



## Timing of tracheostomy in mechanically ventilated COVID-19 patients

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### Abstract

According to the World Health Organization as of September 16, 2021, there have been over 226 million documented cases of coronavirus disease 2019 (COVID-19), which has resulted in more than 4.6 million deaths and approximately 14% develop a more severe disease that requires respiratory assistance such as intubation. Early tracheostomy is recommended for patients that are expected to be on prolonged mechanical ventilation; however, supporting data has not yet been provided for early tracheostomies in COVID-19 patients. The aim of this study was to explore established guidelines for performing tracheostomies in patients diagnosed with COVID-19. Factors considered were patient outcomes such as mortality, ventilator-associated pneumonia, intensive care unit length of stay, complications associated with procedures, and risks to healthcare providers that performed tracheostomies. Various observational studies, meta-analyses, and systematic reviews were collected through a PubMed Database search. Additional sources were found through Google. The search was refined to publications in English and between the years of 2003 and 2021. The keywords used were "Coronavirus" and/or "guidelines" and/or "tracheostomy" and/or "intensive care". Twenty-three studies were retained. Due to the complex presentation of the respiratory virus COVID-19, previously established guidelines for tracheostomies had to be reevaluated to determine if these guidelines were still applicable to these critically ill ventilated patients. More specifically, medical guidelines state benefits to early tracheostomies in critically ill ventilated non-COVID-19 patients. However, after having conducted this review, the assumptions about the benefits of early tracheostomies in critically ill ventilated patients may not be appropriate for COVID-19 patients.

**Key Words:** Tracheostomy; Timing; COVID-19; SARS-CoV-2; Coronavirus

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**Core Tip:** With the sudden onset coronavirus disease 2019 (COVID-19), guidelines for patient care were rapidly evolving to protect both providers and patients. However, it has yet to be determined if performing tracheostomies earlier or later was more beneficial for outcomes in patients infected with COVID-19. This review assesses studies that discuss the timing of tracheostomies in COVID-19 patients to establish appropriate guidelines for best patient outcomes.

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## INTRODUCTION

After the first case of severe acute respiratory syndrome coronavirus 2 [coronavirus disease 2019 (COVID-19)] was documented in China in December 2019, the novel respiratory illness quickly turned into a pandemic and brought about a crisis to the current healthcare system. COVID-19 has played a large role in the number of diagnoses and hospitalizations not just in the United States, but worldwide. According to the World Health Organization (WHO) as of September 16, 2021, there have been over 226 million documented cases of COVID-19, which has resulted in more than 4.6 million deaths[1]. Likewise, hospital and intensive care unit (ICU) admissions have seen a drastic uptick as well. According to WHO, approximately 14% of patients develop a more severe disease, many of whom may require respiratory assistance[2, 3]. Initially, supplemental oxygen is given to patients with non-invasive means such as a nasal cannula, high flow oxygen, continuous positive airway pressure machines, or bilevel positive airway pressure machines. These patients may require a more invasive form of ventilation such as endotracheal intubation with mechanical ventilation. A tracheostomy is a common surgical procedure that is done when patients require prolonged mechanical ventilation[4].

The use of tracheostomies dates as far back to 3600 B.C. The open tracheostomy used to be the procedure of choice, however, over the last few decades, the percutaneous tracheostomy has become more popular since the procedure can be done at the bedside under the guidance of a bronchoscopy[5,6]. Tracheostomies provide several benefits to patients such as increasing patient comfort and have also proven to decrease the incidence of pneumonia and overall length of ICU stay[7]. Despite the many benefits, there is variability in the practice patterns in terms of timing of performing tracheostomies[8]. As for current guidelines in the United States, The American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNS) recommends that tracheostomies should not be performed prior to 14 days of endotracheal intubation[9]. If the patient is expected to be on prolonged mechanical ventilation (more than 3 wk), an early tracheostomy (ET) within the first seven days of intubation can be performed[8]. With proper maintenance, endotracheal intubation can be maintained for about one to two weeks without causing major injury to the larynx before needing to be converted to a tracheostomy[4,10]. With the current COVID-19 pandemic, many of the ventilated patients require prolonged mechanical ventilation and the mortality of these patients is very high as well[11]. Knowing the virulence and lethality of this disease, and taking into consideration that the tracheostomy can aerosolize the disease into the environment very quickly, performing this procedure can pose a potential hazard to providers. Taking this into account, extra precautions have been implemented for the safety of providers that will be performing this procedure such as full personal protective equipment, operating theatres or negative pressure rooms, and paralysis of the patient to prevent the possibility of coughing[12,13]. COVID-19 being a novel disease had very few known treatment options in the beginning. However, the management of the disease has mostly been protocolized but one thing that is still debatable is when and how to safely perform a tracheostomy in a ventilated patient.

