

# Comparison of Hospital Presentations Due to Tracheal Stenosis Before and During the COVID-19 Pandemic

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## ABSTRACT

**Objective:** Prolonged invasive mechanical ventilation (IMV) is the main cause of tracheal stenosis (TS). During the COVID-19 pandemic, the number of patients treated with long-term invasive mechanical ventilator support also increased. This study aimed to examine hospital presentations due to TS before and during the pandemic period.

**Methods:** This retrospective observational study was planned over the 5-year period from October 2017 to October 2022. The data of all patients who presented to the hospital due to TS were screened through the hospital's automation system. The age, gender, presentation unit and complaints, comorbidities, etiology of TS, intensive care admission, mechanical ventilation requirement and duration, the presence of a tracheostomy, the presence of previous surgical intervention, and treatment modalities were recorded in the data form. All variables were compared between the pre-pandemic and pandemic periods. SPSS version 25 statistical software package was used for statistical analyses. The significance level was taken as 0.05 for all tests.

**Results:** The study included a total of 60 patients diagnosed with TS, of whom 21 presented to the hospital before and 39 during the pandemic. Forty of the patients were male and 20 were female, and their ages ranged from 3 to 77 years. The mean number of presentations was 5.25 before the pandemic and increased to 13 during the pandemic, indicating a 2.47-fold increase due to COVID-19. When the groups were examined, the mean age, the presence of diabetes mellitus and hypertension, the presence of stridor, tracheal dilatation, and stenting significantly increased during the pandemic period ( $p < 0.05$ ).

**Conclusion:** According to our results, the increased requirement for IMV due to COVID-19 infection also increased the frequency of TS. Due to our findings, potential cases of TS can be predicted by inquiring about the patient's history of COVID-19 infection and IMV.

## INTRODUCTION

Tracheal stenosis (TS) is a congenital or acquired narrowing and/or obstruction of the trachea relative to its normal diameter. Mild stenosis usually does not produce clinical signs. However, when the trachea diameter is  $< 5$  mm or the stenosis level is more than 50%, it can cause a serious, life-threatening clinical condition manifested by findings such as dyspnea, stridor, and wheezing.<sup>[1]</sup> Acquired TS is significantly more common. Post-intubation TS (PITS) caused by prolonged mechanical ventilation (0.6–21%) is the most common cause of acquired TS.<sup>[2–4]</sup> Local is-

chemia due to intubation and the development of fibrosis in response to ischemia play a role in the pathology of PITS. This leads to TS and clinically manifests as acute respiratory distress syndrome (ARDS). Other factors that increase the risk of PITS development can be listed as obesity, diabetes mellitus (DM), the size of the endotracheal tube (ETT) and tracheostomy cannula (high-diameter tubes), and corticosteroid use.<sup>[5–7]</sup>

Coronavirus disease 2019 (COVID-19), first identified in December 2019, rapidly spread across the world, causing a pandemic in a short time.<sup>[8]</sup> The number of patients who required treatment under mechanical ventilato-

ry support in intensive care units (ICUs) due to ARDS caused by COVID-19 infection increased significantly compared to the pre-pandemic period. ARDS associated with COVID-19 led to the widespread use of mechanical ventilation with high  $\text{FiO}_2$  and high positive end-expiratory pressure (PEEP) as the main treatment strategy on a global scale.<sup>[9,10]</sup> However, recent literature in the form of case series and observational studies indicates that treatment protocols applied for COVID-19-related ARDS pose a risk for the development of PITS.<sup>[11,12]</sup> In light of available medical data, we hypothesized that the pandemic increased the number of patient presentations to the hospital due to TS.

The main aim of this study was to compare the demographic data, etiological factors, and treatment requirements of patients who presented to the hospital with TS before and during the pandemic. Our secondary aim was to compare the demographic data, etiological factors, and treatment requirements between the patient subgroups with and without COVID-19 pneumonia during the pandemic.

