SPECIAL ARTICLE

Difficult Airway Management in Adult Coronavirus Disease 2019 Patients: Statement by the Society of Airway Management

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See Article, p 873

The coronavirus disease 2019 (COVID-19) disease, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), often results in severe hypoxemia requiring airway management. Because SARS-CoV-2 virus is spread via respiratory droplets, bag-mask ventilation, intubation, and extubation may place health care workers (HCW) at risk. While existing recommendations address airway management in patients with COVID-19, no guidance exists specifically for difficult airway management. Some strategies normally recommended for difficult airway management may not be ideal in the setting of COVID-19 infection. To address this issue, the Society for Airway Management (SAM) created a task force to review existing literature and current practice guidelines for difficult airway management by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. The SAM task force created recommendations for the management of known or suspected difficult airway in the setting of known or suspected COVID-19 infection. The goal of the task force was to optimize successful airway management while minimizing exposure risk. Each member conducted a literature review on specific clinical practice section utilizing standard search engines (PubMed, Ovid, Google Scholar). Existing recommendations and evidence for difficult airway management in the COVID-19 context were developed. Each specific recommendation was discussed among task force members and modified until unanimously approved by all task force members. Elements of Appraisal of Guidelines Research and Evaluation (AGREE) Reporting Checklist for dissemination of clinical practice guidelines were utilized to develop this statement.

Airway management in the COVID-19 patient increases HCW exposure risk. Difficult airway management often takes longer and may involve multiple procedures with aerosolization potential, and strict adherence to personal protective equipment (PPE) protocols is mandatory to reduce risk to providers. When a patient's airway risk assessment suggests that awake tracheal intubation is an appropriate choice of technique, and procedures that may cause increased aerosolization of secretions should be avoided. Optimal preoxygenation before induction with a tight seal facemask may be performed to reduce the risk of hypoxemia. Unless the patient is experiencing oxygen desaturation, positive pressure bag-mask ventilation after induction may be avoided to reduce aerosolization. For optimal intubating conditions, patients should be anesthetized with full muscle relaxation. Videolaryngoscopy is recommended as a first-line strategy for airway management. If emergent invasive airway access is indicated, then we recommend a surgical technique such as scalpel-bougie-tube, rather than an aerosolizing generating procedure, such as transtracheal jet ventilation. This statement represents recommendations by the SAM task force for the difficult airway management of adults with COVID-19 with the goal to optimize successful airway management while minimizing the risk of clinician exposure. (Anesth Analg 2021;133:876–90)

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GLOSSARY

AEC = airway exchange catheter; **AGP** = aerosol-generating procedures; **AGREE** = Appraisal of Guidelines Research and Evaluation; **ARDS** = acute respiratory distress syndrome; **ATI** = awake tracheal intubation; **BIPAP** = bilevel positive airway pressure; **BMV** = bag-mask ventilation; **CICO** = cannot intubate, cannot oxygenate; **COVID-19** = coronavirus disease 2019; **CPAP** = continuous positive airway pressure; **CVCI** = cannot ventilate, cannot intubate; **Eto_2** = end-tidal O_2; **ETT** = endotracheal tube; **FDA** = US Food and Drug Administration; **Fio_2 =** fraction of inspired oxygen; **FIS** = flexible intubation scope; **HCW** = health care worker; **HEPA** = high-efficiency particulate absorbing filter; **HFNO** = high-flow nasal oxygen; **NIPPO** = noninvasive positive pressure oxygenation; **NIPPV** = noninvasive positive pressure ventilation; **IPAP** = inhalation positive airway pressure; **IV** = intravenous; **PAPR** = powered air-purifying respirator; **POM** = procedural oxygen mask; **PPE** = personal protective equipment; **RSI** = rapid sequence induction; **SAM** = Society for Airway Management; **SARS-CoV-2** = severe acute respiratory syndrome coronavirus 2; **SGA** = supraglottic airway; **VL** = videolaryngoscopy

The coronavirus disease 2019 (COVID-19) disease, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) 2019, often results in severe hypoxemia requiring airway management. Because the SARS-CoV-2 virus is spread via respiratory droplets, bag-mask ventilation (BMV), intubation, and extubation may all place health care workers (HCW) at risk.[1] While existing recommendations address airway management in patients with COVID-19, no guidance focuses specifically on difficult airway management. In addition, some strategies normally recommended for difficult airway management may not be ideal in the setting of COVID-19 infection. To address this issue, the Society for Airway Management (SAM) created a task force to review existing literature and current Practice Guidelines for the management of the difficult airway by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. The SAM task force then created recommendations for management of a patient with a known or suspected difficult airway in the setting of known or suspected COVID-19 infection. The goals of the task force were to optimize successful airway management while minimizing HCW exposure risk.[2] An unanticipated difficult airway may increase the risk of HCW infection if multiple intubation attempts or multiple providers are needed. This statement considers best practices and includes routine use of personal protective equipment (PPE), oxygenation approaches, and intubation strategies based on available evidence and information from clinical practitioners and airway experts. The recommendations in this statement are not intended to be standards or absolute requirements and may be adopted, modified, or rejected according to clinical needs and constraints and emerging literature.

METHODS

Elements of the Appraisal of Guidelines Research and Evaluation (AGREE) Reporting Checklist for the dissemination of clinical practice guidelines were utilized to develop this statement.[3] A task force of 10 clinical content experts from the SAM were assembled by the Society Executive Director (L.J.F.). Each member of the task force was assigned to conduct a literature review of a clinical practice section using standard search engines (PubMed, Ovid, Google Scholar). The task force members then created a summary of the literature for each subject based on their review. Each member then assembled existing recommendations and evidence for difficult airway management in the context of known or suspected infection with COVID-19. Recommendations were then reviewed by the task force members during scheduled web-based meetings. Each recommendation was discussed among the task force members and modified as needed until unanimously approved.

RESULTS

This report represents recommendations from the SAM task force for the management of the difficult airway in an adult with COVID-19.