This review aims to examine the timing of tracheostomy procedures performed in COVID-19 patients and their impact on outcomes.

## CLINICAL PRESENTATIONS

A total of 23 studies were identified and selected for the review, [Figure 1](#).

### Guidelines

For COVID-19 patients, the AAO-HNS recommends that tracheostomies should not be performed in the first 2-3 wk of endotracheal intubation in hospitalized patients. They add that patients should be stable and preferably have a negative COVID-19 test[9,14]. Similar recommendations have been expressed by The British Association of Otorhinolaryngology, that a tracheostomy should not be performed within the first 14 d of intubation and COVID-19 status should be checked prior to performing the procedure [15]. The Infectious Disease Control Committee at Hospital Italiano de Buenos Aires followed guidelines that were also similar to those of the United States. Guidelines for tracheostomies in India vary slightly from other countries[13]. Because of a shortage of available tests, confirming COVID-19 status was not necessarily required before performing tracheostomy. Guidelines also suggest a more conservative approach where if there are any contradictions to intervention or unclear prognosis then tracheostomy should be delayed beyond the 14-d period.

### Timing of tracheostomy and outcomes

**Systematic reviews, meta-analyses and case report:** Bier-Laning *et al*[16] conducted a study to review 59 institutions treating COVID-19 patients globally. The authors identified variability in the timing of performing tracheostomies in COVID-19 patients. However, while 91% of institutions recommended waiting a minimum of 14 days before performing the tracheostomy, only 78% of centers waited 14 d in order to pass the infectious period and retested patients before performing the procedure.

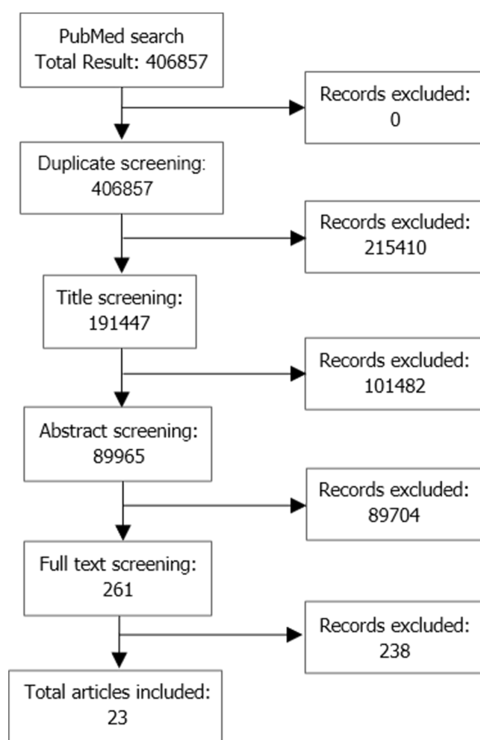
Another review stated that patients diagnosed with COVID-19 who required mechanical ventilation very rapidly deteriorate. The authors mentioned two studies: one from the United States and one from China- both of which showed very high mortality in ventilated patients. Therefore, suggesting that performing a tracheostomy early may not be very helpful[12].

Mandal *et al*[17] performed a review of papers that took into consideration COVID-19 patients that required tracheostomies. This study examined guidelines for timing, staff safety, procedure, technique, and post-operative care. The authors gathered recommended guidelines for tracheostomies from the United States, Canada, and India and assessed the measures concluding that guidelines were very similar. The authors concluded that a tracheostomy can be performed at or after the 2-wk waiting period as long as the patient's prognosis is good and the ventilator setting is at 50% oxygen. However, while the waiting period is strongly recommended, it is not necessary and can be bypassed for a tracheostomy to be performed sooner if the patient is still infectious given that the endotracheal tube is not proving to be sufficient.

A study published by Hiramatsu *et al*[18] included a case study of a patient that received a tracheostomy on the 28<sup>th</sup> day of having COVID-19 symptoms. The patient was elderly with many underlying conditions. After the tracheostomy, the patient's condition improved and was then eligible for transfer to another hospital. This study reflects back to the severe acute respiratory syndrome (SARS) pandemic of 2002. Tracheostomy studies conducted during this time reported that the timing from tracheal intubation to tracheostomy averaged 14 d to 25 d. In COVID-19 patients with acute respiratory failure, it is suggested that ETs (before 10 d) should be avoided.

