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Review Article

Early versus Delayed Intubation and Technique in COVID-19: A Review Article

Zahid Hussain Khan[1], Ahmed Maki AL-Dulaimi[2], Hesam Aldin Varpaei[3], Parsa Mohammadi[4], Mostafa Mohammadi[1*]

[1]*Department of Anesthesiology and Critical Care, Imam Khomeini Hospital Complex, Tehran University of Medical Sciences, Tehran, Iran.*

[2]*Department of Anesthesia and Intensive Care Unit, Al-Furat Al-Awsat Hospital, Health and Medical Technical College, Al-Furat Al-Awsat Technical University, Najaf, Iraq.*

[3]*Department of Nursing, Faculty of Nursing and Midwifery, Islamic Azad University, Tehran Medical Sciences, Tehran, Iran.*

[4]*School of Medicine, Tehran University of Medical Sciences, Tehran, Iran.*

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ABSTRACT

Background: The novel coronavirus 2019 is the cause of the 2020 pandemic that was announced by the world health organization in March 2020. The coronavirus attacks the respiratory system and causes mild to severe hypoxemia. Therefore, a fraction of COVID-19 patients may need intubation and mechanical ventilation.
Methods: We conducted a narrative review by searching for articles that mentioned the time of intubation for COVID-19 patients and intubation techniques in PubMed, Google Scholar, Scopus, the Web of scenic, the Cochrane library, and Embase, as well as manual searching. All the selected reviews and studies were limited to humans and the English language.
Results: The first data from China shows that 5% of patients require intubation and mechanical ventilation (MV), and there has been considerable debate about the timing of intubation for patients with acute respiratory failure and the technique of intubation. At first, the specialists recommended early intubation. Although we are more familiar with the pathophysiology of coronavirus, the drawbacks and the benefits of early intubation are still controversial. In addition, the intubation process itself is an aerosol-generating procedure and carries a high risk for patients and health care providers. In this review, we aim to review the previous studies and guidelines recommendations related to the time of intubation and intubation technique for COVID-19 patients.
Conclusion: Previous research has suggested that early tracheal intubation should be prioritized in severe COVID-19 patients, whereas other studies advocate late intubation due to poor intubation outcomes and weaning difficulties. However, intubation timing should be based on personalized medicine and case-by-case decision making to ensure the best care and benefit of patients. And relying only on theoretical justification may not have good consequences.

SARS-Cov 2 (Origin from Wuhan, China) is the well-known cause of the Pandemic that started in March 2020 [1-2].

Coronavirus attacks the respiratory system and affects whole components of it including the neuromuscular breathing apparatus, the respiratory airways, alveoli, the conducting airways, pulmonary blood flow, and the pulmonary vascular endothelium [3]. So, the COVID-19 patients need respiratory support and according to primary data collected from infected countries mention that 3.2 to

The authors declare no conflicts of interest.
*Corresponding author.
E-mail address: mohammady_mm@tums.ac.ir

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5% of patients require intubation and mechanical ventilation [4]. However, the need for intubation in critically ill patients may be ranging 30 to 100% [5]. The new data mention that intubation and invasive mechanical ventilation in the COVID-19 patient are ranging from 30 to 100 percent [6]. The time of intubation is important and Gattinoni et al. suggested that noninvasive ventilation (NIV) is a controversial option and intubation and mechanical ventilation must be initiate as soon as possible to decrease the risk of delayed intubation and avoiding patient self-inflicted lung injury [7]. However, Tobin et al. believe that despite mechanical ventilation is lifesaving in severe respiratory failure, but it does not mean that it is a good justification for liberal use of endotracheal intubation [8].

Several studies regarding early versus late intubation and their effect on the outcomes of COVID-19 patients have been published. Yet, the evidence and clinical trials are insufficient. Therefore, this study aimed to carry out this article to review the effect (if found) of the timing of intubation on the outcomes of COVID-19 patients.

