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Research Article

Comparison of Surgery and Stent Application in the Treatment of Tracheal Stenosis

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Introduction: Tracheal stenosis is a pathology that is gradually increasing and requires intervention. Surgical treatment has been used as the gold standard for years, but it is difficult to decide on surgery in patients with comorbidities and high surgical risk. We aimed to evaluate the data of both treatment methods applied in our center.

Materials: Our study was designed as retrospective and observational. The data of 61 patients who underwent resection & reconstruction and Methods or stent due to tracheal stenosis in our center between May 2002 - May 2019 were analyzed. Tracheal stenosis classifications, etiology, demography and treatment data, imaging measurements, and a satisfaction survey were used.

Results: 53 patients who met the inclusion criteria were studied. Both treatment methods were found to be effective in reducing the stenosis and regressing the complaints. The average age in the stent group was higher than in the surgery group. As the intensive care period in the intubated state increases; Severe stenosis and deterioration of cartilage integrity increased. The satisfaction score of the surgery group was higher than the stent group.

Conclusion: Both treatment methods are effective in improving respiratory functions and quality of life. The lesion was located higher in the surgical group and was longer in the stent group. Hospitalization times were longer in patients with severe stenosis and antibiotic changes were more frequent in patients using steroids. No statistically significant difference was found.

Keywords: Trachea, Stenosis, Resection, Reconstruction, Stent implantation

1. INTRODUCTION

Tracheal stenosis is an important pathology that we encounter more frequently in recent years and negatively affects the quality of life. Among the benign causes, stenosis that develops after intubation is the most common one.[1] In addition trauma, various infections and benign tumors can be detected, but sometimes the cause cannot be determined. Cases of tracheal stenosis are increasing as a result of increasing human lifespan, increasing number and use of intensive care and advanced life support units.[2]

The main reason is that the cuff of the intubation tube is inflated with more pressure than it should be and this situation continues for a long time due to prolonged intubation times. Thus, submucosal blood flow decreases, resulting in fibrotic stenosis. If the stenosis narrows the lumen by more than 50%, stridor and exertional dyspnea occur.[3] Various endoluminal treatment methods can be chosen to reduce airway stenosis in patients who are not suitable for surgery or in patients with irresectable pathologies. Nowadays, these treatments are combined to increase their effectiveness.

Tracheal stenosis occurs in 0.6-21% after intubation and tracheostomy, and these become

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clinically significant stenosis in less than 1% of patients.[4 5]

The aim of this study is to investigate the effectiveness of both accepted treatments and to assist in the selection and management of treatment in these life-threatening patients.

2. MATERIAL AND METHOD

The Declaration of Helsinki was complied with throughout the entire study process. Our study was approved to conduct scientific research with the approval of the Scientific Board of the University of Health Sciences and the academic board of our hospital. (See Supplementary File-1)

Our study was designed as a retrospective and observational study. Data of patients who underwent tracheal stent or tracheal resection and reconstruction between May 2002 and May 2019 were examined in the hospital medical database and our clinic bronchoscopy reports. 53 Patients who met the inclusion criteria were included in the study. After examining the data of all patients, surgery and stent patients were examined and compared separately.

In tracheal intervention evaluations reported to date, the number of cases was low or multicenter studies were observed. Surgical and endoluminal complications are important in patient follow-up, and other modalities should be applied in combination when necessary in patients who cannot undergo surgery. In this study, we interpreted the interventions preferred in our clinic with their long-term results. We conducted our multivariate analyzes based on patient age, day of ICU admission, postintubation or posttraumatic stenosis, duration of being intubated , DM, anemia, steroid usage (intravenous and/or inhaler), leukocytosis and antibiotherapy revision, cardiac comorbidity, tracheostomy status, cartilage structure integrity. We applied it on Brichet Myer and McCaffrey classifications.

Patient selection and definitions

Inclusion Criteria

- Intervention (surgery or stent) due to tracheal stenosis in all ages (14-83)
- Access of complete anamnesis, thoracic and tracheal imaging, bronchoscopy and laboratory results in the hospital database

Exclusion Criteria

- Insufficient database of patient who underwent these treatments
- Other procedures in stenosis treatment (balloon dilation, dilatation with rigid bronchoscope)

Limitations of the study include being a single center, limited data access before 2008, patients who stopped follow-up early, and the low number of patients in the stent group.

