Published online 2022 July 20 **Original Article**

COVID-19 Patients from Hospitalization to Tracheostomy, the Experience of a High-Volume Center

Mojtaba Mokhber Dezfuli[1], Omid Mosafaeii-Rad[1], Fariba Ghorbani[2], Behrooz Farzanegan[3], Elham Mir-Moeini[2] and Mohammad Behgam Shadmehr[2,*]

[1]Lung Transplantation Research Center, National Research Institute of Tuberculosis and Lung Diseases, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2]Tracheal Diseases Research Center, National Research Institute of Tuberculosis and Lung Diseases, Masih Daneshvari Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[3]Critical Care Quality Improvement Research Centre, Shahid Beheshti University of Medical Sciences, Tehran, Iran

*** *Corresponding author:*** Mohammad Behgam Shadmehr, Tracheal Diseases Research Center, National Research Institute of Tuberculosis and Lung Diseases, Masih Daneshvari Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran. Email: mbshadmehr@yahoo.com

Received 2021 October 15; **Revised** 2021 November 23; **Accepted** 2022 June 09.

Abstract

Background: Making decisions and planning about tracheostomy is not clear yet.
Objectives: This study aimed to report intensive care unit (ICU) admission, intubation, and tracheostomy rates among patients in different settings and compare the outcomes of surgical and Percutaneous dilational tracheostomy (PDT) techniques between COVID-19 and non-COVID patients.
Methods: Patients admitted to Masih Daneshvary hospital were assessed from February 2020 to May 2021 for intubation and tracheostomy rates. Different aspects and outcomes of two methods of tracheostomy, including surgical and PDT tracheostomy, were compared. Among non-COVID patients, 15 ICU admitted patients with different etiologies of pneumonia who required mechanical ventilation and tracheostomy were randomly selected and compared to COVID-19 patients.
Results: A total of 7,748 COVID-19 patients were admitted, with 12.7% admitted to ICU with an intubation rate of 5.13%. Tracheostomy was performed for a total of 36 patients (0.46%) for prolonged intubation with a trend of 0.1% to 1.45% in 16 months. Regarding the technique of tracheostomy, 24% and 33.3% of patients survived in surgical and PDT groups, respectively (P=0.44). Surgical tracheostomy and PDT were performed in 26.5% and 40% of non-COVID patients, respectively (P=0.5). The mortality rate was 72.2% and 20% in the surgical tracheostomy and PDT groups, respectively (P=0.003).
Conclusion: Given the study results, both surgical and percutaneous techniques are feasible for COVID-19 patients, and the decision about the optimal timing of intubation needs more inquiry.

Keywords: COVID-19, Intubation, Surgical technique, Tracheostomy

1. Background

In late 2019, COVID-19 developed into a worldwide epidemic as a clinical picture of atypical pneumonia caused by e-Betacoronavirus SARS-CoV-2 (1). Following some treatment regimens, about 75% of patients recover with no need to receive intensive care (2) while there is a mortality rate of 3.4% (3). In some cases of severe COVID-19, due to respiratory failure, endotracheal intubation and mechanical ventilation are necessary, which last more than seven days. Less than 10% of patients require tracheostomy due to different etiologies, and since prolonged intubation exposes patients to complications, such as tracheal stenosis, tracheostomy is recommended. It reduces respiratory effort and dead space (4); however, tracheostomy has been placed in the second position among aerosol-generating procedures, including tracheal intubation, tracheostomy, noninvasive ventilation (NIV), bronchoscopy, nebulizer treatment, and tracheal suctioning (5). Therefore, decision-making and planning considering tracheostomy are not clear yet. In this regard, Adril et al. stated that performing an early tracheostomy within seven days after intubation not only reduces intensive care unit (ICU) stay and the duration of mechanical ventilation but also decreases the mortality rate (6). In contrast, some guidelines recommended postponing tracheostomy at least for two couple of weeks (7-9). Beyond tracheostomy timing, the method of procedure, whether percutaneous or surgical, is another concern (10).