## MATERIALS AND METHODS

This single-center study was conducted at the Anesthesiology and Reanimation Clinic of Kartal Dr. Lütfi Kırdar City Hospital. The study was planned with a retrospective observational design and included patients who presented to our hospital with the diagnosis of TS over a 5-year period (October 2017–2022). The medical histories of the patients treated in our hospital with the diagnosis of TS were screened through the hospital's automation system. The patients' age, gender, presentation unit (emergency department or outpatient clinic) and complaints, comorbidities, etiology of TS, intensive care and mechanical ventilation requirements, duration of mechanical ventilation use, the presence of a tracheostomy, the presence of previous surgical intervention, treatment modalities, and length of hospital stay were recorded. These data were obtained from the records and statistically evaluated by dividing the patients into two groups according to their presentation periods: Pre-pandemic (October 2017–February 2020) and pandemic (March 2020–October 2022). A further comparison was made between the patient subgroups with and without a history of COVID-19 during the pandemic period.

### Statistical analysis

SPSS version 25 statistical software package was used for statistical analyses. The data were summarized using descriptive statistical methods (mean, frequency, and percentage). The Shapiro–Wilk test was used to check the normality of data distribution for continuous variables. To investigate differences between the two groups, the t-test was used for continuous variables with a normal distribution, and the Mann–Whitney U test for non-normally distributed data. Two-by-two cross-tables were formed for the classified variables, and their relationships were

investigated with Fisher's exact test. The significance level was taken as 0.05 for all tests.

## RESULTS

The study included a total of 60 patients diagnosed with TS, of whom 21 presented to the hospital during the pre-pandemic period and 39 during the pandemic period. Forty patients were male and 20 were female, with their ages ranging from 3 to 77 years. During the pandemic, 19 (48.72%) of the 39 patients were treated in ICU due to COVID-19. For the pre-pandemic period, the number of patients who presented to the hospital was 5 in 2017, 6 in 2018, 6 in 2019, and 4 in January and February 2020. During the pandemic period, the number of patients presenting to the hospital with TS was determined to be 6 for March–December 2020, 16 for 2021, and 17 for 2022. Accordingly, the mean number of hospital presentations was 5.25 patients/year in the pre-pandemic period and increased to 13 patients/year in the pandemic period, indicating a 2.47-fold increase due to COVID-19.

Table 1 shows the mean, frequency, and percentage values of the investigated variables and the p values of the statistical tests performed to examine the significance of differences between the two periods. When the pre-pandemic and pandemic periods were compared, the mean age of the patients statistically significantly increased from 38 to 50.64 years ( $p=0.008$ ). While DM was seen in 28.6% of the patients with TS during the pre-pandemic period, this rate doubled to 56.4% in the pandemic period ( $p=0.036$ ). HT was also seen at a rate of 28.6% before the pandemic but increased significantly during the pandemic, reaching 43.6% ( $p=0.032$ ). The most common presentation symptom was dyspnea (71.4%) in the pre-pandemic period and stridor in the pandemic period (79.5%). The rate of patients with the stridor complaint statistically significantly increased from 47.6% in the pre-pandemic period to 79.5% in the pandemic period ( $p=0.013$ ). Tracheal dilation was the most frequently used surgical treatment method in both groups. Among the treatment modalities applied during the pandemic period, both the tracheal dilation and stenting rates statistically significantly increased when evaluated individually, but the rate of resection significantly decreased ( $p=0.05$  for all). The frequency of the combined treatment of tracheal dilation and stenting was 4.76% in the pre-pandemic period, significantly increasing to 23.08% in the pandemic period. The patients who presented to the hospital with TS during the pandemic were further divided into two subgroups as those with and without COVID-19. The mean, frequency, and percentage values of the investigated variables for these two subgroups and the p values of their statistical comparisons are given in Table 2. Among the statistical results obtained, only the p value of the presence of DM was lower than 0.05, showing a significant difference in the incidence of DM between the patients hospitalized due to COVID-19 and non-COVID-19 reasons ( $p=0.007$ ).

**Table 1.** Comparison of demographic data, comorbidities, symptoms, and treatment modalities of patients diagnosed with tracheal stenosis before and during the pandemic