Nonanatomic Difficult Airway Considerations in Adult COVID-19 Patients

- A difficult airway may be present due to the inability to ventilate, intubate, oxygenate, or any combination of the preceding. The baseline incidence of the difficult airway may be increased in COVID-19 patients due to anatomical, physiological, and contextual issues.

In addition to known anatomic considerations, critically ill COVID-19 patients may have a physiologically difficult airway. These patients are often critically ill, may have already failed noninvasive positive pressure oxygenation (NIPPO/high-flow nasal oxygen [HFNO]) or ventilation, may require urgent/emergent intubation due to cardiorespiratory collapse, and are at risk of worsening hemodynamic instability during intubation.[4,5] COVID-19 patients may also develop airway edema, acute respiratory distress syndrome (ARDS), acute kidney injury, myocardial dysfunction, and coagulation abnormalities.[6–8] Under these situations, the difficulty of airway management and incidence of complications are increased. In the emergent setting outside the operating room, additional space constraints and lack of needed equipment and personnel add additional challenges.[8–10] While not all COVID-19 patients may exhibit anatomic or physiological predictors of difficulty, early recognition of the difficult airway is important to permit adequate preparation to reduce exposure risk and complications.

Risk of Aerosolization, PPE, and Intubation Team

During airway management, BMV, tracheal intubation, and extubation are aerosol-generating procedures (AGP).[1,11–14] Currently, neither the magnitude of the viral load that can be aerosolized nor the minimum infectious dose for COVID-19 has been established.[15] While the infection rate in health care providers after performing intubations in COVID-19–positive patients is unclear, studies suggest that HCWs may be at increased risk of COVID-19 infection after an airway management episode involving an infected patient.[16–19] In patients with a difficult airway, airway management may take longer and involve more HCW and aerosolizing procedures.[20] Therefore, the same or greater level of aerosol protection should apply to all airway procedures in COVID-19 patients with a difficult airway, including diligent use of PPE. Although a powered air-purifying respirator (PAPR) is the preferred level of PPE during airway management, these systems are more difficult and take more time to don than an N95 mask and face shield. Therefore, an early assessment of the need to manage the airway of a known or suspected COVID-19 patient should be made.

Additionally, airway management of a known or suspected COVID-19–infected patient should be performed in a negative pressure room, if available.[19]

Many lessons have been learned from the SARS, Ebola, and currently with the COVID-19 outbreak related to airway management, PPE, and the intubation team.[21,22] To minimize the number of HCW in the room, the intubation team should consist of highly skilled personnel to minimize the number of HCW in the room if feasible. As an illustration, an intubation team would include the following:

1. Intubator: A provider experienced in advanced airway management techniques (increases success rate and decreases the number of personnel needed in the room).[23,24]
2. Spotter: To help don and doff team's PPE, provide needed equipment from a difficult airway cart kept outside the patient room.
3. Respiratory therapist (for difficult airways outside of the operating room).
4. The second assistant to the intubator (if possible) to administer medications.
5. The patient's nurse.

Difficult Airway Equipment. A difficult airway cart should be located directly outside of the room. The cart need not be brought into the room unless needed to minimize contamination of equipment. Equipment should include different sized endotracheal tubes (ETT), intubating supraglottic airway (SGA; preferably second generation), Macintosh and Miller blade and handle, drugs, scalpel and bougie, videolaryngoscope, and flexible intubation scope (FIS). Use of disposable equipment is preferred, if available (Figure 1).

Before entering the room, the intubation team should discuss the airway management plan and verify that all equipment and medications are available ("airway time out").Verbal communication among providers may also be more difficult while wearing a PAPR, which adds additional importance to the airway time out and clear delineation of roles.[25]

Use of PPE and adherence to appropriate PPE protocols reduces the incidence of contamination during intubation and doffing, and their use has been described elsewhere for COVID-19 intubations.[24,26–33] The effect of PPE may not only impair communication between the airway team, but studies have also shown prolonged time to intubation during airway management, which should be taken into consideration.[9–11]

AIRWAY MANAGEMENT BARRIERS (PLEXIGLASS BOX AND PLASTIC COVERS)

In addition to PPE availability and use,[34,35] barrier methods have been developed to protect HCWs from contamination with biohazards and viral particle spread during AGPs. Protective shields and barrier-enclosure systems were approved by the US Food and Drug Administration (FDA) in May 2020 to be used in addition, not as alternatives to proper PPE to decrease the spread of viral particles associated with the care of COVID-19 patients.[36] Concerns about safety performance prompted the FDA to revoke the permit in August 2020. Barrier enclosures without the possibility of additional negative pressure are no longer recommended.[37]

The effectiveness of barriers in decreasing viral transmission to HCW during airway management remains unclear in part due to the lack of proper scrutiny and research. Transmission of SARS-CoV-2 viral particles can still occur with barrier use via aerosolized viral particle escape through the existent operative holes or when the box is removed.[38,39] In addition, barriers deviate from standard practice, potentially worsening performance, and may increase the complexity and duration of the intubation process. They limit the use of airway management devices that require space and impair the use of a second pair of hands to assist during the procedure. During an emergency, when rescue airway procedures are required, barriers may