A case report by Holmen *et al*[19] presented a case of a COVID-19 patient that required an extensive ICU stay due to prolonged endotracheal intubation. The patient tested negative for COVID-19 on the 37<sup>th</sup> day and a tracheostomy was later performed. Using this case, the authors raised questions about the guidelines regarding the infectivity period in COVID-19 patients[20].

An additional case report was assessed for this study. Two cases were presented, each in which the patients on mechanical ventilation underwent percutaneous tracheostomy within the two weeks of observing infectivity. Despite patients testing positive for COVID-19, the procedure can be performed safely with minimal infectivity and danger to the patients[21].



**Figure 1** PRISMA Diagram for Literature Screening using the keywords “Coronavirus” and/or “guidelines” and/or “tracheostomy” and/or “intensive care”. Observational studies, systematic reviews and meta-analyses were included in the selection process. This review was performed in accordance with PRISMA guidelines.

**Observational Studies:** A study conducted in China analyzed data from 80 patients who underwent elective tracheostomies. An ET was defined as the tracheostomy that was performed before 14 d and a late tracheostomy was defined as the procedure that was performed after 14 d. From this cohort, the median duration from endotracheal intubation to tracheostomy was 17.5 d. At the 60-d follow-up, 31 (38.8%) patients had been successfully weaned from the ventilator, 17 (21.2%) patients had been discharged from the ICU and a total of 43 (53.8%) patients had died. Late tracheostomy was associated with a lower death rate compared to ET, the hazard ratio of late tracheostomy was 0.34 (95% confidence interval: 0.17–0.70). Tracheostoma bleeding was a complication that occurred in 4 (13.3%) of ET patients and 10 (20.0%) of late tracheostomy patients. Subcutaneous emphysema occurred in one patient in each group. There was one incidence of both tracheostoma infection and mediastinal emphysema in the late tracheostomy group[22].

In a study from Italy, 50 patients were admitted in the ICU and were put on mechanical ventilation. The study cohort consisted of 23 patients who underwent a tracheostomy. ET was defined as if the procedure was performed before 10 d and late tracheostomy was defined as the tracheostomy was performed after 10 d. The average time between the initial intubation and tracheostomy was 13 d. The mean time that the patients were mechanically ventilated was 29 d and the mean length of stay in the ICU was 27 d. Nine tracheostomies were performed early, and 14 tracheostomies were performed late. After a median follow-up of 50 d, 9 (39.0 %) patients died, 5 (22.0%) were still receiving invasive mechanical ventilation (IMV) in the ICU, 3 (13.0%) were discharged from the ICU to be moved to the sub-intensive unit, and 6 (26.0%) were decannulated and discharged. Among the patients that were alive, the mean time from tracheostomy and decannulation was 26.8 d. Among deceased mean time from tracheostomy and death was 13.7 d. In this study, an ET was associated with a higher risk of mortality[23].

A study conducted in the United States of ten hospitals in the Chicagoland metropolitan area collected data from 486 hospitalized patients. Of the 138 patients that required IMV, only 19 (13.8%) intubated patients required tracheostomies. From the 138 IMV patients, 78 (56.5%) were eventually extubated and 21 had died making the mortality rate 15.2%. The timing of tracheostomy was not mentioned therefore information about the relationship of timing of tracheostomy to successful weaning or overall mortality was not provided. Thirty-nine patients remained intubated at the last

follow-up. The mean length of stay for hospitalized patients was 19 d. Of the 78 patients that were extubated, 30 (38.5%) were extubated within 1-7 d, 42 (53.8%) were extubated within 7-14 d, and 6 (7.7%) were extubated after 14 d. In this study, most deaths occurred within the 14-d incubation period[10].

Schuler *et al*[23] conducted a study consisting of 18 patients. Tracheostomies were performed between 2 d and 16 d after intubation. The authors state that while delaying tracheostomies minimizes risk to healthcare providers, complications such as myopathy, ventilator-associated respiratory muscle atrophy, neuropathy, and inability to wean, as well as other concerns such as over-occupation of ICU beds, lengthier sedation, and inability to communicate. In this study, ETs also reduced the number of patients requiring prone positioning which often leads to accidental decannulation of the ventilation tube. The authors state that taking into consideration the clinical state of the patient, performing an earlier tracheostomy may be beneficial.