Methods

We conducted a narrative review by searching in articles published from inception to June 2021 in PubMed, Google Scholar, Scopus, the web of scenic, the Cochrane library, and Embase that mentioned the time of intubation for COVID-19 patients and intubation techniques, as well as manual searching. We use the following keywords in this review: COVID-19, non-invasive ventilation, invasive ventilation, intubation, early, delayed intubation, rapid sequence induction, and RSI. This review includes 36 related studies and as following (5 cross-section studies, 12 review studies, 6 cohort studies, 3 experimental studies and, 10 observational studies) and as shown in graphic prism 8. Besides, our review involved many experts and guidelines recommendations that related to our object. The exclusion criteria were comments, opinions, correspondences, spotlight, pediatric age groups, and case reports. All the selected reviews were limited to humans and the English language. This study was confirmed by the ethical committee of Tehran University Medical Sciences (IR.TUMS.SPH.REC. 1399.317).

Result

Non-invasive ventilation (NIV) and high-flow nasal cannula (HFNC) have been proposed in some guidelines as a useful strategy in the treatment of COVID-19 patients. Early intubation can be considered for patients under close monitoring in the ICU, in the event of no improvement in oxygenation after a 1-2 hour trial. Although some studies suggested that NIV could be used for a longer period of time, others suggested using it (in selected patients) as an alternative to mechanical ventilation [9-11].Besides, numerous guidelines from China, the United States of America, Australia, and the United Kingdom recommend early intubation of severe acute respiratory failure of COVID-19 patients as a primary way to keep staff away from infection and to avoid complications (such as cardiac arrest) related to "crash" intubations [12–15]. The summary of studies and guidelines are provided in (Table 1).

Table 1- Summary of included studies

Guideline/Study	Comment	Grade of Recommendation	Result
Guidelines on the management of critically ill adults with (COVID-19) [16].	A panel of 36 experts from 12 countries.	D	They recommended applying traditional oxygen as the first-line when SpO2 is < 90% and if insufficient, HFNC or NIV used to preserve SpO2 between 92 and 96%. It also mentioned the significance of close monitoring and early intubation if deterioration occurs.
German recommendations for critically ill patients with COVID-19 [17].	Guidelines and Recommendations	D	Patients with severe hypoxemia (PaO2/FiO2 ≤200mmHg) are recommended performance early intubation and invasive mechanical ventilation.
Anesthesiology and the Anesthesiologists at COVID-19 [18].	_	D	Favor early intubation.
US Department of Defense COVID management guidelines [18].	_	D	Early intubation over NIV if HFNC fails.
A Chinese retrospective study [19].	_	C	Showed that emergency intubation for COVID-19-ARDS patients can be hampered by risk complications, such as worsening hypoxia, hypotension, and cardiac arrest.

Observational multicenter study [20].	Among the 704 patients, the In-hospital mortality was 43% and just the duration of NIV usage before ICU admission and age (elderly) were recognized as independent risk factors of in-hospital mortality; while the duration of NIV usage after ICU admission did not affect patient outcome.	C	The findings propose that intubation should be considered in the case of the absence of enhancement in oxygenation after 2 days of NIV application outside ICU.
Retrospective study [21].	Among 222 patients were enrolled. The mortality was 77.5%. The mortality rate for the early intubation group was 82%, while delay intubation and use NIV was 84%, and for the patient that using NIV- only was 69%.	C	Regarding patients that intubated after NIV, the mortality rate was not significantly different than for those intubated early. The secondary analysis showed that all patients who got NIV support have less mortality rate than patients who were intubated without NIV.
A systematic review and meta-analysis of non-randomized cohort studies [22].	Including 8944 COVID-19 patients. Early versus Late intubation 45.4% versus 39.1%, this is the mortality rate for two groups	A	They suggest that the timing of intubation maybe not affect the mortality of severely ill COVID-19 patients.
A retrospective cohort included 65 adult COVID-19 at two hospitals in Hubei, China [8].		C	The late-intubation group showed less severity at admission but a higher risk of in-hospital death than the early-intubation group.
A prospective archive is creating of all COVID-19 patients who were admitted to the urban academic medical center from March 2020 to July 2020[23].		C	Delay intubations were relating to a high mortality rate when adjusted for age and body mass index.
A retrospective study [24].		C	Patients who are delay intubated during their hospitalization seem to have more compliance and potentially higher mortality rate
An observational study [25]	A total of 101 patients	C	The result shows the patients who underwent early intubated did not appear worse clinical outcomes compared to patients who delayed or no intubation
An observational study [26].	111 patients	C	They found that the timing of intubation did not seem to be related to worse clinical outcomes in COVID-19 patients. Also, the time of intubation may be directly associated with disease severity and the rate of deterioration. So, the trial of NIV as an effort to avoid intubation may be proper action.
A randomized in situ simulation [47].	Twenty anesthetists and intensivists intubated a simulated patient with COVID-19.	B	No differences were seen in the two groups in terms of the failed first attempt, heart rate changes, or intubation time. But, the risk of contamination and potential aerosol-generating events was significantly higher in the late-intubation group. Late intubation may be an appropriate strategy in a time of limited resources.