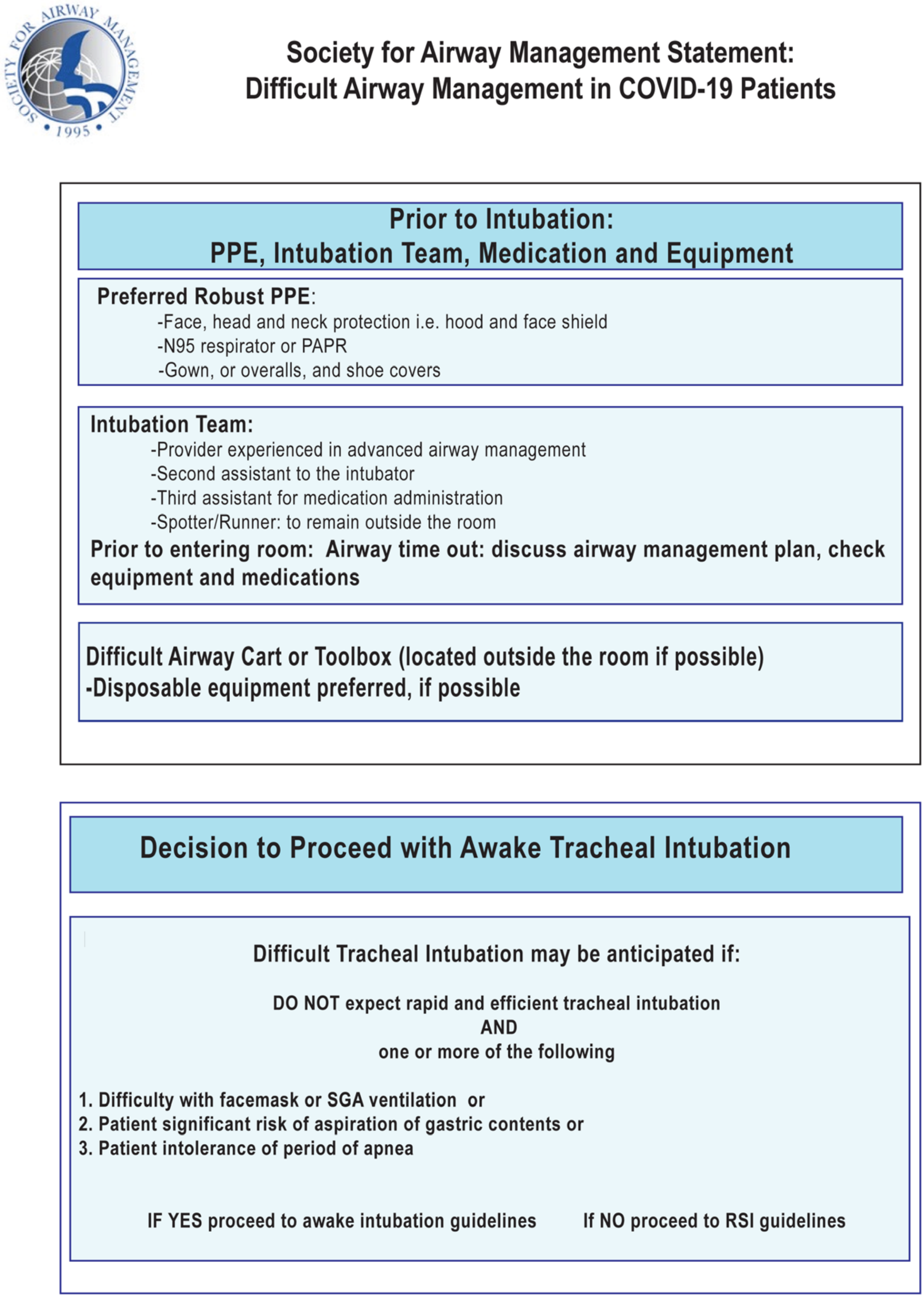

Figure 1. Society for Airway Management recommendations: before intubation preparation and decision to proceed with awake tracheal intubation. COVID-19 indicates coronavirus disease 2019; PAPR, powered air-purifying respirator; PPE, personal protective equipment; RSI, rapid sequence induction; SGA, supraglottic airway.

prevent an effective response. Simulation experiences have demonstrated that aerosol boxes for intubation are associated with higher failure rates and prolonged intubation times.[40] These limitations are concerning during the intubation of routine airways and extubation, and in case there is a difficult airway.[41]
Recommendations:

1. Risk factors for the physiologically difficult airway should be weighed before formulating an intubation plan. In COVID-19 patients, these include hypovolemia from aggressive diuresis, chronic oxygen desaturation, pulmonary hypertension, myocardial dysfunction, and cardiovascular collapse.
2. If feasible, the intubation team for difficult airway management should consist of 4 providers: a provider experienced in advanced airway management techniques, a second assistant also familiar with airway management, a respiratory therapist, and a spotter (who remains outside the room).
3. Use PPE as described in COVID-19 airway management guidelines for nondifficult airways.
4. If available, we recommend the use of a PAPR device as the first line of PPE for emergent intubations.
5. A difficult airway cart, which remains outside the patient room, should include disposable equipment, when possible.
6. An intubating "box" or barrier device is not recommended for management of the difficult airway in the known or suspected COVID-19 patient.

Preintubation Oxygenation

COVID-19 patients with respiratory distress due to hypoxemia may require tracheal intubation and mechanical ventilation.[42,43] Preoxygenation increases the time to oxygen desaturation after induction/relaxation and may reduce the likelihood of cardiorespiratory arrest due to severe hypoxemia. In the COVID-19 patient with the difficult airway, preoxygenation is critically important due to the high likelihood of hypoxemia and because the duration of difficult airway management may be longer than in a nondifficult airway.

Preoxygenation Before Induction. Preoxygenation in COVID-19 patients with a known or suspected difficult airway is similar to that in a COVID-19 patient without a suspected difficult airway. In both circumstances, an appropriate facemask with a tight seal and attached to a high-efficiency particulate absorbing filter (HEPA) filter provides optimal preoxygenation in a spontaneously breathing patient. The goal is to achieve an end-tidal O_2 (Eto_2) level of 90% as measured by a gas analyzer or for 3 minutes if an analyzer is not available. In the physiologically difficult airway where cardiorespiratory arrest may be imminent, neither goal may be possible, and attempts to deliver oxygen should continue throughout the intubation process.

In patients with respiratory insufficiency due to COVID-19, HFNO or noninvasive positive pressure ventilation (NIPPV: continuous positive airway pressure [CPAP]/bilevel positive airway pressure [BIPAP]/inhalation positive airway pressure [IPAP]) is commonly used.[44–46] These strategies do not preoxygenate as effectively as a well-sealed facemask.[4,32,47–54] In addition, Eto_2 cannot be measured with HFNO and the risk of aerosolization/contamination may be higher than when preoxygenation is delivered by facemask. Particularly for the difficult airway, facemask oxygenation if possible is likely to deliver better preoxygenation.

