CURRENT OPINION

Airway management in the critically ill patient with COVID-19

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Purpose of review

Critically ill Coronavirus disease 2019 (COVID-19) patients needing endotracheal intubation are on the verge of rapid decompensation. The aims of this review were to assess the risks, the preoxygenation, the device and the hemodynamic management of a patient with COVID-19.

Recent findings

The proceduralist performing endotracheal intubation with the entire team are at an increased risk for exposure to COVID-19. Appropriate personal protective equipment and other measures remain essential. For preoxygenation, noninvasive ventilation allows higher oxygen saturation during intubation in severely hypoxemic patients and can be associated with apneic oxygenation and mask ventilation during apnea in selected cases. The COVID-19 pandemic has further highlighted the place of videolaryngoscopy during intubation in intensive care unit (ICU). Hemodynamic optimization is mandatory to limit hypotension and cardiac arrest associated with airway management.

Summary

Future trials will better define the role of videolaryngoscopy, apneic oxygenation and mask ventilation during apnea for intubation of COVID-19 patients in ICU. The use of fluid loading and vasopressors remains to be investigated in large randomized controlled studies. Choosing the right time for intubation remains uncertain in clinical practice, and future works will probably help to identify earlier the patients who will need intubation.

Keywords

airway, COVID-19, critically ill patients, intensive care unit

INTRODUCTION

Although airway management in critically ill patients represents a challenge for the anesthesiologist, the critically ill patient with coronavirus disease 2019 (COVID-19) is considerably more difficult [1]. Postintubation hypotension and hypoxemia are common in critically ill patients and may be associated with poor outcomes [2■■]. Specifically, critically ill COVID-19 patients needing endotracheal intubation are on the verge of rapid cardiorespiratory decompensation. They have been exposed to long durations of noninvasive and sometimes high-pressure ventilation, or a combination of various high flow oxygen delivery devices. In addition, patients with COVID-19 are often managed on the 'drier side' so most are hypovolemic by the time intubation becomes a necessity. Finally, a large majority of these patients are hypoxemic, tachypnoeic, tachycardic and encephalopathic as well. In combination, these factors suggest that sudden and catastrophic cardiorespiratory compromise is possible prior to and immediately after endotracheal intubation. COVID-19 associated barotrauma-related (ARDS) and changes in lung compliance prior to and after intubation vary in published [3,4]. Taken together, the limited preintubation physiological reserve, increased propensity for sudden cardiovascular collapse during intubation, increased risk of peri-intubation hypoxemia and postintubation barotrauma related complications make for a substantially increased intubation risk in these patients [1]. In

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KEY POINTS

- Airway management of a patient with COVID-19 is especially difficult and associated with increased risk of complications.
- Appropriate protection of the healthcare workers, airway instrumentation providers, good preoxygenation, choice of device and hemodynamic optimization is mandatory to limit the complications associated with airway management.
- Although some of this evidence has changed and evolved as we have gathered more data, choosing the right time for intubation remains fundamental to further decrease these complications.

addition, a challenge unique to these patients is the high degree of aerosol borne transmissibility of the virus, thereby threatening infection for the anaesthesiologist or other personnel performing airway instrumentation. This review will assess the risks, the preoxygenation, the device and the hemodynamic management of a patient with COVID-19. The important points are summarized in Table 1.

SPECIFIC CONSIDERATIONS – RISK TO PERSONNEL

The novel coronavirus imposes an increased risk for aerosol borne transmission of viral particles to personnel performing endotracheal intubation. COVID-19 is predominantly transmitted through droplet, aerosol and fomite spread [5]. Although droplets can only travel minimal distances, aerosols may remain suspended in air for a long time and travel longer distances [6]. Fomites might on the other hand get secondarily contaminated by viral particles [7]. Several procedures associated with airway management including but not limited to, bag mask ventilation, high-flow nasal oxygen (HFNO),