Additional recommendations suggested keeping apply of HFNC or NIV for mild hypoxemia, accompanied by taking on a low threshold for intubation [27].

Deciding to intubation vs utilizing NIV of COVID-19 patients is a challenging concern for critically ill patients. As a general idea, early intubation could result in unnecessary intubation and MV of patients who would have a chance to improve on NIV without intubation and related complications. On the other side, delaying intubation may result in further worsening of clinical conditions and outcomes [28-29].

The results of the study proposed that early intubation versus no intubation or delayed intubation, may not be associated with worse outcomes through critically ill patients with COVID-19 like mortality, ventilator-free days, and ICU-free days [30]. It was suggested that early intubation may be beneficial as an infection control estimate, also serve as a method to prevent patient self-inflicting lung injury and avoidance of emergent intubation. As avoidance of emergent intubation could enhance outcomes, which include death due to the incidence of hypoxemia [19,31]. Some of the first guidelines for respiratory support in COVID-19 mention that we should be careful with NIV usage and note that early intubation was associated with better outcomes. Advanced reports found a lower mortality rate for COVID-19 patients with NIV usage than with early intubation and invasive ventilation [21].

The advantages of early intubation for COVID-19-ARDS patients include the ability to control ventilation, free sedation use, applying prone position, muscle paralysis, precise control, and monitoring of ventilation parameters that help to improve oxygenation and even outcomes [11]. On the other hand, the significant point that we should mention is that intubation itself has risks for all patients and healthcare providers. A previous study that included 202 sequential tracheal intubations, observed that 73% of cases had exposure to peri-procedural hypoxemia, 40% of cases hypotension, and cardiac arrest in 2% of cases; as well, pneumothorax happened in 6% of patients and loss of life during the first 24 hours after intubation was 10% [19]. Also, several previous studies mentioned the rate of intubation as 5 to 88% in COVID-19 patients and 1.4 - 44.5% of these patients were successfully extubated. Obesity and age (elderly) were found as the risk factors for delayed or difficult extubation [5]. The death rate of invasively ventilated patients is not encouraging as in one of the first reports from Wuhan so that China the mortality percentage for patients under MV was 86%, in another report from other hospitals was 97%, and in the multicenter study from New York, it was 88% [33-34].

The evidence regarding early intubation in COVID-19 patients with acute respiratory failure is still insufficient. Besides, the researchers and clinicians failed to detect a substantial (significant) difference in mortality rate and time of intubation [21]. Accordingly, the time of intubation can be serious, and delayed intubation might cause poor outcomes and an increased mortality rate [28]. Besides, the timing and the decision of intubation may be unique to COVID- 19 patients "case by case" and the threshold of intubation and invasive mechanical ventilation may be lower in COVID-19 [35-36].

Discussion

COVID-19 associated acute respiratory distress syndrome (CARDS) occurs in approximately 14-17% of patients [15]. Before considering intubation, it was recommended that utilizing HFNC or NIV (properly) but keep in mind the risk of nosocomial transmission of SARS [27]. About 15% of COVID-19 patients required endotracheal intubation and mechanical ventilation [39]. The risk for healthcare workers is that tracheal intubation may lead to an aerosol-generating procedure that is considered hazardous [32]. Health care providers who manage the airways of COVID-19 patients are exposed to aerosol transmission, especially with aerosol-generating events (AGE) such as coughing or suctioning. So, they are at high risk due to the peak viral load and contamination [39-40]. Besides, the COVID-19 patients may be agitated, and as a consequence, keeping the barrier protection and safe distance may be difficult [41]. In addition, the intubation process can result in a high volume of airway aerosolization, therefore, rapid sequence induction (RSI) is suggested as one of the possible measures to control infection [37].