Oxygenation During the Period Between Muscle Relaxant Administration and Successful Intubation. During the apneic period between induction and successful intubation, patients may desaturate due to lack of ventilation.[53] In patients with COVID-19, desaturation can be rapid and persistent. The optimal method to deliver oxygen during this period is unclear. Evidence supporting the efficacy of apneic oxygenation during intubation with either HFNO or low flow nasal oxygenation (5–15 L/min) is mixed.[54–63] Additionally, apneic oxygenation may increase the risk of droplet aerosolization.[17,46] In patients with COVID-19 and a difficult airway, in light of the limited efficacy of apneic oxygenation to prevent oxygen desaturation after induction/muscle relaxation, and potentially increased risk of aerosolization, when hypoxemia is present or imminent, we recommend BMV with a well-sealed face mask.[1,64] If BMV results in a significant mask leak, an SGA could be inserted to improve seal and facilitate ventilation.[65] A second-generation intubating SGA could also serve as a conduit for flexible scope-guided tracheal intubation. Apneic nasal oxygenation may be considered; however, if the nasal cannula is adversely affecting the BMV seal, it should be removed. HFNO should not be used in conjunction with BMV due to concern of gastric insufflation.[66,67]
Recommendations:
Preoxygenation before induction:

1. Deliver Fio_2 1.0 using a well-sealed facemask with a HEPA filter.
2. Target Eto_2 90% if possible (when a gas analyzer is available).
3. HFNO/NIPPV may be considered as an alternative technique, but end-tidal gas analysis is not available, and it may increase aerosolization risk.

Oxygenation after induction:

1. When hypoxemic, perform BMV with a well-sealed facemask.

2. When BMV is ineffective or results in a significant leak, insert a SGA, preferably a second-generation intubating SGA, to facilitate ventilation.
3. Consider the application or continuation of apneic nasal oxygenation.

Pharmacology for Airway Management

Clinical characteristics of COVID-19 patients requiring intubation include hypoxemia, tachypnea, hypotension, tachycardia, pulmonary hypertension, and altered mental status.[19] Acute kidney injury and hypercoagulability are also features of severe COVID-19 infection.[6,7]

Thus, the presence of the previous risk factors in critically ill COVID-19 patients thus increases the risk of a physiologically difficult airway. Precautions for such patients have been published previously, with recommendations about choice of induction agent and use of lower doses to avoid exacerbating hemodynamic instability, and ready availability of vasopressor infusions and resuscitation tools.[5,19] Muscle relaxants should be selected to provide optimal intubating conditions and may require redosing for repeated attempts or reversal to facilitate reestablishment of spontaneous breathing. Succinylcholine should be used with caution in COVID-19 patients who present with acute kidney injury, as they may have elevated potassium levels.[6,7]

In combative or delirious patients who will not cooperate with awake intubation, the use of ketamine in small increments or dexmedetomidine may be considered because each is less likely to cause respiratory depression.[5]

Recommendations:

1. Review patients for risk factors for physiological difficulty.
2. Consider lower doses of induction agents.
3. Ready availability of vasopressor infusions and resuscitation tools.
4. Succinylcholine should be used with caution.

Awake Tracheal Intubation

Awake tracheal intubation (ATI) is often used to manage the difficult airway patient when routine induction of anesthesia, with or without neuromuscular relaxation, may result in a cannot intubate–cannot ventilate situation or other complications. The decision to use ATI is based on an assessment that weighs the risk of routine induction of anesthesia against the likelihood of awake intubation success, the ability of the patient to cooperate with the procedure, and the consequences of this more prolonged intubation technique. In patients with COVID-19, the extended time needed to perform ATI may increase the risk of severe oxygen desaturation and cardiorespiratory arrest and prolong HCW exposure. Additionally, preparation of the patient for ATI, as well as inadequate airway analgesia during airway management, may be associated with cough and gag, which likely result in increased airway secretion aerosolization. These COVID-19–related patient and HCW risks can temper the decision to proceed with ATI.[68,69]

Decision to Proceed With ATI

As noted earlier, few absolute indications exist for awake intubation. Importantly, any decisions regarding the approach to securing an airway must be made by the particular clinician tasked with caring for that patient and be based on variability in experience, availability of devices and skilled aid, and the context in which airway management will take place. When evaluating a patient at risk of having a difficult airway, 3 airway findings may trigger a decision to perform ATI: (1) tracheal intubation and facemask or SGA ventilation are not expected to be rapidly and efficiently achieved; (2) tracheal intubation is not expected to be rapidly and efficiently achieved and the patient is at significant risk of aspiration of gastric contents; (3) tracheal intubation is not expected to be rapidly and efficiently achieved and the patient may not tolerate the period of apnea that would accompany routine or complicated induction of hypnosis and airway control (Figure 1).

Because of the risk to both the patient and HCWs described earlier, alternatives to ATI may be considered. These options include consultation with a more experienced clinician, if available, whose risk assessment or assistance may allow routine management, or, in the case of medical consultation for airway management in an ICU setting, explore options for medical intervention that do not involve tracheal intubation.[52] The need for tracheal intubation and the assessed need to use an ATI technique are independent. When the risk of ATI (to both the patient and HCW) is high, seeking an alternative to tracheal intubation may be warranted.

Specific Issues With ATI

A provider experienced in advanced airway management techniques should evaluate the patient and decide whether ATI is needed.

Options to provide supplemental oxygen during the procedure include use of respiratory masks that allow endoscope passage (eg, endoscopy mask; Figure 2), use of low or high flow nasal cannula, and use of bronchoscope adaptors (when using a SGA as a conduit). As noted previously, HFNO/NIPPO increases the risk of aerosolization and may increase the risk of disease transmission.