Table 1. Specificities of airway management in COVID-19 patients

Risk assessment 1. Hypoxemia 2. Hemodynamic instability 3. Difficulty of intubation (e.g., MACOCHA score)
Timing of intubation 1. Do not intubate too late, or too early, best approach based on clinician experience or judgement 2. The ROX index (ratio of SpO2/FiO2 to respiratory rate) may help (threshold >5 associated with a lower risk for intubation).
Preintubation 1. Appropriate personal protective equipment (based on local protocols, but at minimum should cover the whole upper body) 2. For preoxygenation, consider upright position (20–30° bed) 3. Preoxygenation with at least 3 min with noninvasive ventilation in case of hypoxemic acute respiratory failure (FiO_2 100%, pressure support between 5 and 10 cmH_2O to obtain an expired tidal volume between 6 and 8 mL/kg and a PEEP of 5 cmH_2O), associated with apnoeic oxygenation when available and high-risk of hypoxaemia (OPTINIV method – (NIV combined to HFNO)) 4. Hemodynamic optimization: consider fluid loading based on assessment and early introduction of vasopressors 5. Organize airway equipment and team members in the ICU room to ensure workflow management and minimize frequent need for entering and exiting the contaminated environment
Per-intubation 1. Use first videolaryngoscope for intubation procedure, if no videolaryngoscope available, consider direct Macintosh laryngoscopy with Stylet 2. Rapid sequence induction: – Etomidate 0.2–0.3 mg/kg or ketamine 1.5–3mg/kg – Succinylcholine 1 mg/kg (without contra-indications) – Rocuronium: 1.2 mg/kg IVD in case of contra-indications to succinylcholine 3. Ventilation in case of oxygenation desaturation < 90% or if elevated risk of oxygen desaturation higher than the risk of aspiration
Postintubation Gentle ventilation soon after intubation, to limit hemodynamic complications associated with intubation: low tidal volume, low respiratory rate, low positive end-expiratory pressure. Titrate to best PaO2/FiO2 and lung compliance mechanics as the patient reaches a point of cardiovascular stability. During all procedures, avoid ventilator and circuit disconnections, and air leaks around mask during manual ventilation to limit aerosolization.
Extubation 1. Appropriate PPE same as intubation 2. Preparation of airway equipment and drugs in case of the need for rapid-reintubation 3. Arrangements made beforehand for necessary postextubation oxygen delivery devices

COVID-19, Coronavirus disease 2019; HFNO, high-flow nasal oxygen; ICU, intensive care unit; MACOCHA, Mallampati score III or IV, Apnea syndrome (obstructive), Cervical spine limitation, Opening mouth <3 cm, Coma, Hypoxia, Anesthesiologist nontrained; NIV, noninvasive ventilation; PPE, personal protective equipment; ROX, respiratory rate oxygenation.

noninvasive ventilation (NIV), tracheal intubation, open suctioning, bronchoscopy, tracheal extubation, and tracheostomy may be considered as significant risk aerosol-generating procedures in the intensive care unit (ICU) [8▪].

Since the proceduralist performing endotracheal intubation (and often the primary intubation team) are in very close proximity to the patient's upper respiratory tract where the viral load is high, they are at an increased risk for exposure to COVID-19 through both droplets, aerosols or fomite pathways. In addition, exposure to high viral loads has been associated with more severe disease in healthcare workers [9]. Although there are recommendations for effective prevention of contamination using appropriate personal protective equipment (PPE), these steps add another layer of impediment to intubation workflow and communication. For example, the commonly used powered air purifying respirator (PAPR) device to safeguard healthcare workers against contaminated air can also impair audible communication between airway team members and limit visual cues. Airway 'boxes' are made of plexiglass that covers the patients face and oral nasal passages whereas allowing the airway manager physical access to the patient also exist. Here again, the dual use of bulky PPE such as the PAPR and these 'protection boxes' can further limit physical access to the patient. Mannequin studies have identified an increase in intubation attempts, contamination of PPE and the need for procedures to optimize airway views with the use of an aerosol box [10]. These communication and access challenges are very different from what most providers are accustomed to for routine critically ill patient requiring airway management.