An additional study observed 29 patients with COVID-19 that were admitted to the ICU and underwent a tracheostomy. Outcomes were mortality, ICU stay, and time on mechanical ventilation. Although the average time to tracheostomy was 15.2 d, which is considered a delayed procedure. The authors found that for each day of delay in performing the procedure, the number of days on mechanical ventilation increased by 0.6 d. Delayed tracheostomies did not impact ICU stay or mortality[24].

A study conducted in the United States at the University of Pennsylvania, tracheostomies were performed in 53 COVID-19 patients with acute respiratory failure. In these patients, the average (range) time from intubation to tracheostomy was 19.7 (8-42) d. At the time of follow-up, 30 (56.6%) patients had been removed from ventilator support, 16 (30.2%) had been discharged, 7 (13.2%) had been decannulated, and 6 (11.3%) had died. There was a weak positive correlation of ET to weaning the patients from the ventilator[25].

Botti *et al*[26] conducted a retrospective study on 44 COVID-19 ICU patients in Italy that underwent tracheostomies. This retrospective cohort study was focused on patients over 18 years of age with severe COVID-19 pneumonia that required mechanical ventilation. Average time from intubation to tracheostomy was 7 d. Of the 44 patients, 25 (56.8%) had reported complications at follow-up such as subcutaneous emphysema, infection, or mild hemorrhage. A total of 15 (34.1%) patients had died at follow-up but there was no correlation between the timing of tracheostomy and mortality ( $P = 0.82$ ). ETs were performed at this center in order to increase ICU capacity but not necessarily because of the success of performing the procedure earlier.

A study conducted in Japan included 16 patients that received tracheal intubation but nearly a third (31.0%) required tracheostomies. The average time from intubation to tracheostomy was 20 d (14-27 d) which followed the study guidelines for performing a tracheostomy after 2-3 wk of intubation. There were no reported infections amongst providers[27].

**Editorials and letters to the editor:** In a letter to the editor, Ferri *et al*[28] analyzed a sample of 8 patients that underwent tracheostomies. Tracheostomies were performed on patients that were intubated for at least 14 days. Of these 8 patients, 2 (25%) patients died after the procedure and the median time from tracheostomy to death was 3 days. This mortality rate was lower than that of COVID-19 patients admitted to the ICU at the time. In this study cohort, an intubation period of less than 20 d was associated with an increased risk of death.

An editorial by Mesolella[29] discusses if the timing of tracheostomies is a factor that influences the clinical outcome of patients. In this editorial, the author states that even while early procedures have shown better outcomes such as mortality, pneumonia, and time of mechanical ventilation, there are many complications to performing a tracheostomy that outweighs the benefits. The author suggests that by the end of the waiting period of 21 d, the viral load would have decreased, minimizing the risk to health care providers and giving providers a more accurate prognosis for the patient.

A letter to the editor by Kwak *et al*[30] reviewed articles as well as data from NYU Langone Health for the accuracy and efficacy of proposed guidelines for performing tracheostomies on COVID-19 patients. At this center, researchers found that the mean time from endotracheal intubation to tracheostomy was 12.2 d and the onset of symptoms to tracheostomy was 22.8 d. The authors suggest that by day 12 from intubation or day 22 from the onset of symptoms, the viral load should be greatly decreased therefore not causing any more risk than a routine tracheostomy. ETs also showed decreased time on mechanical ventilation by an average of 6.7 d and overall length of hospital stay by an average of 6.9 d. Finally, the authors stated that despite performing ETs, none of the surgeons performing the procedures were infected with