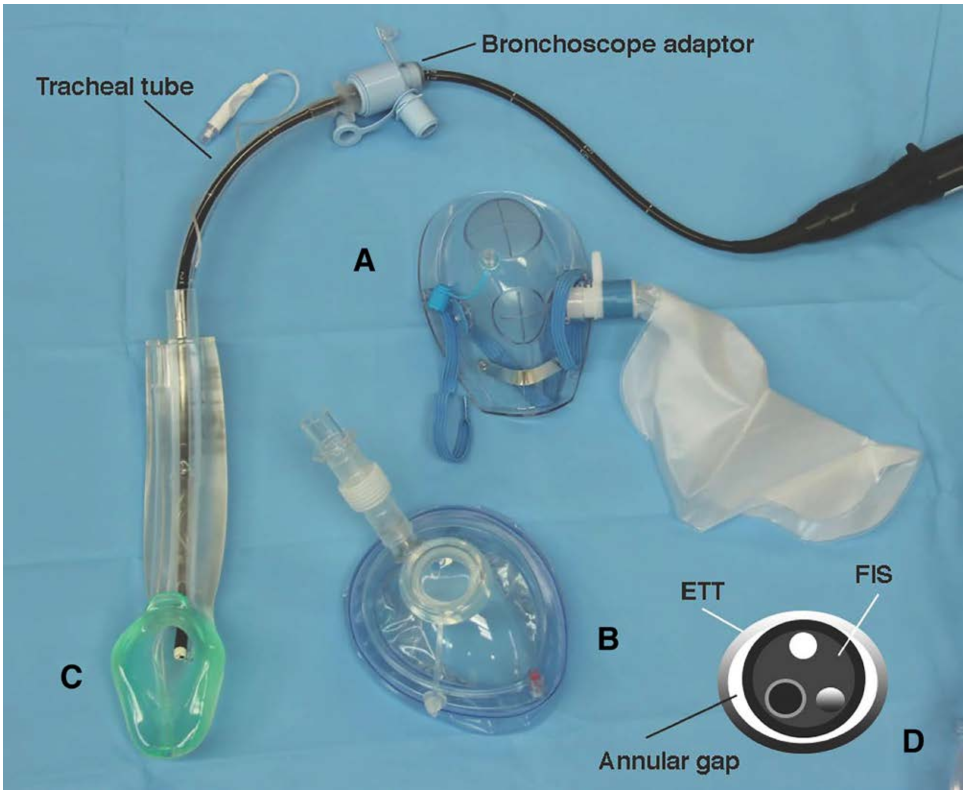

Figure 2. Airway adjuncts providing supplemental oxygen during ATI procedure. A, POM mask (POM Medical LLC), (B) Patil-Syracuse style endoscopy mask, (C) tracheal tube, with bronchoscope adaptor on proximal end, advanced through an SGA with an FIS; (D) illustration of cross-section of tracheal tube-FIS fit demonstrating minimal annular. ATI indicates awake tracheal intubation; ETT, endotracheal tube; FIS, flexible intubation scope; POM, procedural oxygen mask; SGA, supraglottic airway.

If needed, sedation should be administered judiciously. As the patient may be physiologically compromised, the clinician should use their clinical judgement during titration. The goal of sedative use should be to alleviate patient anxiety while maintaining adequate spontaneous ventilation and cooperation. Small amounts of opioids (eg, 25–50 μg fentanyl intravenous [IV]) may reduce coughing. Antisialogogues, such as glycopyrrolate, can be administered before ATI to facilitate topical blocks and decrease airway secretions.

Because the nasal cavity may have a high viral particle load, nasal tracheal intubation may increase the risk of disease transmission.[70,71] However, if contextual conditions (eg, patient condition, operator experience, etc) favor this route, then nasal tracheal intubation is a viable alternative.

Topical anesthesia is needed for ATI and administration should be routine as per the practice of the operator. In difficult airway patients with COVID-19, procedures with a high risk of coughing such as transtracheal (translaryngeal) injection of local anesthetics should be avoided. Using techniques such as injecting local anesthetics into the larynx and trachea via a flexible bronchoscope or encouraging the patient to aspirate viscous or solutions of local anesthetic delivered to the hypopharynx can be used (eg, holding the patient's tongue with a gauze pad as a local anesthetic is trickled into the pharynx.)

Possible Intubation Techniques

Flexible Intubation Scope. If an FIS is used, then a remote screen (video image) should be used if possible as it moves the operator's face away from the patient's airway and reduces the chance of infectious exposure during coughing and other aerosolizing patient reactions. The gap between the outer diameter of the FIS and the inner diameter of the tracheal tube should be minimized to reduce the likelihood of difficulty passing the tracheal tube past the vocal cords and thus limit aerosol spread during intubation. Single-use FIS is preferable due to difficulties in cleaning reusable devices. Properly secured suction through the working channel is unlikely to increase infection risk. In contrast, oxygen insufflation may increase the likelihood of aerosolization. An endoscopy mask (Figure 2) may be used to enclose the patient's mouth and nose during the procedure.

Videolaryngoscope. If a videolaryngoscope is used for ATI, then a detached screen will allow the operator to move his/her face away from the path of coughing and other aerosolizing patient reactions.
Recommendations:

1. A provider experienced in advanced airway management techniques should determine and perform ATI if it is required.
2. Take steps to minimize aerosolization during airway topicalization whenever possible, and

weigh risks and benefits of atomizing nebulizing and transtracheal injection techniques.

3. Consider oral intubation as a first-line approach whenever possible.
4. When feasible, performing the ATI through the access ports on a full-facemask device (eg, endoscopic mask) may reduce operator exposure to respiratory secretions.

INTUBATION AFTER INDUCTION

Videolaryngoscopy

Several specialty groups and societies have now addressed intubation approaches for the COVID-19 patient.[19,43,72–74] Taken together, these recommendations uniformly call for videolaryngoscopy as the primary intubation approach for patients with COVID pneumonia.

