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RESEARCH ARTICLE

Etiological Analysis of 'Post-Intubation Tracheal Stenosis' Cases Requiring Intervention: A 2-Year Case Evaluation

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ABSTRACT

Objectives: The aim of this study was to retrospectively investigate the tracheal stenosis (TS) etiologies of patients with a diagnosis of TS after intubation who underwent rigid bronchoscopy balloon dilation/rigid bronchoscopy balloon dilatation+stent/tracheal resection and reconstruction at our clinic.

Methods: Medical records of all adult patients who underwent procedures for TS between March 1, 2020, and April 30, 2022, at our clinic were retrospectively reviewed. Age, gender, previous ASA score, comorbidities, etiology of TS, type of surgery performed, length of hospital stay after the surgical procedure, morbidity, and mortality data were recorded.

Results: It was determined that interventions were performed on a total of 101 patients due to post-intubation TS. Among these patients, it was observed that 37 (36.6%) had experienced intubation due to coronavirus, 19 (18.8%) due to neurological diseases, and 14 (13.9%) due to multiple traumas. Of the patients, 57 (56.43%) were male and 44 (43.57%) were female. The most common accompanying comorbidities were hypertension (25.7%) and diabetes (21.7%). The mean age was 50.3±17.2 years, and the mean duration of intubation was 25.4±17.8 days. Rigid bronchoscopy balloon dilatation was performed a median of 2 times per patient. Rigid bronchoscopy balloon dilatation+stent was performed in four patients, and tracheal resection and reconstruction was performed in 58 patients.

Conclusion: In the cross-sectional evaluation of the patients, it was determined that the most common cause of TS developing after intubation was coronavirus.

Keywords: Coronavirus, etiology, post-intubation tracheal stenosis, rigid bronchoscopy, tracheal resection

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Introduction

Tracheal stenosis (TS) is a serious complication that occurs in approximately 10–22% of patients due to prolonged endotracheal intubation.[1,2] It results from a series of iatrogenic events fundamentally involving ischemia as a consequence of endotracheal intubation and tracheostomy. Risk factors for TS include hyperinflation of the endotracheal tube cuff, the use of large tubes, advanced age, female gender, smoking, obesity, and diabetes.[1,3] TS should be considered when a patient has a history of intensive care and subsequently develops shortness of breath, snoring, or recurrent infections.[4] The primary treatment for TS is surgery. Various treatment modalities have been proposed, like endoscopic laser-assisted dilatation, balloon dilatation, tracheoplasty or tracheal reconstruction, tracheal resection and anastomosis, Shiann Yann Lee's tracheoplasty, slide tracheoplasty, and many more. Despite the availability of a variety of surgical modalities, none have been able to achieve the status of being the gold standard.[5]

In December 2019, a new coronavirus pandemic emerged in China, leading to severe consequences. The most common and serious complication in COVID patients is acute respiratory distress syndrome (ARDS), which requires oxygen and ventilation therapies.[6] Many patients have been monitored in intensive care units after being intubated. Moreover, concerns about aerosol generation

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and the use of prone positioning that arose with the coronavirus pandemic have led to delays in tracheostomy decisions and the use of uncontrolled high cuff pressures, paving the way for TS.[3,7] During the pandemic, almost half of the COVID patients in the intensive care unit required invasive mechanical ventilation. Although the incidence of TS in these patients has been reported to range from 3.3% to 40%, the exact number is not known.[7] With the COVID pandemic, the number of TS cases requiring intervention in our clinic has increased significantly.

In this study, we aimed to retrospectively investigate the etiologies of TS in patients who underwent rigid bronchoscopy balloon dilatation/tracheal resection and reconstruction for post-intubation TS at our clinic.

Methods

This retrospective, cross-sectional study was conducted following the principles of the Helsinki Declaration, after obtaining approval from the Ethics Committee of Ankara Bilkent City Hospital (IRB: E.Kurul-E1-22-3142, December 28, 2022). The trial was registered on www.clinicaltrials.gov (https://clinicaltrials.gov/) under the identifier NCT05682651 on 07.01.2023. The medical records of all adult patients who underwent procedures for TS at our clinic between March 1, 2020, and April 30, 2022, were retrospectively evaluated. Pediatric patients and patients who underwent TS surgery due to malignancy were excluded from the study. Data on age, gender, previous American Society of Anesthesiologists (ASA) score, comorbidities, etiology (reasons for intubation and intubation duration), whether tracheostomy was performed or not, type of the surgery performed, length of hospital stay after the surgical procedure, morbidity, and mortality were recorded.