2. Objectives

The present study aimed to explore the role of tracheostomy in managing COVID-19 patients using surgical and Percutaneous dilational tracheostomy (PDT) techniques. It also compared some features of tracheostomy between COVID-19 and non-COVID patients.

3. Methods

This cross-sectional study reported single-center experiences regarding COVID-19 patients, who underwent tracheostomy for airway management, and compared it to performing tracheostomy for non-

COVID patients before the COVID pandemic.

3.1. COVID-19 Patients

From February 2020 to May 2021, all patients admitted to Masih Daneshvari Hospital (Tehran, Iran), either intensive care unit or internal wards, were assessed regarding demographic characteristics. Intubated ICU admitted patients who had weaning failure, long-term mechanical ventilation, and inability to manage secretions were a candidate for tracheostomy, either by open tracheostomy or PDT.

Every tracheostomy was performed by one of the two teams of experienced thoracic surgeons or intensive care specialists with full protective wearing, including an N95 respirator, gown, cap, eye protection, and gloves.

Patients included in this study were above 18 years and had confirmed diagnoses of COVID-19. The rates of ICU admission, intubation, and tracheostomy during 16 months of the pandemic were depicted considering the fluctuation of incidence rate, according to the data acquired from Worldometer (https://www.worldometers.info/coronavirus/), which reports the trend of COVID-19, new cases, as well as mortality in each country.

3.2. Non-COVID Patients

To compare demographic characteristics, tracheostomy methods, and outcomes, 15 ICU admitted patients with different etiologies of pneumonia in need of mechanical ventilation and tracheostomy were assessed during the study period. In the center under study, tracheostomy is not common for patients with pneumonia other than COVID-19. The authors retrospectively evaluated all ICU patients to find out if tracheostomy was performed or not. During the study period, all non-COVID tracheostomy was also considered. Indeed, almost all patients were COVID-19 in the first year of the pandemic situation.

3.3. Outcome

To analyze the outcome in tracheostomy patients, improvement (discharge from hospital) or death were evaluated.

3.4. Tracheostomy Rate

Tracheostomy rate was the number of tracheostomy procedures divided by the total number of COVID-19 hospitalization each month, during 16 months of follow-up.

3.5. Surgical Tracheostomy

Tracheostomy was performed as an elective surgery in the operating room (OR) by two thoracic surgeons to observe all protection considerations and shorten the procedure. All OR staff used tight protection equipment. The patient's position was supine with neck extension, and oxygen (FIO2 100%) was continuously delivered.

A 3-cm transverse collar incision was performed below the cricoid cartilage around the second to fourth tracheal rings. First, the platysma was cut, and the strap muscles were separated in the midline. Afterward, the thyroid isthmus was cut with LigaSure, and then, the second, third, and fourth tracheal rings were exposed. A vertical tracheotomy was performed through the second, third, and fourth tracheal rings. Ventilation was then shortly ceased to avoid viral spreading as much as possible. After that, the endotracheal tube was quickly taken out, and a tracheostomy tube was inserted into the trachea. The tracheostomy tube cuff was then inflated appropriately and the tube was fixed and connected to the ventilator to continue mechanical ventilation. Next, an antimicrobial filter was placed in between the tracheostomy and ventilator connecting tubes to minimize viral contamination. Finally, the wound was repaired with two 3-0 nylon sutures, and the tracheostomy tube was fixed in place with its tape and two nylon sutures.

3.6. Percutaneous Dilational Tracheostomy

Before the procedure, the patient was sedated with 0.3 to 0.35 mg/kg midazolam, 0.1 mg fentanyl, and 0.2 mg/kg cisatracurium. First, the ventilator was set up to provide a respiratory rate of 15 breaths/min, a tidal volume of 500 ccs, and a positive end-expiratory pressure of 5 cm H2O. The patient was then oxygenated with 100% FIO2 for a few min before switching off the ventilator. After that, the endotracheal tube was pulled back and located proximal to the planned site (usually below the second ring) of needle insertion. The introducer needle was then entered into the tracheal lumen from the anterior part of the trachea. Finally, an appropriate skin incision was made, and a tracheostomy tube was inserted by the Seldinger technique.