Although videolaryngoscopy is not new to routine or difficult airway management, the benefit in COVID-19 is that it allows physical distance between the provider's face and the patient's airway, thus potentially reducing the chance of exposure to droplet-based infection. Existing data suggest that use of videolaryngoscopy may also result in easier intubation performance with less failure and fewer attempts than direct laryngoscopy when used by an experienced provider.[75] In difficult airway patients, videolaryngoscopy improves intubation success when compared to direct laryngoscopy.[19,75–78] Thus, for the COVID-19 patient with a difficult airway, it is thus logical to deploy dedicated airway teams facile with videolaryngoscopy for urgent tracheal intubation. A recent series of emergency COVID-19 tracheal intubations from Wuhan supports the use of videolaryngoscopy.[19] A dedicated team of 54 anesthesiologists achieved a high success rate of tracheal intubation, mostly utilizing videolaryngoscopy.

Hyperangulated videolaryngoscopy does have some drawbacks when compared to direct laryngoscopy. If secretions or blood are present, then visualization through a dirty camera lens may be substandard. Also, the increased curvature of hyperangulated videolaryngoscopes can increase the difficulty of passing the ETT through the cords even if they are well visualized. Although such limitations are uncommon, patients who require intubation for COVID-19 are often in extremis and little time is available to switch to a different laryngoscope. This time constraint is even more acute when the airway is difficult. We thus recommend that airway managers have a direct laryngoscope readily available in case videolaryngoscopy fails.

Recommendation:

Videolaryngoscopy by a skilled provider should be the primary laryngoscopic technique for asleep intubation of the difficult airway COVID-19 patient if available. If a provider is more skilled with direct laryngoscopy for difficult airway management, or if videolaryngoscopy fails, then those tools should be available as well (Figure 3).

Intubation Through an SGA

When initial attempts at intubation are unsuccessful, oxygenation with tightly sealed BMV and a HEPA filter may minimize aerosolization while placement of an intubating SGA is considered.[79] Preferably, a second-generation SGA may be used due to its higher oropharyngeal leak pressure, allowing for higher respiratory pressure as well as possible drainage of regurgitated material.[80,81]

When FIS-facilitated intubation is planned via an intubating SGA, attaching a HEPA filter to the breathing circuit will reduce exposure to exhaled droplets and allow for the insufflation of oxygen throughout the intubation procedure. In addition, placement of an ETT with a bronchoscope adapter and inflation of its cuff within the SGA can reduce leaking during the procedure (Figure 2).

A nonintubating SGA may also be considered but requires the use of an intermediate Aintree Catheter and FIS. When the placement of the SGA is unsuccessful, perform BMV as described previously while preparing for emergency invasive airway management (Figure 2).

Recommendations:

1. Use tight seal BMV to minimize aerosolization, and use of an intubating SGA (preferably second generation) to facilitate intubation.
2. If SGA placement is unsuccessful, then perform BMV as described previously while preparing for emergency invasive airway management.

Emergent Invasive Airway Management

Emergent invasive airway management (cricothyrotomy) may be necessary for COVID-19 adult patients if noninvasive airway management fails or in the "cannot ventilate, cannot intubate" (CVCI) or "cannot intubate, cannot oxygenate" (CICO) situation. Although recommendations for airway management are often based on patient, institutional, and geographic factors, many guidelines recommend a scalpel-based, open surgical airway for patients with COVID-19.[42,82]

A surgical airway is traditionally performed by making an incision through the skin, subcutaneous tissue, and cricothyroid membrane into the lumen of the trachea, followed by the insertion of an ETT.[83] With respect to COVID-19, clinicians must balance the complexity and need for special equipment characteristic of many open surgical emergency surgical airway techniques with more simple surgical airway techniques.