For intensive care unit patients, standard RSI includes the use of ketamine or other hypnotic drugs at an optional or weight-based dose for induction to achieve the adequate depth of anesthesia required for airway manipulation. This can result in hemodynamic instability or adverse events during the period of unreasonably deep anesthesia following the intubation. It can be potentially harmful to the most delicate or hemodynamically unstable patients (like heart failure) [38]. As a result, we should methodically use an induction technique that possibly is less harmful to the patient. The following points are the most significant measures regarding intubation of COVID-19 patients:

- Use 3–5 min or in some studies 5-10 min of preoxygenation by 100% oxygen and Spontaneous ventilation. Assisted bag-mask ventilation through preoxygenation should be evaded. NIV may be needed to provide adequate preoxygenation for safe apnea time. The anesthesiologist should make an effort to minimize air leaks [42].
- Rapid sequence induction (RSI) can be achieved by using succinylcholine or rocuronium as muscle relaxants.
- Rocuronium provides a proper duration of muscular blockade. So, airway reflexes such as coughing can be blocked during undertaking intubation.
- Succinylcholine (1mg/kg) is preferred for a patient who is suspected of difficult intubation (if there is no contraindication) [40].
- For a patient with stable hemodynamic, intravenous lidocaine instead of opioids can be used, as the opioids may precipitate coughing [41].
- Induction agents especially thiopental and propofol can cause hypotension. It can be minimized the side effect by using a crystalloid bolus and decrease the

induction dose or use of vasopressors. (More study is needed for confirmation).

- Other agents such as Midazolam are not preferred for COVID-19 patients. Because they had a slow onset of action. Etomidate is related to lower-required level intubating conditions than propofol and may cause adrenocortical suppression.
- For patients with a high risk of cardiovascular instability, Ketamine can be used [43].
- Regarding the type of laryngoscope, previous studies and expert recommendations show an increased application of video laryngoscopy for COVID-19 patients. Video laryngoscopes provide a proper distance between the patient and the anesthesiologist during intubation performance. In addition, reduced intubation attempts or decreased peri-intubation hypoxia incidence [13,41,44-45].
- Endotracheal tube placement confirmation performed by EtCO2 monitoring. Observable bilateral chest rise, and auscultation may not be an accurate option [46].

It seems that there were no differences in terms of intubation time, the incidence of failed first attempt laryngoscopy, or heart rate changes in the early versus late intubation group [47]. Recent studies have been stated that the timing of intubation (whether early or late) may have no survival effect for COVID-19 patients [22]. Tsolaki et al. suggested that in the time of crisis (like COVID-19 pandemic), when different physicians encountering in the decision making of intubation, the formal thresholds or protocols can be introduced [48].

Gattinoni et al. defended an early intubation strategy, as COVID-19 has been characterized by sudden exacerbation and lengthy time episodes [49]. In addition, they believed that most physicians delay extubation. But it should be noted that premature liberation without adequate COVID resolution has led to high reintubation rates. This approach may result in increased morbidity, mortality, and risk to healthcare workers. They have advocated that "Intubation should be prioritized to avoid excessive intrathoracic negative pressures and self-inflicted lung injury in patients who are treated with continuous positive airway pressure or noninvasive ventilation and who present with clinical signs of excessive inspiratory efforts" [50]. In contrast, Tobin et al. stated that each day of mechanical ventilation puts the patients at the risk of complications and increases mortality [51]. They also advocated that patient self-induced lung injury (P-SILI) should not be the only reason for early intubation of COVID-19 patients [8]. They concluded that there is various complications consequent to intubation and P-SILI should not be the reason to recommend early intubation. It should not be overlooked that the mortality rate after intubation in general ICUs has been reported to be 30% (in non-COVID-19 settings) [52]. This experience for clinicians may affect the decision of intubating a COVID-19 patient. And for this reason, they may postpone the intubation of COVID-19 patients.

Conclusion

Some of the previous studies, guidelines, and expert recommendations suggest early tracheal intubation in severe COVID-19 patients may have priority, while other cases with mild or moderate ARF take advantage of HFNC or NIV with a trial period under close monitoring. Besides, other studies advocate late intubation due to poor outcomes of intubation and weaning difficulties. The most recent meta-analysis has revealed that none of these methods will change the outcomes. According to these pieces of evidence, we can conclude that intubation time should be based on personalized medicine and case-by-case decision making to ensure the best care and benefit of patients. And relying only on theoretical justification may not have good consequences.