3.7. Statistical Analysis

Data were gathered and analyzed using the SPSS software (version 23, IBM Inc., Chicago, IL, USA). Qualitative variables were reported as percentages and compared by the Chi-square test. On the other hand, continuous variables were reported as mean±SD. Regarding normal distribution, quantitative variables were compared using t student test, with the statistical significance fixed at 0.05.

4. Results

4.1. COVID-19 Patients

From February 2020 to May 2021, a total of 7,748 COVID-19 patients were admitted to Masih Daneshvari Hospital (Tehran, Iran). Among all hospitalized patients, the ICU admission rate was 12.7% (n=990), and the intubation rate was 5.13%

(n=398). Tracheostomy was also performed for 0.46% (n=36) of all COVID-19 patients. Among all COVID-19 patients admitted to ICU, tracheal intubation was performed on 40.3% and tracheostomy on 3.6% (Figure 1).

During 16 months of follow-up, the tracheostomy rate was in the range of 0.1% to 1.45%. Indeed, tracheostomy was performed on a total of 36 patients for prolonged intubation. In total, 58.3% of patients (n=21) were male with an average age of 58.33±15.78 years, and 41.07% were female with a mean age of 64.67±8.6 years. There was no significant difference between both genders regarding their age (P=0.56).

The outcome was patient improvement or death. Overall, the mortality rate was 34.24% among patients in ICU and 72.2% among intubated patients requiring tracheostomy; otherwise (when tracheostomy was not performed), it was 68.72%. In the tracheostomy group, the mean age was 50.67±18.18 and 62.2±12.51 years in the survived and expired cases, respectively (P=0.038). Moreover, 27.3% of male patients and 23.1% of female patients survived (P=0.55) (Table 1).

Mucus plaque was the main complication after tracheostomy tube insertion. Tracheostomy site bleeding was reported only in one patient's fistula, and infection was not reported at all. The mean time for tracheostomy was 18.57±5.9 and 19.5 ±0.7 days in the surgical tracheostomy and PDT, respectively, after hospital admission. Additionally, the time from tracheal intubation to tracheostomy was 11.5±5.6 and 8.7±2.4 (P=0.302). Moreover, the mean procedure time was 33±15 and 20±12 min in surgical and PDT, respectively. (P=0.42).

Post-tracheostomy mechanical ventilation duration was 11.20±8.7 and 14.60±5.9 days in surgical and PDT, respectively (P=0.49). Duration from tracheostomy to decannulation in surgical and PDT was 10.5±4.9 and 6±1.4 days, respectively (P=0.34).

From the outcome point of view, 24% of patients in the surgical method and 33.3% of those in the PDT group survived (P=0.44)

4.2. COVID-19 vs Non-COVID Tracheostomy

The mean age in all COVID-19 and non-COVID patients who had undergone tracheostomy was 59.54±15.05 and 50.20±26.92, respectively (P=0.22).