**Table 1 A description of studies collected for the review**

Ref.	Title	Country	Following Guidelines for COVID-19 in the United States?	Timing of Tracheostomy	Type of Tracheostomy	Where was the Tracheostomy Done	Patient Outcome
Parker <i>et al</i> [9]	AAO Position Statement: Tracheotomy Recommendations During the COVID-19 Pandemic	United States	Yes	Can be considered after 2-3 weeks from intubation with negative COVID test	Unknown	ICU or operating room	Inconclusive
Hur <i>et al</i> [10]	Factors Associated with Intubation and Prolonged Intubation in Hospitalized Patients with Covid-19	United States	Yes	Assessed after ICU admission and intubation	Open	Operating Room	Unknown
Meng <i>et al</i> [11]	Early <i>vs</i> Late Tracheostomy in Critically Ill Patients: A Systematic Review and Meta-analysis	China	No	Various Timings	Open and Percutaneous	ICU or CCU	Early trach does not significantly alter the mortality, incidence of VAP duration of MV or length of ICU stay
Shiba <i>et al</i> [12]	Tracheostomy Considerations During the COVID-19 Pandemic	Global	Yes	Avoided if the patient is still infectious	Open and Percutaneous	Operating Room and ICU bedside	If the patient cannot be intubated, a laryngeal mask airway may be preferred over an emergent trach
Smith <i>et al</i> [13]	Tracheostomy in the intensive care unit: Guidelines during COVID-19 worldwide pandemic	Argentina	No	After 21 days, negative COVID-19 test	Percutaneous	ICU	No benefits to early trach, but benefits to trach may be the possibility of decreasing sedation and delirium, increasing patient comfort, and reducing the incidence of laryngotracheal stenosis, ICU stay, and pneumonia
Heyd <i>et al</i> [14]	Tracheostomy Protocols During COVID-19 Pandemic	Global	Yes	>21 days depending on vent settings; patient shouldn't be infectious	Open	ICU or operating room	Inconclusive
Takhar, <i>et al</i> [15]	Recommendation of a Practical Guideline for Safe Tracheostomy During the COVID-19 Pandemic	Global	Yes	At least 14 days	Open and Percutaneous	Operating Room and ICU bedside	Tracheostomy should be avoided if the prognosis is not deemed favorable since the mortality is ~50%
Bier-Laning <i>et al</i> [16]	Tracheostomy During the COVID-19 Pandemic: Comparison of International Perioperative Care Protocols and Practices in 26 Countries	Global	Yes	2-3 weeks from intubation preferably with negative COVID-19 test and falling inflammatory markers	Open and Percutaneous	Negative pressure room in ICU or Operating Room	Should reduce risk of virus exposure to providers and increase patient stability
Mandal <i>et al</i> [17]	A Systematic Review on Tracheostomy in COVID-19 Patients: Current Guidelines and Safety Measures	Global	Yes	At least 14 days; Patient should no longer be infectious	Open and Percutaneous	Operating Room and ICU bedside	Inconclusive
Hiramatsu <i>et al</i> [18]	Anesthetic and Surgical Management of Tracheostomy in a Patient With COVID-19	Japan	Yes	Day 28 of hospitalization	Open	Negative-pressure room in ICU	Patient improved by day 35 and transferred to another hospital
Holmen <i>et al</i> [19]	Delayed Tracheostomy in a Patient With Prolonged Invasive	United States	Yes	Day 41 of intubation	Unknown	Unknown	Patient status improved and was discharged to rehab facility on day 58