Statistical Analysis

Data analyses were performed using SPSS for Windows, version 22.0 (SPSS Inc., Chicago, IL, United States). Whether the distribution of continuous variables was normal or not was determined by the Kolmogorov-Smirnov test. The Levene test was used for the evaluation of the homogeneity of variances. Unless specified otherwise, continuous data were described as mean±SD for normal distributions, and median (interquartile range) for skewed distributions. Categorical data were described as a number of cases (%). Statistical analysis differences in normally distributed variables between two independent groups were compared using the Student's t-test, and the Mann-Whitney U test was applied to compare the non-normally distributed data. Categorical variables were compared using Pearson's chi-square test or Fisher's exact test. A p-value<0.05 was accepted as the significance level in all statistical analyses.

Results

Between March 1, 2020, and April 30, 2022, surgical procedures were performed for tracheal stenosis in a total of 138 patients. Excluding 28 patients with tracheal malignancy and 9 pediatric patients treated for congenital TS, a total of 101 patients underwent surgical interventions for post-intubation TS (Fig. 1. CONSORT 2010 Flow Diagram).

It was found that 37 patients (36.6%) were intubated due to coronavirus, 19 (18.8%) due to neurological diseases, 14 (13.9%) due to multiple trauma, 13 (12.9%) due to cardiovascular diseases, 6 (5.9%) due to respiratory system diseases, 4 (4.0%) due to intoxications, and 8 (7.9%) due to others. It was found that 57% (56.43%) of the patients were male, 44% (43.57%) were female, and accompanying comorbidities were frequently hypertension (25.74%)

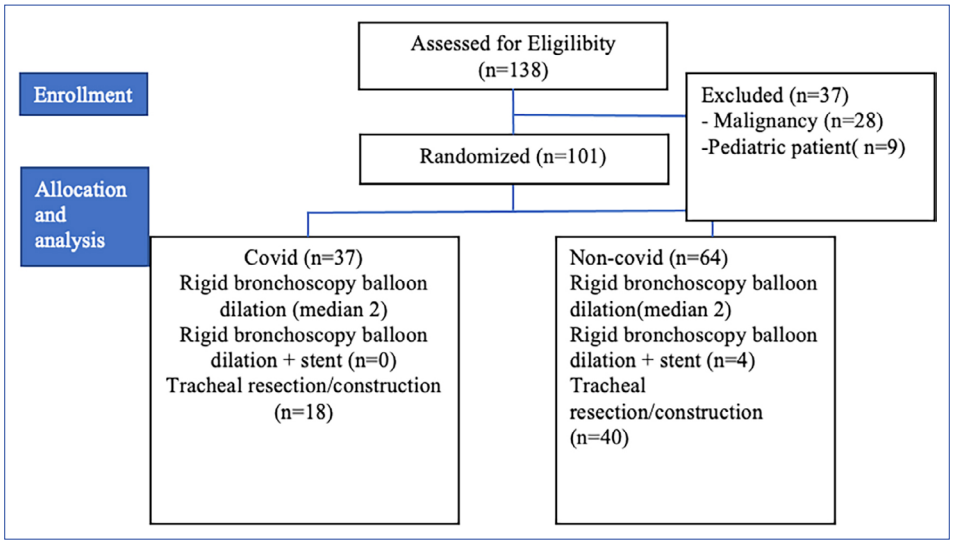

Figure 1. Flowchart of the patients.

and diabetes (21.78%). The mean intubation duration was 25.4±17.8 days, and tracheostomy was performed in 26 patients. Rigid bronchoscopy balloon dilatation was applied to all patients an average of 2.3±1.6 (median 2) times. Rigid bronchoscopy balloon dilatation+stent was performed in four (3.96%) patients, and tracheal resection and reconstruction was performed in 68 (67.32%) patients (Table 1).

After determining that coronavirus was the most common cause among all indications, COVID-related TS patients were compared with non-COVID-related TS patients. Non-COVID-related TS patients included those with neurological diseases, trauma, cardiovascular diseases, pulmonary diseases, intoxications, and others. The groups were found to have similar age and gender ratios (respectively, p=0.130 and p=0.230). In the non-COVID group, the rates of coronary artery disease (CAD), cerebrovascular accident (CVA), and ASA III were statistically significantly higher (respectively, p=0.004, p=0.015, and p=0.011). The intubation durations and tracheostomy rates were similar between the groups. Median rigid bronchoscopy with balloon dilatation was performed twice on patients in both groups (p=0.897). Four patients in the non-COVID group received stents (p=0.295). Tracheal resection and reconstruction were performed on 18 patients in the COVID group and 40 patients in the non-COVID group, with no statistically significant difference observed between the groups (p=0.175). Mean hospital stays and mortality rates after TS surgical procedures were found to be similar (respectively, p=0.075 and p=0.999) (Table 2).