From a gender point of view, the percentage of

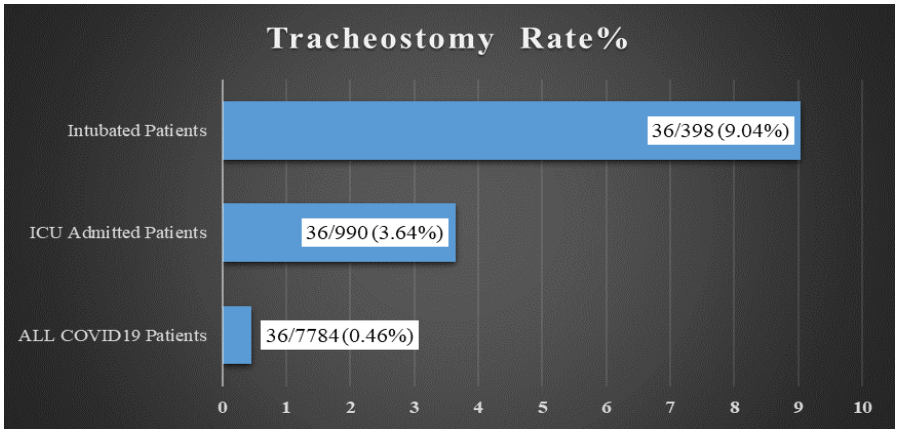

Figure 1. Rate of tracheostomy in hospitalized COVID-19 patients

Table 1. Demographic characteristics of patients

		Expired Cases	Survived cases
All COVID-19 patients (n=7748)	No	808	6940
	Age, year	66.04±14.8	54.31±17.02
	Male, %	64.10%	54.80%
ICU admitted COVID-19 patients (n=987)	No	651	336
	Age, year	57.14±17.88	65.93±14.9
	Male, %	66.70%	64.30%
Intubated COVID-19 patients (n=398)	No	341	57
	Age, year	64.83±15.18	56.28±18.6
	Male, %	63.90%	68.40%
Tracheostomy COVID-19 patients (n=36)	No	27	9
	Age, year	62.2±12.51	50.67±18.18
	Male, %	59.30%	66.70%
Non-COVID Tracheostomy (n=10)	No	2	8
	Age, year	72.5±21.9	52.5±28.5
	Male, %	50%	50%

ICU: Intensive Care Unit

male patients was 62.9% and 66.7% in COVID-19 and non-COVID groups, respectively (P=1).

The mortality rate was 72.2% in COVID-19 patients and 20% in non-COVID ones (P=0.003).

The time from tracheal intubation to tracheostomy was 9.4±4.2 and 15±5 in COVID-19 and non-COVID patients, respectively (P=0.007).

Regarding tracheostomy technique, surgical tracheostomy was performed for 26.5% of COVID-19 patients, while in non-COVID patients, the rate of surgical tracheostomy was 40% (P=0.5).

5. Discussion

This report on the rate of tracheostomy in different time points found various rates of tracheostomy ranging from 0.1% to 1.45% in the admitted patients during 16 months of follow-up. Some items that could influence the rate of tracheostomy include different demographic characteristics of the admitted patients, the improvement of the proposed experiences in managing critically ill patients, different scenarios of the disease, changes in the treatment options, and hospital bed occupancy rate. Indeed, in the COVID-19 pandemic, tracheostomy is an inevitable and essential procedure for patients requiring prolonged tracheal intubation and in the case of laryngeal edema (11). Furthermore, providing tracheostomy is considerable to manage both equipment and human resources and reduce the risk of ventilator-associated pneumonia, as well as the duration of sedation (12). As Martin‐Villares et al. pointed out, tracheostomy could be effective for both weaning and decannulation of COVID-19 patients (4); therefore, making decisions regarding this high-risk procedure is very important.

Recently, Morvan et al. stated that "PDT is associated with a better risk/benefit in terms of speed and safety" while some reports argue that surgical tracheostomy is preferable to percutaneous cricothyrotomy because of the ability for an air-flow cessation to prevent secretion emission (13). The present study showed that both PDT and surgical tracheostomy are feasible with the same outcomes.