Furthermore, it should be noted that there is no unique definition of intubation timing (early, intermediate, and late intubation) across the world. Therefore, it is not easy to evaluate the quality of recommendations based on studies, and more studies are needed.

References

[1] Shereen MA, Khan S, Kazmi A, Bashir N, Siddique R. COVID-19 infection: Origin, transmission, and characteristics of human coronaviruses. J Adv Res. 2020; 24:91–8.

[2] Mohammadi M, Hadian M R, Varpaei H A. Exercise in COVID-19: Intensity and Timing. Asian J Sports Med.12(3):e113266.

[3] Brosnahan SB, Jonkman AH, Kugler MC, Munger JS, Kaufman DA. Covid-19 and respiratory system disorders current knowledge, future clinical and translational research questions. Arterioscler Thromb Vasc Biol. 2020; 40(11):2586-2597.

[4] Privitera D, Angaroni L, Capsoni N, Forni E, Pierotti F, Vincenti F, et al. Flowchart for non-invasive ventilation support in COVID-19 patients from a northern Italy Emergency Department. Intern Emerg Med. 2020; 15(5):767-771.

[5] Mohammadi M, Khafaee Pour Khamseh A, Varpaei H A. Invasive Airway "Intubation" in COVID-19 Patients; Statistics, Causes, and Recommendations: A Review Article. Anesth Pain Med. 2021;11(3):e115868.

[6] Yang X, Yu Y, Xu J, Shu H, Xia J, Liu H, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. Lancet Respir Med.

2020;8(5):475–81.

[7] Gattinoni L, Chiumello D, Caironi P, Busana M, Romitti F, Brazzi L, et al. COVID-19 pneumonia: different respiratory treatments for different phenotypes? Intensive Care Med. 2020; 46(6):1099–102.

[8] Tobin MJ, Laghi F, Jubran A. Caution about early intubation and mechanical ventilation in COVID-19. Ann Intensive Care. 2020;10(1):78.

[9] Diurno F, Numis FG, Porta G, Cirillo F, Maddaluno S, Ragozzino A, et al. Eculizumab treatment in patients with COVID-19: preliminary results from real life ASL Napoli 2 Nord experience. Eur Rev Med Pharmacol Sci. 2020; 24(7):4040–7.

[10] Piva S, Filippini M, Turla F, Catteneo S, Margola A, De Fulviis S, et al. Clinical presentation and initial management critically ill patients with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection in Brescia, Italy. J Crit Care. 2020; 58:29-33.

[11] Cabrini L, Ghislanzoni L, Severgnini P, Landoni G, Baiardo Redaelli M, Franchi F, et al. Early versus late tracheal intubation in COVID-19 patients: a pro-con debate also considering heart-lung interactions. Minerva Cardiol Angiol. 2021; 69(5):596-605.

[12] Marini JJ, Gattinoni L. Management of COVID-19 respiratory distress. JAMA. 2020; 323(22): 2329–30.

[13] Cook TM, El-Boghdadly K, McGuire B, McNarry AF, Patel A, Higgs A. Consensus guidelines for managing the airway in patients with COVID-19: Guidelines from the Difficult Airway Society, the Association of Anaesthetists the Intensive Care Society, the Faculty of Intensive Care Medicine and the Royal College of Anaesthetist. Anaesthesia. 2020;75(6):785–99.

[14] Zuo M, Huang Y, Ma W, Xue Z, Zhang J, Gong Y, et al. Expert Recommendations for Tracheal Intubation in Critically III Patients with Noval Coronavirus Disease 2019. Chinese Med Sci J. 2020;35(2):105–9.

[15] Brewster DJ, Chrimes NC, Do TBT, Fraser K, Groombridge CJ, Higgs A, et al. Consensus statement: Safe Airway Society principles of airway management and tracheal intubation specific to the COVID-19 adult patient group. Med J Aust. 2020;212(10):472–81.

[16] Alhazzani W, Møller 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;46(5):854-887.

[17] Kluge S, Janssens U, Welte T, Weber-Carstens S, Marx G, Karagiannidis C. German recommendations for critically ill patients with COVID‐19. Med Klin Intensivmed Notfmed. 2020 Dec;115(Suppl 3):111-114.