Despite the learning curve and some challenges associated with use, appropriate PPE remains essential to decreasing risk of transmission of infection to healthcare workers. Choice of PPE should be based on established local and institutional guidelines and protocols and a close review of available data and specifications for individual devices. In addition, user comfort, appropriate simplicity for removal without contamination after procedure, and ease of disposability should be considered. Using a Delphi-based consensus, Nasa *et al.* led a group of 39 experts, who did not reach agreement on a specific PPE combination as the most superior protection [8▪]. Similarly, a meta-analysis of nearly 2300 participants could not establish a difference amongst PPE types and prevention of infection [11]. At a minimum, whatever type of PPE chosen should cover the whole upper body. A checklist and observer or team-based approach to help the primary airway manager can help not only with a methodological PPE donning and doffing mechanism, but also with preorganization of airway equipment, necessary drugs, and ancillary support during the intubation process [12▪]. Workgroups and guidelines statements also emphasize the need for appropriate positioning of airway equipment and team members in the ICU room, workflow management, use of simulation sessions, appropriate PPE drills, repeated practice environments, and organization of familiar airway team members, all of which can help mitigate some contamination issues [12▪,13]. To minimise frequent entry and exit from this environment, one best practice to keep all necessary equipment at close proximity and be ready with a procedure cart to establish emergent central venous and intra-arterial access whereas in the room and at the time of intubation. The risk of viral exposure is also dependent on the rate of air-exchange in the intubation environment in the ICU, and recommendations suggest the use of negative pressure rooms along with at least 12 air exchanges per hour to achieve this goal [12▪,14]. Tracheal extubation, when deemed appropriate by the treating ICU team, should be conducted to minimize patient coughing. To this end, preextubation physiotherapy, and gentle endotracheal suctioning may facilitate the clearance of secretions [12▪]. Because proximity to respiratory passages is the same as for intubation, PPE requirements should be the same as intubation and preparation of airway equipment and drugs in case of the need for rapid-reintubation and arrangements made beforehand for necessary postextubation oxygen delivery devices is helpful.

PREOXYGENATION AND APNEIC OXYGENATION

Critically ill patients with COVID-19 are often severely hypoxemic at the time of endotracheal intubation is. Pre intubation hypoxemia is a key risk factors for severe hypoxemia during an intubation procedure [15]. Severe hypoxemia occurring during an intubation procedure can result in cardiac arrest [16,17], cerebral anoxia, and death [18]. Therefore, preoxygenation of the critically ill patients with COVID-19 should be optimized to avoid these life-threatening complications [12▪,19,20▪].

Among available preoxygenation methods, i.e. bag valve mask [21], HFNO [22], NIV (pressure support associated with positive end-expiratory pressure (PEEP)) [23] and OPTINIV method (NIV combined to HFNO) [24], the two methods of choice in the very hypoxemic patient are NIV alone or combined with HFNO (OPTINIV method) [19]. This latter method allows higher oxygen saturation during intubation in severely hypoxemic patients [24]. Despite the risk of aerosolization in COVID-19 patients, a limited degree of manual ventilation after rapid sequence induction should be considered [25], with a face mask tightly applied. Bag valve mask ventilation in those patients may help to limit the rapid drop in oxygen saturation which is very common in patients with COVID-19 [25].

DEVICES FOR INTUBATION

A combination of difficult intubation and COVID-19 as a reason for acute respiratory failure can be especially risky. Difficult intubation is associated with life-threatening complications [23,26–30]. Similarly, the failure of first-attempt intubation is a major factor for developing life-threatening complications related to intubation [31▪]. In this setting, the Mallampati score III or IV, Apnea syndrome (obstructive), Cervical spine limitation, Opening mouth <3 cm, Coma, Hypoxia, Anesthesiologist nontrained score [32] can help to identify the patients at high-risk of difficult intubation. The main predictors of difficult intubation are related to the patient (Mallampati score III or IV, obstructive apnea syndrome, reduced mobility of cervical spine, limited mouth Opening), the pathology (Coma, severe Hypoxia) and the operator (non-Anesthesiologist). To reject difficult intubation with certainty, a cutoff of 3 or greater is appropriate, allowing an optimal negative predictive value (respectively 97% and 98% in the original and validation cohorts for the MACHOCHA score) and sensitivity (respectively 76% and 73% in the original and validation cohorts) [32].

However, the place of videolaryngoscopy for intubation in critically ill patientsremains an open question [19,33]. Recently, the COVID-19 pandemic highlighted the potential utility of video laryngoscopy to both reduce difficult intubation with its associated complications and reduce intubation provider contamination [12▪,20▪,34].