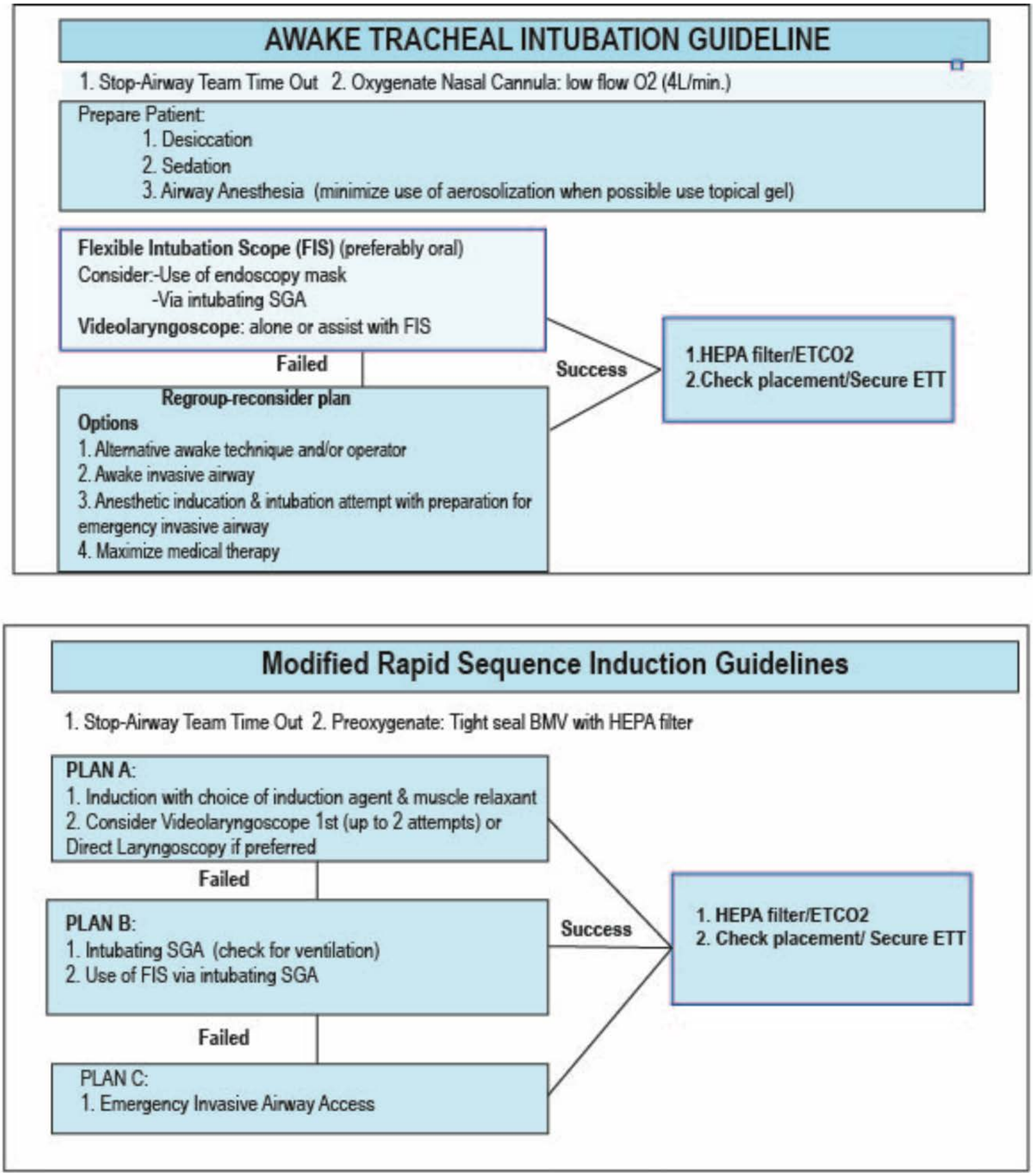

Figure 3. Algorithms for awake tracheal intubation and modified rapid sequence induction. ETT indicates endotracheal tube; FIS, flexible intubation scope; HEPA, high-efficiency particulate absorbing filter; SGA, supraglottic airway.

For COVID-19 patients who require invasive surgical access, concerns include a high first-pass success rate, the least amount of patient harm, and to minimizing infectious risk to providers.[84] Given the time-critical nature of the emergency invasive airway, the technique used should be as simple and rapid as possible, be well-rehearsed, and not require special equipment.

We believe that appropriate decision making, availability of equipment, technical ability, and human factors considerations are essential for the appropriate and successful performance of emergency invasive airway access techniques when a CICO event occurs.[85] An experienced anesthesiologist, surgeon, or another experienced practitioner should perform the procedure (not trainees). In addition to full sedation/

analgesia, adequate neuromuscular blockade should be provided to prevent coughing and resultant aerosolization of respiratory droplets.

We recommend the performance of the bougie-assisted cricothyrotomy[86] or scalpel-bougie-tube technique[87] in COVID-19 adult patients who require emergent airway rescue. Such an approach has a high success rate in non–COVID patients and should translate to patients with COVID-19.[88,89] Ventilation should be discontinued before opening the cricothyroid membrane and held until placement of the definitive airway. If difficulty is encountered in placing the airway and the patient needs to be ventilated again by a bag-valve-mask, then the cricothyrotomy opening should be occluded with a finger to prevent air leak. If the cricothyroid membrane cannot be located, then an open cricothyrotomy is recommended.[89]

In non–COVID-19 patients, the need for invasive emergency airway has been associated with low survival rates.[90] In the COVID-19 era, recovery from cardiac arrest has likewise been low.[91] Because the performance of these invasive procedures increases HCW exposure to COVID-19 infection, the decision to include emergency invasive airway procedures in this process should be considered by each institution. Recommendations:

1. Use simple surgical techniques, such as the scalpel-bougie-tube cricothyrotomy, in airway emergencies requiring invasive airway access.
2. Refrain from using jet ventilation as it increases aerosolization of viral particles.
3. Discontinue ventilation immediately before the cricothyroid membrane puncture to minimize aerosolization through the cricothyroid puncture site.
4. Include a scalpel, ≤6.0 ETT, and adult bougie as equipment in the difficult airway cart.
5. Technical competency and familiarity with emergency invasive airway access techniques may improve the successful management of emergent airway rescue situations.

ETT Exchange

ETT exchange or manipulation may be needed in COVID-19 patients due to cuff rupture, inadvertent extubation, or acute ETT obstruction caused by thick secretions and/or sloughed tracheobronchial tissues and inflammatory cells.[92] Such obstruction may limit the ability to oxygenate and ventilate and places the patient at risk for further desaturation. In patients with a difficult airway, this risk is increased as the time needed to change the ETT may be prolonged. The procedure may increase HCW exposure to aerosolized secretions.

To minimize exposure and increase the rate of success, patients should be fully paralyzed and sedated during the procedure. An airway exchange catheter (AEC) is recommended to facilitate ETT exchange and a bronchoscope adaptor placed between the ETT and ventilator circuit will allow an AEC to be used with less aerosolization of secretions. As patients may have airway edema, and to reduce the duration of extubation or aerosolization, a videolaryngoscope is recommended during tube exchange to improve visualization of the glottis and passage of the new ETT during exchange[93] (Figure 4). Recommendations:

1. Use an AEC through bronchoscope adapter between ETT and ventilator circuit.
2. Use videolaryngoscope during ETT exchange.

Extubation Considerations

The risk of contamination during extubation is potentially even higher than for intubation, as muscle relaxation has been reversed, and the patient is spontaneously ventilating and may cough or exhale forcefully. A recent study of aerosolization during perioperative airway management found more detectable aerosol (15-fold) during extubation when compared to intubation.[94] Complications that occur during extubation, such as stridor, laryngospasm, or acute airway obstruction, may require positive pressure ventilation by mask and reintubation, which generate aerosols.

Risk factors have been described for complications during extubation.[95,96] These risks include difficult reintubation and anatomical changes that increase concern for difficult reintubation, such as airway edema and restricted access to the airway. COVID-19 patients displaying any of these characteristics should be considered at high risk for extubation.[71]

In the context of a difficult airway, the COVID-19 patient may be difficult to reintubate, with the associated increased risk of provider exposure; therefore, an awake extubation is recommended. While asleep extubation may reduce coughing, we believe the risks outweigh that benefit.