Variable		Before pandemic	During pandemic	p-value
Age, mean±SE		38.00±3.52	50.64±2.76	0.008 <sup>3</sup>
Gender, frequency (percentage)	Female	6 (28.6)	14 (35.9)	0.391 <sup>1</sup>
	Male	15 (71.4)	25 (64.1)	
Diabetes mellitus, frequency (percentage)	Absent	15 (71.4)	17 (43.6)	0.036 <sup>1</sup>
	Present	6 (28.6)	22 (56.4)	
Hypertension, frequency (percentage)	Absent	13 (71.4)	13 (56.4)	0.032 <sup>1</sup>
	Present	8 (28.6)	26 (43.6)	
Coronary artery disease, frequency (percentage)	Absent	15 (71.4)	29 (74.4)	0.518 <sup>1</sup>
	Present	6 (28.6)	10 (25.6)	
Arrhythmia, frequency (percentage)	Absent	20 (71.4)	36 (74.4)	--
	Present	1 (28.6)	3 (25.6)	
COPD, frequency (percentage)	Absent	15 (71.4)	30 (76.9)	0.432 <sup>1</sup>
	Present	6 (28.6)	9 (23.1)	
Epilepsy, frequency (percentage)	Absent	15 (71.4)	33 (84.6)	0.188 <sup>1</sup>
	Present	6 (28.6)	6 (15.4)	
CVE, frequency (percentage)	Absent	19 (90.5)	36 (92.3)	--
	Present	2 (9.5)	3 (7.7)	
Laryngeal cancer, frequency (percentage)	Absent	20 (95.2)	35 (89.7)	--
	Present	1 (4.8)	4 (10.3)	
Other malignancy, frequency (percentage)	Absent	14 (66.7)	31 (79.5)	0.216 <sup>1</sup>
	Present	7 (33.3)	8 (20.5)	
Total length of hospital stay, mean±SE		48.00±9.55	40.64±3.63	0.957 <sup>2</sup>
ICU admission, frequency (percentage)	Absent	0 (0)	0 (0)	--
	Present	20 (100)	39 (100)	
ICU admission indication				--
COVID-19 pneumonia		0 (0)	19 (48.7)	
Intracranial hemorrhage		1 (4.8)	1 (2.6)	
Methyl alcohol intoxication		0 (0)	1 (2.6)	
Myocardial infarction		2 (9.5)	0 (0)	
Pneumonia		0 (0)	2 (5.1)	
Post-pneumonectomy		0 (0)	2 (5.1)	
Post-laryngectomy		1 (4.8)	3 (7.7)	
Other operations		3 (14.3)	3 (7.7)	
Status epilepticus		4 (19)	3 (7.7)	
CVE		2 (9.5)	2 (5.1)	
Urosepsis		0 (0)	1 (2.6)	
Burn		3 (14.3)	0 (0)	
High-energy trauma		5 (23.8)	2 (5.1)	
MV, frequency (percentage)	Absent	0 (0)	0 (0)	--
	Present	21 (100)	39 (100)	
MV duration, mean±SE		24.71±3.30	20.51±2.47	0.1872
Tracheostomy, frequency (percentage)	Absent	14 (66.7)	30 (76.9)	0.2881
	Present	7 (33.3)	9 (23.1)	
Presentation unit, frequency (percentage)	Outpatient clinic	14 (66.7)	30 (76.9)	0.2881
	Emergency department	7 (33.3)	9 (23.1)	
Dyspnea, frequency (percentage)	Absent	6 (28.6)	13 (33.3)	0.4701
	Present	15 (71.4)	26 (66.7)	
Stridor, frequency (percentage)	Absent	11 (52.4)	8 (20.5)	0.0131
	Present	10 (47.6)	31 (79.5)	
Wheezing, frequency (percentage)	Absent	20 (95.2)	37 (94.9)	--
	Present	1 (4.8)	2 (5.1)	

**Table 1.** Comparison of demographic data, comorbidities, symptoms, and treatment modalities of patients diagnosed with tracheal stenosis before and during the pandemic (*continue*)

Variable		Before pandemic	During pandemic	p-value
Tracheal dilation, frequency (percentage)	Absent	8 (38.1)	6 (15.4)	0.051
	Present	13 (61.9)	33 (84.6)	
Stenting, frequency (percentage)	Absent	16 (76.2)	20 (51.3)	0.051
	Present	5 (23.8)	19 (48.7)	
Resection, frequency (percentage)	Absent	13 (61.9)	33 (84.6)	0.051
	Present	8 (38.1)	6 (15.4)	
Treatment modality, frequency (percentage)				--
Emergency tracheostomy + tracheal dilation		1 (4.76)	0 (0)	
Tracheal dilation		11 (52.38)	22 (56.41)	
Tracheal dilation + stenting		1 (4.76)	9 (23.08)	
Resection		5 (23.81)	1 (2.56)	
Resection + tracheal dilation		0 (0)	1 (2.56)	
Resection + tracheal dilation +		2 (9.52)	3 (7.69)	
Stenting		1 (4.76)	3 (7.69)	

<sup>1</sup>Fisher's exact test; <sup>2</sup>Mann-Whitney U test; <sup>3</sup>t-test. SE: Standard error; COPD: Chronic obstructive pulmonary disease; CVE: Cerebrovascular event; ICU: Intensive care unit; MV: Mechanical ventilation.