In the center under study, 12.7% of all COVID-19 positive patients were admitted to ICU while in a study conducted on 1,099, only 5% of them were admitted to ICU (14). Moreover, 5.13% of all hospitalized patients underwent tracheal intubation, and 0.46% of them required tracheostomy. Differently put, among all ICU admitted patients, 3.64% underwent tracheostomy for prolonged intubation. Bellani et al. analyzed data from 50 countries and revealed that tracheostomy was performed in 13% of patients (15). In this regard, there is a wide range of 2.3% to 42% invasive ventilation in COVID-19 patients (16). In a retrospective report from China, 26% of all hospitalized COVID-19 patients were admitted to ICU due to respiratory distress, and 12% of all COVID-19 hospitalized patients in New York City required tracheal intubation with more than 80% mortality after invasive mechanical ventilation (17). The present study indicated a mortality rate of 68.72 % among intubated patients since only 5.13% of all COVID-19 patients underwent intubation. In a report from the early stages of the pandemic, 62.1% of patients who required high oxygen were intubated with a mortality rate of 57.3%. (18). A death rate of 24.3% and 9.7% have been stated when the intubation rate was 37.1% and 17.2%, respectively (19)(20). The intubation rate of patients in this study was 5.6 times less than that indicated in a systematic review (28%). Therefore, the pooled mortality rate of 14% was in line with the present study (21) since in the center under study, NIV is recommended rather than early intubation (22).

It is worth mentioning that in the center under study, bronchoscopy was omitted during PDT with no inconvenience. Although more views created by bronchoscopy resulted in a more accurate process, PDT via bronchoscopy increases the risk of high exposure to aerosolized particles and viral secretions during the manipulation of airways (23).

Previous studies found a survival rate of less than 20% (24) when mechanical ventilation was a part of the treatment approach. In the center under study, however, 27.8% of patients who required tracheostomy survived. As data obtained from non-COVID indicated, after performing tracheostomy, the mortality rate in COVID-19 was about 3.6 folds, compared to non-COVID patients.

While mucous plug was common, bleeding was reported in only one patient. Other complications, such as cuff rupture or leakage, pneumomediastinum, and massive bleeding from the tracheostomy site, were not observed. In some studies, these complications have been reported from 0.05% to 5% (intra-operative bleeding), 0.05% (cuff leakage), 0.05% (pneumothorax) (25),(11). In this study, an antithrombotic regimen was used as prophylaxis of micro and macro thrombosis to prevent venous thromboembolism, which was reported in 27.9% of critically ill COVID-19 patients (26). In the center under study, all tracheostomies for COVID-19 were provided by intensive care specialists or thoracic surgeons, and as Yu Chow et al. (27) stated, it is recommended that experienced ICU specialists, as well as head and neck or thoracic surgeons, perform tracheostomy.

Special protection after tracheostomy is mandatory considering the high risk of virus spreading when patients with tracheostomy are not decannulated or weaned from mechanical ventilation and viral transmission via tracheal secretions through the stoma. In the center under study, an antimicrobial/antiviral ventilator filter was