Table 1. Patient characteristics

	n	%
Patients	101	100
Males	57	56.43
Age (mean)	50.3±17.2	
Diagnoses		
Covid	37	36.6
Neurological disease	19	18.8
Trauma	14	13.9
Cardiovascular disease	13	12.9
Pulmonary disease	6	5.9
Intoxication	4	4.0
Others	8	7.9
Comorbidity	45	44.55
Hypertension	25	24.75
Diabetes mellitus	22	21.78
Coronary artery disease	11	10.89
Cerebrovascular accident	7	6.93
Chronic kidney disease	5	4.95
Chronic obstructive pulmonary disease	3	2.97
Previous endotracheal intubation duration (days)	25.4±17.8	
Tracheotomy	26	25.74
Rigid bronchoscopy balloon dilation, median	2	
Rigid bronchoscopy balloon dilation+stent	4	3.96
Tracheal resection/ reconstruction	58	57.43

Discussion

In our cross-sectional assessment, we found that the most common cause in the etiology of patients who developed tracheal stenosis after endotracheal intubation and underwent rigid bronchoscopy balloon dilatation/rigid bronchoscopy balloon dilatation+stent/tracheal resection and reconstruction was related to the coronavirus. When evaluated as two groups—COVID and non-COVID—all characteristics were found to be similar except that CAD, CVA rates, and previous ASA scores were significantly higher in the non-COVID group.

One of the most important causes of tracheal stenosis in its etiology is trauma due to prolonged intubation or excessive endotracheal tube cuff pressure. However, it has also been shown that infections, gastroesophageal reflux disease, systemic inflammatory diseases, radiation therapy, tracheal malignancies, and congenital abnormalities can lead to tracheal stenosis.[7,8] In our clinic, 28 patients underwent procedures for tracheal malignancy, and 9 pediatric patients underwent procedures for congenital TS. These patients were excluded from the study due to the primary cause originating from the trachea.

Before the COVID pandemic, the rate of tracheal stenosis after intubation was approximately 10–22%.[7,9,10] However, during the COVID period, rates as high as 40% have been reported.[11,12] Tintiago[3] and Piazza[13] also suggested that TS rates were higher than those seen in the pre-COVID period. In our clinic, the number of TS cases requiring intervention has increased significantly with the COVID pandemic. In our clinic, 36.6% of the patients who underwent procedures for TS were COVID patients. This was followed by neurological diseases at a rate of 18.8%. TS caused by COVID was twice as common as the next closest cause. Given that our clinic is considered a tertiary care center for TS, we believe that these statistical rates may reflect the true nationwide incidence of COVID-related TS.

Fang et al.[14] reported a mean intubation time of 23.1 days for patients who were able to be weaned from mechanical ventilation. In our study, the average duration of intubation for COVID-related TS patients was found to be 23 days. In the literature, it is noted that COVID patients remain intubated for at least 1–2 weeks.[15,16] This may be related to the prognosis of the patients or the progressive course of the disease. Early mortality may have caused the relatively shorter intubation times.

In the literature, the need for intubation and the duration of mechanical ventilation vary depending on the patient's current condition and comorbidities at the time

Table 2. Characteristics of groups

	Covid (n=37)		Non-Covid (n=64)		p
	n	%	n	%	
Age (mean±SD)	53.49±14.58		48.42±18.34		0.130
Gender					
Male	18	48.6	39	60.9	0.230
Female	19	51.4	25	39.1	
Comorbidity					
No	23	62.2	33	51.6	0.302
Yes	14	37.8	31	48.4	
Hypertension					
No	1	7.7	–	–	0.481
Yes	12	92.3	14	100.0	
Diabetes mellitus					
No	3	25.0	2	13.3	0.628
Yes	9	75.0	13	86.7	
CAD					
No	4	80.0	–	–	**0.004**
Yes	1	20.0	10	100.0	
COPD					
No	3	100.0	–	–	0.100
Yes	–	–	3	100.0	
CVA					
No	4	80.0	–	–	**0.015**
Yes	1	20.0	6	100.0	
CKD					
No	2	40.0	–	–	0.999
Yes	3	60.0	2	100.0	
Previous ASA score					
ASA I	22	59.5	22	34.4	**0.011**
ASA II	10	27.0	16	25.0	
ASA III	5	13.5	26	40.6	
Previous ETI duration (days), (median)	23 (15)		21 (19)		0.634
Previous Tracheotomy					
No	26	70.3	49	76.6	0.486
Yes	11	29.7	15	23.4	
*Rigid bronchoscopy balloon dilation (median)	2 (2)		2 (2)		0.897
Rigid bronchoscopy balloon dilation+ stent					
No	37	100.0	60	93.8	0.295
Yes			4	6.3	
Tracheal resection/ reconstruction					
No	19	51.4	24	37.5	0.175
Yes	18	48.6	40	62.5	
**Hospital stay duration (days)	8(8)		12 (11.5)		0.075
Mortality					
No	36	97.3	63	98.4	0.999
Yes	1	2.7	1	1.6	