## DISCUSSION

According to the results of our study, the number of patients presenting to the hospital with TS increased significantly during the pandemic compared to the pre-pandemic period.

TS is often caused by prolonged intubation and manifests with dyspnea, stridor, and wheezing.<sup>[13–16]</sup> The main risk factors for PITS are invasive mechanical ventilation (IMV) treatment that lasts longer than 7 days in ICUs, high-volume ventilation, and high cuff pressure.<sup>[2,17,18]</sup> During the pandemic, the main treatment strategy has been to hospitalize symptomatic patients and apply for respiratory support in ICUs if needed. According to the data reported from different countries, 33.1–88% of patients treated in ICUs required IMV support.<sup>[19,20]</sup>

In this study, it was determined that all patients in both groups received IMV support in ICU. The duration of IMV treatment was 24.71±3.30 days in the pre-pandemic period and 20.51±2.47 days (mean±standard deviation) in the pandemic period, revealing no significant difference ( $p=0.187$ ). Therefore, in both groups, prolonged IMV treatment ( $\geq 7$  days) was required, which is specified as a risk factor for TS in the literature.<sup>[21]</sup>

High  $\text{FiO}_2$ , low tidal volume, and high PEEP are commonly used as a mechanical ventilation treatment strategy in COVID-19-related ARDS.<sup>[22]</sup> In addition, the prone position is often preferred to minimize the ventilation/perfusion disturbance caused by widespread pneumonic infiltrates.<sup>[23]</sup> However, the prone position may increase the risk of TS by elevating the cuff pressure and changing the ETT location.<sup>[24]</sup> Many case series and studies have proven that the risk of TS increases after COVID-19 due to the effects of all these proposed treatment strategies.

<sup>[25]</sup> When the indications for ICU admission were examined in our study (Table 1), the most common indication in the pre-pandemic period was determined to be high-energy trauma (23.8%), followed by status epilepticus (19%), burns (14.3%), and post-operative follow-up (14.3%). In the pandemic period, the most frequent reason for hospitalization was COVID-19 (48.72%). Therefore, our findings indicate the effect of COVID-19-related intensive care requirements on the frequency and etiology of TS, which is consistent with the literature.<sup>[26]</sup>

Studies have shown that advanced age, male gender, and comorbidities such as HT, DM, and chronic obstructive pulmonary disease are risk factors for COVID-19.<sup>[27]</sup> In our study, the mean age of the patients who presented to the hospital with TS was 50.64±2.76 years (mean±standard error) during the pandemic period, indicating a statistically significant increase compared to the pre-pandemic period ( $p=0.008$ ). However, contrary to the literature, we observed no significant difference between the ages of the patients admitted to ICU for COVID-19 and non-COVID-19 reasons ( $p=0.916$ ).

DM and HT are the most common comorbidities in patients with COVID-19. In addition to posing a high risk for COVID-19 infection, DM also increases the length of hospital stay and mortality, as proven by observational studies.<sup>[28]</sup> In addition, regardless of its relationship with COVID-19, diabetic patients have been shown to have a different fibroblast response to local trauma and ischemia in the trachea due to intubation and a higher frequency of PITS, up to an eight-fold increase.<sup>[29]</sup> In our study, when the comorbidities of the patients were examined, DM, HT, and coronary artery disease were the most common comorbidities in both the pre-pandemic and pandemic periods (28.6% for all in the pre-pandemic period and 56.4%, 43.6%, and 25.6%, respectively, in the pandemic period).