Despite the better visualization of the glottis with videolaryngoscopes, a key challenge when using videolaryngoscopes lies in cannulating the trachea. Achieving a 100% percentage of glottis opening (POGO) view (corresponding to a Cormack-Lehane grade 1 in direct laryngoscopy) during videolaryngoscopy does not guarantee successful intubation [33].

In the early 2010s, clinicians considered whether videolaryngoscopes could reduce the difficult intubation rate in critically ill patients [35,36]. In a before-after study reporting a quality improvement process using a videolaryngoscope in an airway management algorithm [37], the systematic use of a Macintosh videolaryngoscope for intubation significantly reduced the incidence of difficult intubation and/or difficult laryngoscopy [37]. In addition, in a subgroup of patients with MACHOCHA-predicted difficult intubation [26], the incidence of difficult intubation was much higher in the ‘standard laryngoscopy’ group (47%) than in the ‘Macintosh videolaryngoscope’ group (0%).

These results were further supported in 2014 by a systematic review and meta-analysis establishing that use of videolaryngoscopes for intubation in ICU could reduce the rate of difficult intubation [25]. However, in 2016, Lascarrou *et al.* [38] showed in a large multicenter randomized controlled trial that videolaryngoscopy compared with direct laryngoscopy did not improve first-pass oro-tracheal intubation rates and was associated with higher rates of severe life-threatening complications. These conflicting results may be explained by the variable rate of use of a Stylet and the expertise of the operators. In the study of Lascarrou *et al.* [38], 80% of the operators were nonexpert. A team recently implemented the McGrath MAC videolaryngoscope (Medtronic) for first-line intubation as part of a quality improvement initiative [39▪]. In a multivariate analysis, the absence of dedicated videolaryngoscopy expertise, junior status of the performing individual, and the presence of coma were independent risk factors for first-attempt failure. Thereby, specific videolaryngoscopy skill training, assessed by the number of previous intubations performed with videolaryngoscope, was an independent factor for first-attempt intubation success. Moreover, first-attempt success rate increased with the operators' level of expertise, with a threshold of more than 15 video laryngoscopies associated with a first-pass success rate of 87%.

The COVID-19 pandemic has further highlighted the place of videolaryngoscopy during intubation in ICU to limit the contamination of the intubating provider. International guidelines recommend using video laryngoscopy to increase the distance between the patient and intubating provider, and to perform intubation by the most experienced operator [12▪,20▪]. If a bougie or a stylet is used, the operator is advised to be careful when removing it so as not to spray secretions on the intubating team [12▪].

Future trials will better define the role of videolaryngoscopy for intubation of COVID-19 patients in ICU, especially with respect to appropriate use of airway adjuncts as stylets, and expertise level of operators. In clinical practice, training and education are essential, through clinical simulation and practice with cadaveric specimens, to secure the implementation of videolaryngoscopy in critically ill patients with COVID-19.

HEMODYNAMIC OPTIMIZATION

In a prospective observational study of intubation practices in the critically ill the INTUBE study group investigated 2964 global patients and identified cardiovascular instability as a complication in 42.6%, [2■■]. In the 2020 HEMAIR prospective observational study, 36.8% of 934 medical and surgical ICU patients in the United States experienced postintubation hypotension. Eleven variables were independently associated with postintubation hypotension: increasing illness severity; increasing age; sepsis diagnosis; endotracheal intubation in the setting of cardiac arrest, mean arterial pressure <65 mmHg, and acute respiratory failure; diuretic use 24 h preceding endotracheal intubation; decreasing preintubation systolic blood pressure from 130 mmHg; catecholamine and phenylephrine use immediately prior to endotracheal intubation; and use of etomidate [40]. Other literature suggests a rate of peri-intubation hypotension and cardiovascular collapse varying between 25–46% during endotracheal intubation in the ICU [15,17,41–44]. Early 2020 reports from Wuhan, indicated that about a fifth of all COVID19 patients experienced hypotension either during or immediately after intubation with progression to cardiac arrest in 2% of the cohort [1].