[18] Ferrando C, Colomina MJ, Errando CL, Llau JV. Anesthesiology and the Anesthesiologists at COVID-19. Rev Esp Anestesiol Reanim (Engl Ed). 2020; 67(6):289-291.

[19] Yao W, Wang T, Jiang B, Gao F, Wang L, Zheng H, et al. Emergency tracheal intubation in 202 patients with COVID-19 in Wuhan, China: lessons learnt and international expert recommendations. Br J Anaesth. 2020; 125(1):e28-e37.

[20] Boscolo A, Pasin L. Outcomes of COVID-19 Patients Intubated After Failure of Non-Invasive Ventilation: A Multicenter Observational Study. Sci Rep. 2021; 11(1):17730.

[21] Daniel P, Mecklenburg M, Massiah C, Joseph MA, Wilson C, Parmar P, et al. Non-invasive positive pressure ventilation versus endotracheal intubation in treatment of COVID-19 patients requiring ventilatory support. Am J Emerg Med. 2021; 43:103–8.

[22] Papoutsi E, Giannakoulis VG, Xourgia E, Routsi C, Kotanidou A, Siempos II. Effect of timing of intubation on clinical outcomes of critically ill patients with COVID-19: a systematic review and meta-analysis of non-randomized cohort studies. Crit Care. 2021; 25(1):121.

[23] Pierce A, Payette C, DelPrete B, Woo W, Benjenk I, Chintalapani S, et al. Staving Off Intubation: Characteristics of Outcomes in Early Versus Delayed Intubation in COVID-19. Crit Care Med. 2021; 49(1):62–62.

[24] Pandya A, Kaur NA, Sacher D, O'Corragain O, Salerno D, Desai P, et al. Ventilatory Mechanics in Early vs Late Intubation in a Cohort of Coronavirus Disease 2019 Patients With ARDS: A Single Center's Experience. Chest. 2021; 159(2):653-656.

[25] Siempos II, Xourgia E, Ntaidou TK, Zervakis D, Magira EE, Kotanidou A, et al. Effect of Early vs. Delayed or No Intubation on Clinical Outcomes of Patients With COVID-19: An Observational Study. Front Med. 2020; 7:614152.

[26] Matta A, Chaudhary S, Bryan Lo K, DeJoy R 3rd, Gul F, Torres R, et al. Timing of Intubation and Its Implications on Outcomes in Critically Ill Patients With Coronavirus Disease 2019 Infection. Crit Care Explor. 2020; 2(10):e0262..

[27] Phua J, Weng L, Ling L, Egi M, Lim C-M, Divatia JV, et al. Intensive care management of coronavirus disease 2019 (COVID-19): challenges and recommendations. Lancet Respir Med. 2020; 8(5):506-517.