Periextubation coughing increases aerosolization risk and may be reduced with lidocaine administered IV or topically to the vocal cords, or by injecting into the ETT cuff.[97] A recent meta-analysis found less coughing with dexmedetomidine compared to remifentanil or fentanyl, and that all 3 medications were superior to no treatment.[98]

Preparation and recommendations for extubation of suspected or confirmed COVID-19 patients can help reduce coughing or protection of secretions during extubation.[92,98–102] Taking into consideration the risks of extubation in the setting of a difficult airway and COVID-19, the following steps to reduce risks and complications are reasonable (Figure 4):

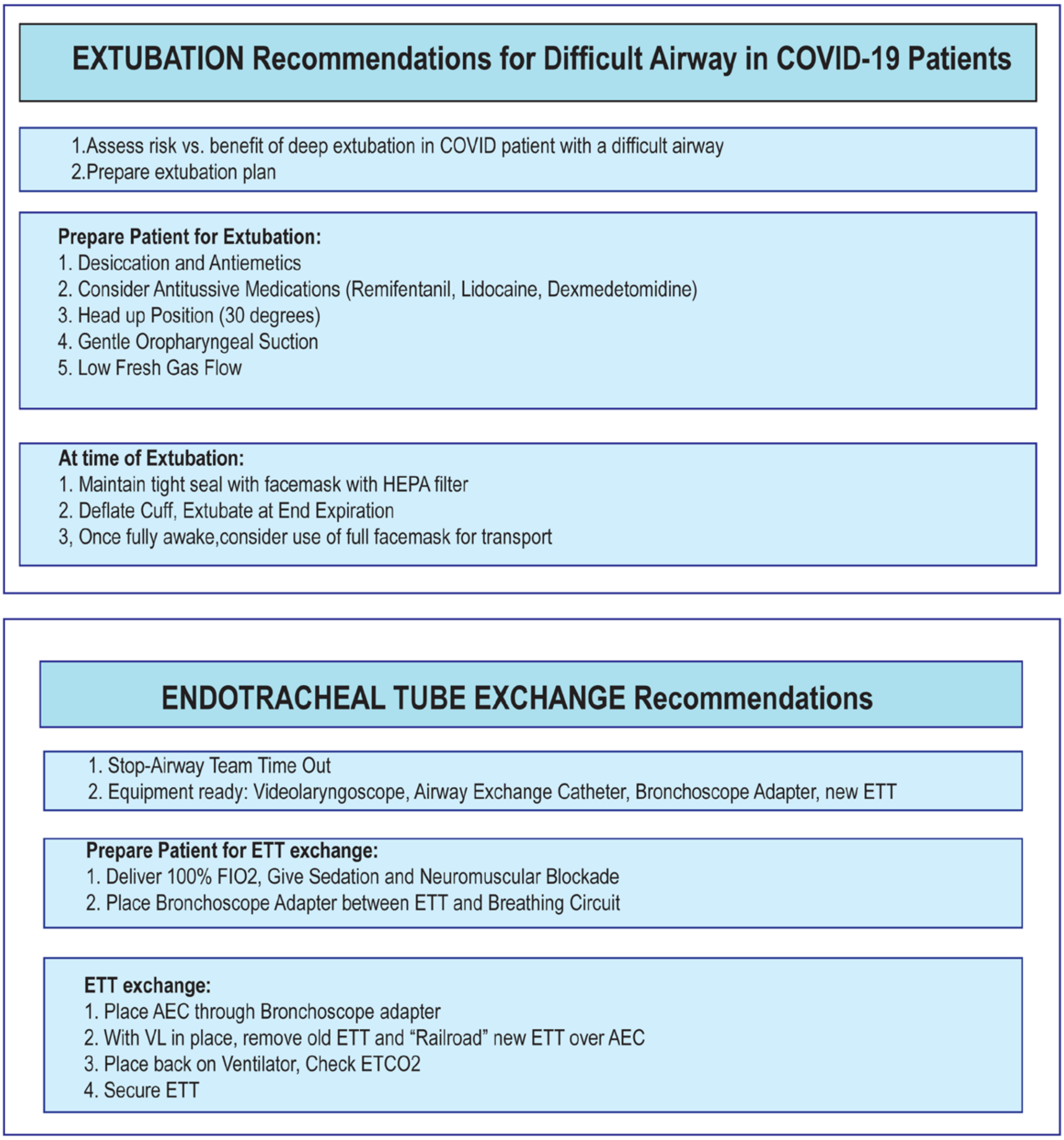

Figure 4. Algorithms for extubation for difficult airway and endotracheal tube exchange. AEC indicates airway exchange catheter; COVID-19, coronavirus disease 2019; ETT, endotracheal tube; F_{IO_2}, fraction of inspired oxygen; HEPA, high-efficiency particulate absorbing; VL, videolaryngoscope.

1. Consider the administration of medications to reduce coughing.
2. Consider the administration of medications to prevent nausea and vomiting.
3. Assess the risks versus benefits of deep extubation in COVID-19 patients with a difficult airway.
4. Consider awake extubation in COVID-19 patients with a difficult airway.

CONCLUSIONS

The SAM has developed a statement for difficult airway management of the adult patient with COVID-19. Unlike standard difficult airway guidelines, COVID-19 adds an additional dimension of provider exposure risk during intubation and extubation. Because difficult airway management may take longer than standard airway management, strict adherence to PPE protocols will reduce exposure risk to providers during difficult airway management. Optimal preoxygenation and minimizing BMV can also reduce aerosolization risk. The risks and benefits of various strategies to deliver supplemental oxygen throughout the process of difficult airway management should be considered. When a patient’s airway risk assessment suggests that ATI is an appropriate choice of technique, procedures that may cause increased aerosolization of secretions should be avoided. For optimal intubating conditions, the patient should be anesthetized with full muscle relaxation before intubation. Videolaryngoscopy is recommended as a first-line strategy for airway management, assuming availability and expertise. If emergent invasive airway access is indicated, then we recommend the use of a simple surgical technique, such as scalpel-bougie-tube, rather than an aerosolizing generating procedure, such as transtracheal jet ventilation. This report represents the collaborative recommendations of the management of an adult with COVID-19 and difficulties in intubation and extubation to minimize provider risk, maximize first-pass success, and maintain patient safety (Figures 1, 3, 4).

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