As in non-COVID patients, hemodynamic instability in the intubation period is largely driven by pharmacologically induced sympatholytic action, thereby necessitating a smaller dose of induction agent. Although the debate continues, early intubation in a semi-elective scenario may be an option that prevents postintubation hypotension and allows for better preintubation hemodynamic optimization [45]. Prophylactic use of appropriately titrated fluid boluses as a ‘preload’ with measures of volume responsiveness continually assessed is an important preintubation intervention. No specific recommendations for type of vasopressor support have been suggested in the literature, though the use of pharmacotherapy to increase afterload and or inotropy during and after the procedure has been articulated [46]. A systolic blood pressure of <130 mmHg prior to intubation is associated with postintubation hypotension in critically ill patients and this threshold will likely apply to COVID19 patients as well [40]. Vasopressor rescue or push doses should be available at the times of intubation, and may include phenylephrine, ephedrine, norepinephrine, and or epinephrine depending on clinical assessment, severity and needs. Although most COVID19 patients are normo- or even hypertensive during intubation, this hemodynamic state is driven by the high sympathetic drive and prolonged hypoxemia prior to the procedure. Most often there is a rapid transition to hypotension, during and after intubation so the use of continuous infusion of vasopressor agents either during or immediately after intubation may be an important measure. Postintubation mechanical ventilation additionally shifts negative-pressure to positive-pressure ventilation, compromising venous return and removing hypoxic and hypercarbic sympathetic drive. It is therefore critical to adjust mechanical ventilation to avoid large tidal volumes, increased intra-thoracic pressures, minimize barotrauma and volutrauma and allow for a more gradual correction of hypercapnia and hypoxemia. These interventions may help counteract hemodynamic instability in the immediate postintubation period. Vasodilatory shock is a manifestation of septic shock and the most likely cause of prolonged hypotension later in the course, though hypovolemia and a transition to cardiac injury and myocardial damage associated shock states cannot be ruled out without serial bedside assessments and imaging. The strong postulated association of the novel coronavirus with the Angiotensin Converting Enzyme (ACE2), has led to some investigation into the use of Angiotensin II as a vasopressor of benefit via a decrease in expression of ACE2, although data remain limited [46–49].

TIMING OF INTUBATION

Appropriate timing of intubation is very important in all critically ill patients, to avoid unnecessary complications of invasive mechanical ventilation, but also to avoid complications of noninvasive methods, such as NIV or HFNO. In the specific critically ill COVID-19 population, a first study [50] showed no association between intubation timing (time from admission to intubation) and mortality. However, in another study performed in COVID-19 patients who were intubated and mechanically ventilated [51], intubation earlier during hospital admission was associated with improved survival. Discordantly, in a more recent study [52], early invasive mechanical ventilation was associated with an increased risk of day-60 mortality. Those apparent conflicting results may be explained by different strategies used in the course of a pandemic: very (likely extremely) early intubation at the beginning of the pandemic, and more (likely substantially) delayed intubation during the time course of the evolution of the pandemic. Concomitantly, the overall prognosis of critically ill patients ventilated with COVID-19 has improved [53,54]. Following these studies, a meta-analysis [45] performed in 12 studies from Africa, Asia, Europe and America, involving 8944 critically ill patients (7639 early, 1305 late) with COVID-19 suggested that timing of intubation had no effect on mortality and morbidity. However, with respect to a 'wait and see' strategy in critically ill COVID-19 patients with acute respiratory failure, the line between 'wait and see' and 'delay intubation' is unclear and mostly relies on clinician common sense and experience. The respiratory rate oxygenation index [55], defined as the ratio of SpO2/FiO2 to respiratory rate [56], may also be used to help the clinician to predict failure of noninvasive strategies [57]. A threshold of more than 5.37 was significantly associated with a lower risk for intubation after H4, in a single-center retrospective study [58]. These results were further supported with a systematic review and meta-analysis [55].

CONCLUSION

Airway management of a patient with COVID-19 is especially difficult and associated with increased risk when compared to critically ill patients without COVID. Appropriate protection of healthcare workers and airway instrumentation providers, aggressive preoxygenation, careful choice of device and hemodynamic optimization are mandatory to limit the cardiorespiratory and other complications associated with airway management. Although COVID-19 management remains a dynamic and evolving field, choosing the right time for intubation remains fundamental to further decrease these complications.

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