[28] Kangelaris KN, Ware LB, Wang CY, Janz DR, Zhuo H, Matthay MA, et al. Timing of Intubation and Clinical Outcomes in Adults With Acute Respiratory Distress Syndrome. Crit Care Med. 2016; 44(1):120-9.
[29] Mosier JM, Sakles JC, Whitmore SP, Hypes CD, Hallett DK, Hawbaker KE, et al. Failed noninvasive positive-pressure ventilation is associated with an increased risk of intubation-related complications. Ann Intensive Care. 2015; 5(1):1–9.
[30] Siempos I, Xourgia E. Effect of early versus delayed or no intubation on clinical outcomes of patients with COVID-19. Front Med (Lausanne). 2020; 7: 614152.
[31] Meng L, Qiu H, Wan L, Ai Y, Xue Z, Guo Q, et al. Intubation and ventilation amid the COVID-19 outbreak: Wuhan's experience. Anesthesiology. 2020;132(6):1317–32.
[32] El- Boghdadly K, Wong DJN, Owen R, Neuman MD, Pocock S, Carlisle JB, et al. Risks to healthcare workers following tracheal intubation of patients with COVID- 19: a prospective international multicentre cohort study. Anaesthesia. 2020; 75(11):1437-1447.
[33] Richardson S, Hirsch JS, Narasimhan M, Crawford JM, McGinn T, Davidson KW, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. Jama. 2020; 323(20):2052-2059.
[34] Wang Y, Lu X, Li Y, Chen H, Chen T, Su N, et al. Clinical course and outcomes of 344 intensive care patients with COVID-19. Am J Respir Crit Care Med. 2020;201(11):1430–4.
[35] Wang J, Hajizadeh N, Moore EE, McIntyre RC, Moore PK, Veress LA, et al. Tissue plasminogen activator (tPA) treatment for COVID-19 associated acute respiratory distress syndrome (ARDS): A case series. J Thromb Haem ost. 2020;18(7):1752–5.
[36] Ling L, Joynt GM, Lipman J, Constantin JM, Joannes-Boyau O. COVID-19: A critical care perspective informed by lessons learnt from other viral epidemics. Anaesth Crit Care Pain Med. 2020; 39(2):163–6.
[37] Bevilacqua S, Bottari V, Galeotti I. Systematic Application of Rapid Sequence Intubation With Remifentanil During COVID-19 Pandemic. Semin Cardiothorac Vasc Anesth. 2021; 25(1): 74–5.
[38] Heffner AC, Swords D, Kline JA, Jones AE. The frequency and significance of postintubation hypotension during emergency airway management. J Crit Care. 2012; 27(4):417.e9-417.e13.
[39] Chahar P, Dugar S, Marciniak D. Airway management considerations in patients with COVID-19. Cleve Clin J Med. 2020;87(5):1–4.
[40] Kapoor D, Atter P, Kang A, Singh M. Emerging Perspectives of Endotracheal Intubation in Patients with Severe COVID- 19 Pneumonia: A Narrative Review. Arch Anesth Crit Care. 2021; 7(Spring):96–102.
[41] Sullivan EH, Gibson LE, Berra L, Chang MG, Bittner EA. In-hospital airway management of COVID- 19 patients. 2020; 24(1):292.
[42] Frat J-P, Ricard J-D, Quenot J-P, Pichon N, Demoule A, Forel J-M, et al. Non-invasive ventilation versus high-flow nasal cannula oxygen therapy with apnoeic oxygenation for preoxygenation before intubation of patients with acute hypoxaemic respiratory failure: a randomised, multicentre, open-label trial. Lancet Respir Med. 2019;7(4):303–12.
[43] Wong P, Lim WY. Aligning difficult airway guidelines with the anesthetic COVID-19 guidelines to develop a COVID-19 difficult airway strategy: a narrative review. J Anesth. 2020; 1–20.
[44] Hawkins A, Stapleton S, Rodriguez G, Mauricio Gonzalez R, Baker WE. Emergency tracheal intubation in patients with covid-19: A single-center, retrospective cohort study. West J Emerg Med. 2021;22(3):678–86.
[45] Cook TM, McGuire B, Mushambi M, Misra U, Carey C, Lucas N, et al. Airway management guidance for the endemic phase of COVID-19. Anaesthesia. 2021;76(2):251–60.
[46] Singh V, Sasidharan S, Nasser A, Dhillon H. Intubation and invasive Mechanical ventilation of COVID-19 Acute Respiratory Distress Syndrome patients. MRIMS J Heal Sci. 2021; 9(1):21.
[47] Lee CP, Yip YY, Chan AK, Ko CP, Joynt GM. Early intubation versus late intubation for COVID-19 patients: An in situ simulation identifying factors affecting performance and infection control in airway management. Anaesth Intensive Care. 2021; 49(4):284-291.
[48] Tsolaki V, Zakynthinos GE. Timing of Intubation in Covid-19 ARDS: What "time" really matters?. Crit Care. 2021; 25(1):173.
[49] Gattinoni L, Marini JJ, Busana M, Chiumello D, Camporota L. Spontaneous breathing, transpulmonary pressure and mathematical trickery. Ann Intensive Care. 2020; 10(1):88.
[50] Gattinoni L, Coppola S, Cressoni M, Busana M, Rossi S, Chiumello D. COVID-19 does not lead to a "typical" acute respiratory distress syndrome. Am J Respir Crit Care Med. 2020; 201(10): 1299-300.
[51] Tobin MJ. Principles and practice of mechanical ventilation. 3rd ed. New York: McGraw Hill;

2013. p. 3–1516.

[52] Hussain Khan Z, Sasaa MA, Mohammadi M, Alipour A, Hajipour A. Mortality Related to Intubation in Adult General ICUs: A Systematic Review and Meta-Analysis. Arch Neurosci. 2020;7(3).