Continuous variables are expressed as either the mean±standard deviation (SD) or the median (interquartile range), and categorical variables are expressed as either frequency or percentage. Continuous variables were compared with an student t test or the mann whitney u test, and categorical variables were compared using Pearson's chi-square test or fisher exact test. Statistically significant p-values are in bold. *: Rigid bronchoscopy balloon dilatation was applied a median of 2 times per patient; **: Hospital stay duration after TS procedure. SD: Standard deviation; CAD: Coronary artery disease; COPD: Chronic obstructive pulmonary disease; CVA: Cerebrovascular accident; CKD: Chronic kidney disease; ASA: American Society of Anesthesiologists; ETI: Endotracheal intubation.

of admission to the ICU.[17] In our study, it was observed that COVID-related TS patients had similar intubation times to non-COVID-related TS patients.

The incidence of iatrogenic tracheal stenosis was much higher in the past. However, the use of low-pressure/high-volume cuffed endotracheal tubes has reduced the frequency of this complication by preventing ischemic trauma. Today, tracheal lesions following endotracheal intubation are considered a rare iatrogenic complication. It has been reported to occur at a rate of 4.9 cases per million population per year.[7] During the COVID pandemic, the use of uncontrolled high cuff pressures due to concerns about aerosol formation, not preferring extubation before the patient has fully recovered, and delays in tracheostomy decisions as a result of prone position applications contributed to the development of TS.[3,7]

During the COVID pandemic, cases of tracheal stenosis have been reported in a COVID patient who did not have a history of endotracheal intubation.[18] COVID-associated severe inflammation, formation of granulation tissue, and plugs may also contribute to the development of TS. Viral-induced laryngeal and tracheal inflammation could be a contributing factor to further upper respiratory tract damage.[19] In our study, all patients had a history of endotracheal intubation.

Early tracheostomy is recommended for patients who require prolonged tracheal intubation.[20] Early tracheostomy (<7 days)[20] facilitates bronchial clearance, feeding, and mobilization of the patient. It reduces the duration of mechanical ventilation and sedation and provides a faster weaning process in patients who will require mechanical ventilation.[21] The global trend for COVID patients admitted to the intensive care unit is to delay tracheostomy until the patient no longer needs mechanical ventilation and is cleared of the virus. This delay is primarily due to the high risk of cross-infection for healthcare workers, in addition to the prone position not allowing for tracheostomy.[22] In our study, we found that 26 patients underwent tracheostomy. All tracheostomies were performed in the late period. It is noteworthy that all of the tracheostomies performed in non-COVID-related patients were performed in the late period. The COVID outbreak may be a factor in this.

After TS surgery, while the average hospital stay in patients with COVID-related TS was 8 days, the average hospital stay in non-COVID-related patients was 12 days. This may be related to the fact that the CAD, CVA rates, and ASA scores of the non-COVID group were significantly higher than those in the COVID group.

The main limitations of our study include its retrospective nature and the limited availability of data due to patients being followed and treated at external centers. Another limitation is that we did not evaluate the etiologies of patients who underwent surgical procedures for TS before the COVID pandemic.

Conclusion

As a result, in the cross-sectional evaluation of the patients, it was determined that the most common cause of TS developing after intubation was coronavirus. The coronavirus epidemic experienced by the whole world has left its mark on TS cases in the last 2 years. This result may have been influenced by the intubation of patients admitted to intensive care due to aerosol generation, high cuff pressures, postponement of tracheostomy, or inflammatory processes.

Disclosures

Ethics Committee Approval: The study was approved by The Ankara Bilkent City Hospital No 1 Clinical Research Ethics Committee (no: E1-22-3142, date: 28/12/2022).

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