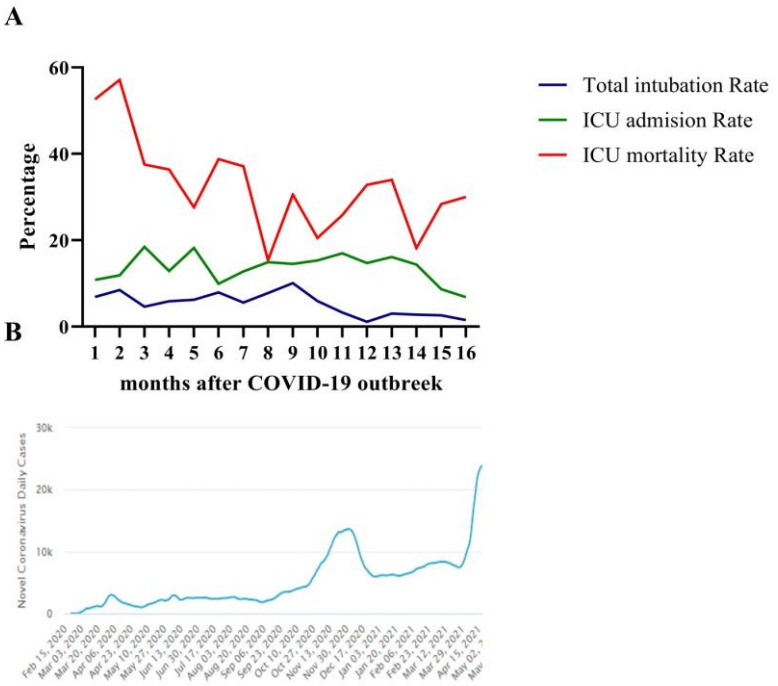

Figure 2. Trend of intubation in COVID-19 patients. A: Trend of changes over time (16 months) respecting ICU admission, ICU mortality, and intubation rate. B: Daily infected patients, according to the Worldometer data [29]

connected to the tracheostomy tube to prevent more contamination (28).

Patient management has been improved in the center under study, and the consideration of specific pathways of hyper-inflammation, as well as microvascular thrombosis associated with COVID-19, may have had a high impact on the reduction of mortality rate. Notwithstanding the increase in the novel coronavirus daily cases during this period, the ICU admission rate did not follow this pattern. Indeed, respiratory failure was managed using intravenous immunoglobulin, pentaglobin, hemoperfusion, plasmapheresis, and cell therapy. In newly admitted patients requiring oxygen therapy through NIV or high flow nasal cannula, Tocilizumab, an IL-6 inhibitor, was administered. Therefore, as Figure 2 illustrates, both intubation and ICU mortality rates have a declining trend.

6. Conclusion

This study has several limitations regarding data collection. Firstly, the hospital information system was used to access COVID-19 patients' records and procedures; therefore, in case of any errors in entering the procedure's code, the patient was lost. In addition, the study is institute-based and single-center, which impacts the level of evidence. Since in some centers, tracheostomy is delayed till the PCR test for COVID-19 turns negative, medical staff should be ready for managing tracheal stenosis patients immediately. Therefore, it is recommended to try and reduce this complication and properly inform patients at the risk of stenosis.

Acknowledgments

The authors would like to gratefully thank all physicians, nurses, and medical staff involved in this scientific report.

Footnotes

Conflicts of Interest: There is no conflict of interest.
Author's contributions: All authors attest that they meet the current ICMJE criteria for Authorship.
Funding: This study was supported by the National Research Institute of Tuberculosis and Lung Diseases, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
Ethical statements: The study was approved by the Ethics Committee of the National Research Institute of Tuberculosis and Lung Diseases, Shahid Beheshti University of Medical Sciences, Tehran, Iran, with the reference number of IR.SBMU.NRITLD.REC.1399.104.

References

1. Jamaati H, Dastan F, Tabarsi P, Marjani M, Saffaei A, Hashemian SM. A fourteen-day experience with coronavirus disease 2019 (COVID-19) induced acute Respiratory Distress Syndrome (ARDS): an iranian treatment protocol. *Iran J Pharm Res*. 2020;**19**(1):31–6. doi: 10.22037/ijpr.2020.113337.14239. [PubMed: 32922466].
2. Metidieri Menegozzo CA, Arap SS, Mariani AW, Minamoto H, Imamura R, Bento RF, et al. Standardization of elective tracheostomies at the central institute of the hospital das clínicas in são paulo during the Covid-19 pandemic. *Rev Col*

