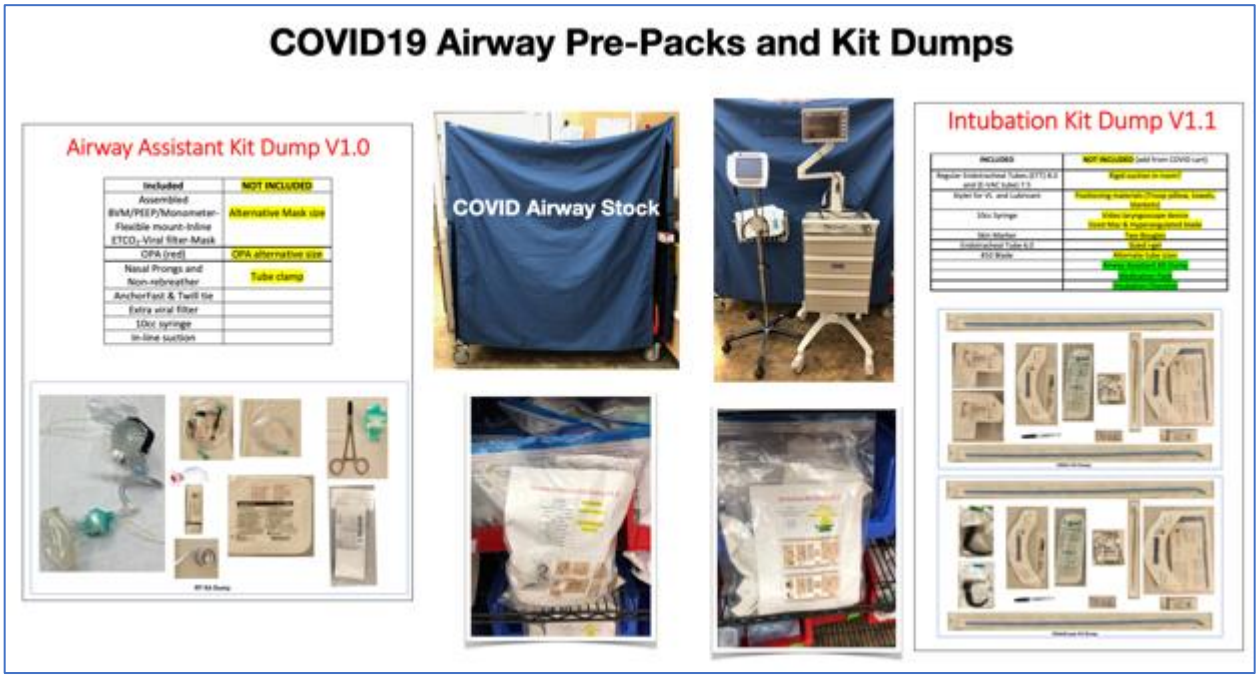


Room Mockup

Appendix 2: RSI algorithm visual aid



Appendix 3: Sample Airway Pre-packs and Kit Dumps



Appendix 4: Sample PPE donning/putting on checklist. Please refer to your institutional guidelines.

DONNING:

Step 1: Perform hand hygiene with alcohol-based hand sanitizer. Use water and soap if hands are visibly soiled.

Step 2: Put on Nitrile (blue) gloves.

Step3: Put on Splash resistant OR gown. Make sure gown covers from neck down. Tie at neck and waist.

Step 4: Put on N95 mask. Perform a seal check with each use. User should be fit tested prior to use.

Step 5: Put on Operator Surgical hood. Place on your Head, cross the straps under your neck and tie behind your neck loosely.

Step 6: Put on Face-shield. Adjust to fit. Note that eye-glasses are NOT acceptable face/eye protection.

Step 7: Put on fitted OR gloves. Ensure that these fit over the wrists of the gown. See image below for finished PPE.

Appendix 5: Sample PPE doffing/removing checklist. Please refer to your institutional guidelines.

DOFFING:

Step 1: Remove your outer, OR gloves. Use glove-to-glove, skinto-Skin technique, with the nitrile undergloves acting as your "skin."

Step 2: Remove the OR gown by untying in the back, and then grasping the outside of the gown by the shoulders and pulling it forward. Carefully turn the gown inside out during removal. Fold in a bundle and dispose.

Step 3: Remove your face shield. Handle only by the headband.

Step 4: Remove the Surgical Hood by untying in the back, and pulling carefully forward over your head.

Step 5: Remove the blue nitrile gloves.

Step 6: Hand hygiene with Ethanol based sanitizer.

Step 7: Exit patient room.

Step 8: Perform hand hygiene

Step 9: Remove N95 respirator. Remove the bottom tie first, then top. Allow to fall away from face.

Step 10: Perform hand hygiene.

Appendix 6: Sample Checklist in use in ED