**Table 2.** Comparison of demographic data, comorbidities, symptoms, and treatment modalities between the patients hospitalized for COVID-19 and non-COVID-19 reasons during the pandemic

Variable		Hospitalized for COVID-19	Hospitalized for non-COVID-19 reasons	p-value
Age, mean±SE		50.35±4.70	50.95±3.00	0.9163
Gender, frequency (percentage)	Female	6 (30)	8 (42.1)	0.3251
	Male	14 (70)	11 (57.9)	
Diabetes mellitus, frequency (percentage)	Absent	13 (65)	4 (21.1)	0.0071
	Present	7 (35)	15 (78.9)	
Hypertension, frequency (percentage)	Absent	6 (30)	7 (36.8)	0.4551
	Present	14 (70)	12 (63.2)	
Coronary artery disease, frequency (percentage)	Absent	15 (71.4)	14 (74.4)	0.6051
	Present	5 (28.6)	5 (25.6)	
Arrhythmia, frequency (percentage)	Absent	18 (90)	18 (94.7)	--
	Present	2 (10)	1 (5.30)	
COPD, frequency (percentage)	Absent	15 (75)	15 (78.9)	--
	Present	5 (25)	4 (21.1)	
Epilepsy, frequency (percentage)	Absent	15 (71.4)	18 (84.6)	--
	Present	5 (28.6)	1 (15.4)	
CVE, frequency (percentage)	Absent	17 (85)	19 (100)	--
	Present	3 (15)	0 (0)	
Laryngeal cancer, frequency (percentage)	Absent	16 (80)	19 (100)	--
	Present	4 (20)	0 (0)	
Other malignancy, frequency (percentage)	Absent	15 (70)	16 (73.7)	--
	Present	5 (30)	3 (26.3)	
Total length of hospital stay, mean±SE		36.45±5.08	45.05±5.13	0.2413
ICU admission, frequency (percentage)	Present	20 (100)	19 (100)	
MV, frequency (percentage)	Absent	0 (0)	0 (0)	--
	Present	21 (100)	19 (100)	
MV duration, mean±SE		20.10±3.76	20.95±3.28	0.4282
Tracheostomy, frequency (percentage)	Absent	16 (66.7)	14 (76.9)	0.4651
	Present	4 (33.3)	5 (23.1)	
Presentation unit, frequency (percentage)	Outpatient clinic	15 (70)	15 (73.7)	--
	Emergency department	5 (30)	4 (26.3)	
Dyspnea, frequency (percentage)	Absent	8 (40)	5 (26.3)	0.2861
	Present	12 (60)	14 (73.7)	
Stridor, frequency (percentage)	Absent	5 (25)	3 (15.8)	--
	Present	15 (75)	16 (84.2)	
Wheezing, frequency (percentage)	Absent	19 (95)	18 (94.7)	--
	Present	1 (5)	1 (5.3)	
Tracheal dilation, frequency (percentage)	Absent	4 (20)	2 (10.5)	--
	Present	16 (80)	17 (89.5)	
Stenting, frequency (percentage)	Absent	12 (60)	8 (42.1)	0.2131
	Present	8 (40)	11 (57.9)	
Resection, frequency (percentage)	Absent	16 (80)	17 (89.5)	--
	Present	4 (20)	2 (10.5)	
Treatment modality, frequency (percentage)			--	
Tracheal dilation		12 (60)	10 (52.60)	
Tracheal dilation + stenting		3 (15)	6 (31.60)	
Resection		0 (0)	1 (5.30)	
Resection + tracheal dilation		0 (0)	1 (5.30)	
Resection + tracheal dilation +		3 (15)	0 (0)	
Stenting		2 (10)	1 (5.30)	

<sup>1</sup>Fisher's exact test; <sup>2</sup>Mann-Whitney U test; <sup>3</sup>t-test. SE: Standard error; COPD: Chronic obstructive pulmonary disease; CVE: Cerebrovascular event; ICU: Intensive care unit; MV: Mechanical ventilation.



With the pandemic, the rate of patients diagnosed with DM almost doubled due to the number of COVID-19 cases requiring intensive care ( $p=0.036$ ). When the patients presenting to the hospital during the pandemic were further evaluated in two subgroups; according to the presence of a COVID-19 history, the presence of DM (78.9%) was significantly higher among those with a history of COVID-19 ( $p=0.007$ ).

The main limitation of our study is the inability to evaluate patients who presented to other health-care institutions and those who did not visit the hospital due to being asymptomatic or having mild symptoms.