	Mechanical Ventilation due to COVID-19						of hospitalization
Marzban-Rad <i>et al</i> [20]	Early percutaneous dilational tracheostomy in COVID-19 patients: A case report	Iran	No	<10 days	Percutaneous	ICU	Early tracheostomy can be safely performed and improve patients' condition when necessary
Tang <i>et al</i> [21]	Tracheostomy in 80 COVID-9 Patients: A Multicenter, Retrospective, Observational Study	China	Yes	Before 14 days or after 14 days	Open and Percutaneous	ICU or Operating room	Trachs within 14 days were associated with an increased mortality rate
Volo <i>et al</i> [22]	Elective Tracheostomy During COVID-19 Outbreak: To Whom, When, How? Early Experience from Venice, Italy	Italy	No	Median timing was 13 days- 10 days was the cut off for early to late	Open and Percutaneous	ICU	Early tracheostomy was associated with a greater risk of mortality. This conclusion was combined with SOFA scores greater than 6 and D-dimer greater than 4
Schuler <i>et al</i> [23]	Surgical tracheostomy in a cohort of COVID-19 patients	Germany	No	Between 2-16 days	Open	ICU	No infection to staff, decreased sedatives, decrease the risk of myopathy, neuropathy, shortened ICU stay
Mata-Castro <i>et al</i> [24]	Tracheostomy in patients with SARS-CoV-2 reduces time on mechanical ventilation but not intensive care unit stay	Spain	No	15.2 days	Unknown	Operating theatre in ICU	Delay in trach increased days of mechanical ventilation
Chao <i>et al</i> [25]	Outcomes After Tracheostomy in COVID-19 Patients	United States	Yes	8-30 days, average 17.5 days	Open and percutaneous	Negative pressure room in ICU	Patients who underwent earlier trachs achieved ventilator liberation sooner than late trach, patients with ARDS on vents should be delayed
Botti <i>et al</i> [26]	The Role of Tracheotomy and Timing of Weaning and Decannulation in Patients Affected by Severe COVID-19	Italy	No	2-17 days, average 7 days	Open or percutaneous	Negative pressure room in ICU	Tracheostomies proved to be an easier approach for patients with blockages
Nishio <i>et al</i> [27]	Surgical strategy and optimal timing of tracheostomy in patients with COVID-19: Early experiences in Japan	Japan	Yes	14-27 days, average 20 days	Open	ICU	No differences in blood loss or infection from pre to post-procedure
Ferri <i>et al</i> [28]	Indications and Times for Tracheostomy in Patients With SARS CoV2-related	Italy	No	Intubated 14 days or more	Open	ICU	The mortality rate amongst trached patients was 25% compared to 26%
Mesolella <i>et al</i> [29]	Is Timing of Tracheotomy a Factor Influencing the Clinical Course in COVID-19 Patients?	Italy	Yes	After 18 days	Unknown	ICU	Decreased pneumonia, MV rates, ability to oral feed, avoid injury to the larynx
Kwak <i>et al</i> [30]	Tracheostomy in COVID-19 Patients: Why Delay or Avoid?	United States	No	12.8 Days	Unknown	Unknown	Decreased LOS, decreased MV, no infection to providers
McGrath <i>et al</i> [31]	Tracheostomy for COVID-19: business as usual?	United Kingdom	No	Case-specific	Open, percutaneous or hybrid	ICU or operating theatre	Safe for providers and patients, prevents prolonged ventilation, physiological status of patient is more important than the viral load

Observational studies, systematic reviews and meta-analyses were included in the selection process. This review was performed in accordance with

## COVID-19.

McGrath *et al*[31] discussed the changes that had been implemented for tracheostomies with the onset of COVID-19. The authors gathered that 30-d survival improved significantly with tracheostomy in general, and ICU length of stay was reported to be shorter with ETs. The authors concluded that the recommendation to postpone tracheostomies to minimize infectivity is second to the physiological status of the individual patient.

## CONCLUSION

Due to the complicated presentation of COVID-19, the best practice for patient care and disease management has yet to be established. Case by case management, risk-benefit analysis, and justified medical judgement seems to provide the optimum course of action when presented with the role of providing care to these unique cases. Also, based on how critically ill COVID-19 patients are managed, guidelines will need to be established on appropriate landmarks for patients.

Various studies mention the complications associated with delaying tracheostomies [17,21,29]. Complications can be related to early or late procedure, severity of disease, comorbidities, type of tracheostomy performed, where the procedure was performed, and individual patient demographics. Many sources discussed the risk to providers performing tracheostomies on patients. The waiting period of a minimum of 14 d was mostly implemented to wait for the infectious period to pass in order to protect healthcare providers. However, in the studies that allowed ETs, there was no presentation of COVID-19 infection in providers from performing the procedure[30].

Studies on the timing of tracheostomies are still very scarce considering the novelty of the virus. However, using the limited data that is available and reflecting on studies from the 1918 H1N1 pandemic and the 2002 SARS pandemic, researchers and providers can attempt to predict how tracheostomies will define outcomes for COVID-19 patients. Other limitations of this study included varying qualities of studies gathered. Due to the novelty of the virus, researchers were limited in the number of participants that were able to be included in the study prior to publication. All eligible studies were included in this review regardless of quality due to a lack of available content. Further studies by authors aim to address these limitations.

Considering that tracheostomies are an aerosol-generating procedure, waiting to perform this procedure after the infectious period of 2-3 wk, may prevent or reduce the transmission of disease creating a safer environment for healthcare providers[18]. It was also mentioned that tracheostomies in general may not be beneficial in COVID-19 patients who are suffering from rapidly progressing disease[12]. The majority of studies showed a waiting period of 2 wk from the timing of intubation to performing a tracheostomy, Table 1.

In summary, the timing of tracheostomy in COVID-19 patients varied from institution to institution. However, the majority of data support delaying tracheostomies for after the first two weeks of intubation. Furthermore, the patient's overall health condition, physiological parameters, hemodynamics status and disease burden must be considered prior to proceeding with a tracheostomy.

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