Bras Cir. 2020;**47**(1):1–7. doi: 10.1590/0100-6991e-20202574. [PubMed: 32578696].
3. Hasani H, Mardi S, Shakerian S, Taherzadeh-Ghahfarokhi N, Mardi P. The novel coronavirus disease (COVID-19): A PRISMA Systematic Review and Meta-analysis of clinical and paraclinical characteristics. *Biomed Res Int.* 2020;**2020**:1-16. doi: 10.1155/2020/3149020. [PubMed: 32851061].
4. Martin-Villares C, Perez Molina-Ramirez C, Bartolome-Benito M, Bernal-Sprekelsen M. Outcome of 1890 tracheostomies for critical COVID-19 patients: a national cohort study in Spain. *Eur Arch Otorhinolaryngol.* 2021;**278**(5):1605-12. doi: 10.1007/s00405-020-06220-3. [PubMed: 32749607].
5. Tran K, Cimon K, Severn M, Pessoa-Silva CL, Conly J. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. *PLoS One*. 2012;**7**(4):1-8. doi: 10.1371/journal.pone.0035797. [PubMed: 22563403].
6. Adly A, Youssef TA, El-Begermy MM, Younis HM. Timing of tracheostomy in patients with prolonged endotracheal intubation: a systematic review. *Eur Arch Otorhinolaryngol.* 2018;**275**(3):679–90. doi: 10.1007/s00405-017-4838-7. [PubMed: 29255970].
7. Takhar A, Walker A, Tricklebank S, Wyncoll D, Hart N, Jacob T, et al. Recommendation of a practical guideline for safe tracheostomy during the COVID-19 pandemic. *Eur Arch Otorhinolaryngol.* 2020;**277**(8):2173-84. Doi: 10.1007/s00405-020-05993-x. [PubMed: 32314050].
8. Mooney B, Lawrence C, Johnson EG, Slaboden A, Ball K. How COVID-19 patients were moved to speak: a rehabilitation interdisciplinary case series. *HSS J.* 2020;**16**(1):56-63. doi: 10.1007/s11420-020-09778-0. [PubMed: 32868977].
9. Volo T, Stritoni P, Battel I, Zennaro B, Lazzari F, Bellin M, et al. Elective tracheostomy during COVID-19 outbreak: to whom, when, how? Early experience from Venice, Italy. *Eur Arch Otorhinolaryngol.* 2021;**278**(3):781-9. doi: 10.1007/s00405-020-06190-6. [PubMed: 32656673].
10. Chiang SS, Aboutanos MB, Jawa RS, Kaul SK, Houng APH, Dicker RA, et al. Controversies in tracheostomy for Patients With COVID-19: The when, where, and how. *Respir Care*. 2020;**65**(11):1767-72. doi: 10.4187/respcare.08100. [PubMed: 32873749].
11. Courtney A, Lignos L, Ward PA, Vizcaychipi MP. Surgical tracheostomy outcomes in COVID-19–positive patients. *OTO Open*. 2021;**5**(1):1–6. doi: 10.1177/2473974X20984998. [PubMed: 33474524].
12. Cheung NH, Napolitano LM. Tracheostomy: epidemiology, indications, timing, technique, and outcomes. *Respir Care*. 2014;**59**(6):895–915. doi: 10.4187/respcare.02971. [PubMed: 24891198].
13. Shiba T, Ghazizadeh S, Chhetri D, St John M, Long J. Tracheostomy considerations during the COVID-19 pandemic. *OTO open.2020*;**4**)ץ(: 1-5. doi: 10.1177/2473974X20922528. [PubMed: 32342026].
14. Guan WJ, Ni ZY, Hu Y, Liang WH, Ou C, He J, et al. Clinical characteristics of coronavirus disease 2019 in China. *Ann Palliat Med.* 2020;**382**(18):1708-20. doi: 10.1056/NEJMoa2002032. [PubMed: 32109013].
15. Gattinoni L, Laffey JG, Pham T, Brochard L, Esteban A, Gattinoni L. epidemiology, patterns of care, and mortality for patients with acute respiratory Distress Syndrome in intensive care units in 50 countries. *JAMA*. 2016;**315**(8):788-800. doi: 10.1001/jama.2016.0291. [PubMed: 26903337].