## CONCLUSION

During the COVID-19 pandemic, the number of patients who required IMV increased. Accordingly, as revealed by the results of our study, there was a dramatic increase in hospital presentations due to TS. In pandemics caused by factors affecting the respiratory tract, it is necessary to be prepared for complications such as TS.

### Ethics Committee Approval

This study was approved by the Kartal Dr. Lütfi Kırdar City Hospital Clinical Research Ethics Committee (Date: 27.07.2022, Decision No: 2022/514/230/16).

### Informed Consent

Retrospective study.

### Peer-review

Externally peer-reviewed.

### Authorship Contributions

Concept: U.D.H.; Design: D.G., J.S.K.; Supervision: U.D.H., G.A., K.T.S.; Fundings: K.T.S., G.A.; Materials: R.D., G.A.; Data: J.S.K., D.G.; Analysis: U.D.H., R.D.; Literature Search: G.A., D.G.; Writing: U.D.H., J.S.K.; Critical revision: R.D., K.T.S.

### Conflict of Interest

None declared.

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## Trakeal Stenoz Nedenli Hastane Başvurularının Pandemi Sırasında ve Öncesinde Karşılaştırılması

**Amaç:** Uzun süreli invaziv mekanik ventilasyon trakeal stenozun (TS) ana nedenidir. COVID-19 pandemisi boyunca uzun süreli invaziv mekanik ventilatör desteği altında tedavi gören hasta sayısı da artmıştır. Bu çalışmanın amacı pandemi dönemi öncesi ve sonrası TS nedenli hastane başvurularının incelenmesidir.

**Gereç ve Yöntem:** Bu çalışma Ekim 2017–Ekim 2022 yılları arasındaki beş yıllık dönemde retrospektif, gözlemsel olarak tasarlanmıştır. Trakeal stenoz nedenli hastaneye başvuran tüm hastalar, hastane otomasyon sisteminden taranmıştır. Verisine ulaşılamayan, eksik ya da yanlış bilgi içeren, tedavi ve takip amaçlı başka hastaneye nakil edilen hastalar çalışmadan dışlandı. Hastalar pandeminin başladığı Mart 2020 öncesi ve sonrası olarak pandemi öncesi (PÖ) ve pandemi sonrası (PS) olarak iki gruba ayrıldı. Hastaların yaşı, cinsiyeti, başvuru şekli, başvuru şikayeti, komorbiditeleri, trakeal stenoz etyolojisine dair bilgiler, yoğun bakım yatışı, mekanik ventilatör ile tedavi ihtiyacı, mekanik ventilatör ile tedavi süresi, trakeostomi varlığı, geçirilmiş cerrahi müdahale varlığı, tedavi şekli veri formuna kaydedildi. Tüm değişkenler pandemi öncesi ve sonrası şeklinde kıyaslandı. İstatistiksel analizler için SPSS version 25 istatistik paket programı kullanılmıştır. Yapılan tüm testler için anlamlılık düzeyi 0.05 olarak alınmıştır.

**Bulgular:** Araştırmaya dahil edilen TS tanılı hasta sayısı 60 olup, 21'i PÖ, 39'u ise PS tedavi gören hastalardır. Hastaların 40'ı erkek, 20'si kadındır ve yaşları 3 ile 77 arasında değişmektedir. PÖ dönemde ortalama olarak 5.25 olan başvuru sayısı PS döneminde 13'e çıkmış ve sonuçta COVID-19 nedeniyle başvuru sayısı 2.47 kat artmıştır. Gruplar incelendiğinde PS dönemde ortalama yaş, diabetes mellitus ve hipertansiyon varlığı, stridor bulunması, dilatasyon ve stent uygulaması artmıştır ( $p<0.05$ ).

**Sonuç:** Sonuçlarımıza göre COVID-19 enfeksiyonu sebebiyle artmış invaziv mekanik ventilasyon ihtiyacı, trakeal stenoz görülme sıklığını da arttırmıştır. Bulgularımıza göre, hastaların COVID-19 enfeksiyonu ve invaziv mekanik ventilasyon öyküsü sorgulanarak potansiyel trakeal stenoz vakaları predikte edilebilir.

**Anahtar Sözcükler:** COVID-19; invaziv mekanik ventilasyon; trakeal stenoz; yoğun bakım ünitesi.