16. 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-cen- tered, retrospective, observational study. *Lancet Respir Med.* 2020;**8**(5):465–81. doi: 10.1016/S2213-2600(20)30079-5. [PubMed: 32105632].
17. Holmen IC, Kent A, Lakritz S, Brickson C, Mastalerz K. Delayed tracheostomy in a patient with prolonged invasive mechanical ventilation due to COVID-19. *Cureus*. 2020;**12**(6):1-5. doi: 10.7759/cureus.8644. [PubMed: 32685313].
18. Rojas-Marte G, Talib Hashemi A, Khalid M, Chukwuka N, Fogel J, Munoz-Martinez A, et al. Outcomes in patients with COVID-19 disease and high oxygen requirements. *J Clin Med Res*. 2021;**13**(1):26–37. doi: 10.14740/jocmr4405. [PubMed: 33613798].
19. Vianello A, Turrin M, Guarnieri G, Molena B, Arcaro G, Turato C, et al. Prone positioning is safe and may reduce the rate of intubation in selected COVID-19 patients receiving high-flow nasal oxygen therapy. *J Clin Med*. 2021;**10**(15):1-8. doi: 10.3390/jcm10153404. [PubMed: 34362185].
20. Hernandez-Rubio JC, Sanchez-Carpintero Abad M, Yordi Leon A, Higuera GD, Rodriguez LG, Torrejon CG, et al. Outcomes of an intermediate respiratory care unit in the COVID-19 pandemic. *PLoS One.* 2020;**15**(2):1-12. doi: 10.1371/journal.pone.0243968. [PubMed: 33326484].
21. Cardona S, Downing J, Alfalasi R, Bzhilyanskaya V, Milzman D, Rehan M, et al. American Journal of Emergency Medicine Intubation rate of patients with hypoxia due to COVID-19 treated with awake proning : A meta-analysis. *Am J Emerg Med*. 2021;**43**:88-96. doi: 10.1016/j.ajem.2021.01.058. [PubMed: 33550104].
22. Marjani M, Tabarsi P, Moniri A, Hashemian M, Nadji A, Abtahian Z, et al. NRITLD Protocol for the Management of Patients with COVID-19 Admitted to Hospitals. *Tanaffos*. 2020;**19**(2):91-9. [PubMed: 33262795].
23. Mecham JC, Thomas OJ, Pirgousis P, Janus JR. Utility of tracheostomy in patients with COVID-19 and other special considerations. *Laryngoscope*. 2020;**130**(11):2546-9. doi: 10.1002/lary.28734. [PubMed: 32368799].
24. David AP, Russell MD, El-Sayed IH, Russell MS. Tracheostomy guidelines developed at a large academic medical center during the COVID-19 pandemic. *Head Neck.* 2020;**42**(6):1291-96. doi: 10.1002/hed.26191. [PubMed: 32329926].
25. Rovira A, Tricklebank S, Surda P, Whebell S, Zhang J, Takhar A, et al. Open versus percutaneous tracheostomy in COVID‐19 : a multicentre comparison and recommendation for future resource utilization. *Eur Arch Otorhinolaryngol.* 2021;**278**(6): 2107-14. doi: 10.1007/s00405-020-06597-1. [PubMed: 33420842].
26. Jiménez D, García-Sanchez A, Rali P, Muriel A, Bikdeli B, Ruiz-Artacho P, et al. Incidence of VTE and bleeding among hospitalized patients with coronavirus disease 2019: a systematic review and meta-analysis. *Chest*. 2021;**159**(3):1182-96. doi: 10.1016/j.chest.2020.11.005.]PubMed: 33217420].
27. Yu Chow VL, Wai Chan JY, Yoo Ho VW, Ying Pang SS, Ching Lee GC, Kuen Wong MM, et al. Tracheostomy during COVID-19 pandemic—Novel approach. *Head Neck*. 2020;**42**(7):1367-73. doi: 10.1002/hed.26234. [PubMed: 32358855].
28. Dharmarajan H, Snyderman CH. New safety tool in the setting of COVID-19. *Head Neck.* 2020;**42**(7):1397-1402. doi: 10.1002/hed.26253. [PubMed: 32383532].
29. https://www.worldometers.info/coronavirus/country/iran/.