Operation technique

Silicone stents are placed with a rigid bronchoscope under general anesthesia. The tip of the rigid bronchoscope is placed proximal to stenosis. While stent is being pushed, rigid bronchoscope is kept stationary and the stent is ensured to fit into stenosis area. Position is corrected with forceps. If stent does not fully expand, dilatation is performed with balloons or smaller rigid tubes. Diameter, length and localization of stenosis are determined by tomography and bronchoscopy examinations.

In cases of upper tracheal stenosis, a collar incision is preferred. Control with FOB is made through intubation tube and localization of stenosis is determined. The tube is withdrawn to proximal of stenosis, tracheal lumen is opened with a straight incision distal to stenosis, and distal intubation is performed from surgical area and connected to new sterile ventilation set. Posterior membrane is sutured with continuous 4-0 absorbable sutures,

and tracheal cartilage is sutured with 3-0 or 4-0 absorbable sutures, passing 3-4 mm away from anastomosis line. After suturing, distal intubation tube is withdrawn and orotracheal tube is being pushed without traumatizing the anastomosis, under supervision of surgeon. To reduce tension in anastomosis line, patients chin is sutured to the anterior chest wall, while neck is flexed.[6]

Postoperative follow-up

48 hours after operation, stent site is confirmed and cleaned by control bronchoscopy. Patients should be assisted with nebulizer and importance of humidification should be explained.[7] Risk of contamination from oral flora should not be forgotten and this risk is higher in patients using steroids or patients in DM.[8]

Statistical analysis

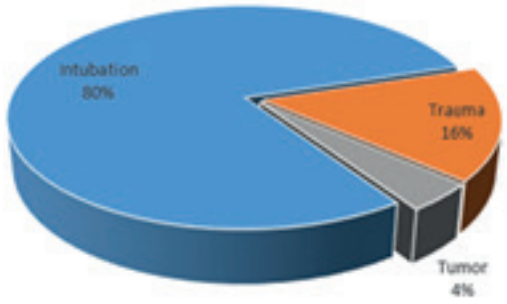
IBM SPSS Statistics 22 software was used for statistical analysis. In this study, nominal variables were given as numbers and percentages, and continuous variables were given as mean and standard deviation. In addition to descriptive statistics, Chi-Square test was used for nominal values when comparing groups, Fisher Exact Chi-Square test was used if expected frequencies were below 5, independent sample t-test was used to compare parametric data, and Mann Whitney U test was used to compare nonparametric data. $P < 0.05$ was accepted for significance in the analyses.

3. RESULTS

40 male and 13 female patients who underwent tracheal resection & reconstruction or stenting were included. There is no significant difference in demographic data for the stent and surgery groups. Resection and reconstruction was performed in 40 patients, and tracheal stent was applied in 13 patients. We applied tracheal stent to one patient who underwent chemoradiotherapy due to primary tracheal tumor. As result of etiological research, stenosis was detected post-intubation in 39 patients (79.6%), post-trauma in 8 patients (16.3%), and due to tumor in 2 patients (Graphic 1).

Graphic 1.

Causes of Tracheal Stenosis in Patients



Considering all patients, average age was determined as 48.45±15.86. Average age of patients who underwent surgery was 47.11±14.23 years, and for stenting group is 53.54±19.62 years. It was determined that surgery was performed in 7 of 8 patients (87.5%) who developed post-traumatic stenosis ($p = 0.212$). In patients who underwent surgery (n:40), cartilage integrity was disrupted in 60.6% of patients, and in those who underwent stenting (n:13), this rate was similar (61.5%) (Table 1).

It was observed that 25 (96.1%) of patients (n: 26) who underwent surgery after intensive care follow-up had prolonged intubation. This rate was 55.5% in patients who underwent stenting after intensive care follow-up ($p=0.003$).

When surgery and stent group patients were examined separately; it was determined that antibiotics were changed in 75% of patients given steroids. This rate is 57.9% in patients who are not being given steroids; it can be interpreted as increased antibiotic change rates in tracheal stenosis patients who are being given steroids, but exact difference could not be shown statistically due to limited number of patients ($p = 0.217$) (Table 1).

According to the Brichet classification, 80.6% of surgical patients have complex stenosis; This rate was found to be 100% in patients who received stents. 97% of surgical patients fall into McCaffrey stage 2, 3 and 97% fall into Myer stage 2, 3. When the intensive care unit stay times of patients with preserved and impaired cartilage structure integrity were compared (16.81±17.45, 18.68±19.92); It was found to be longer in patients with damaged cartilage structure, with a difference of approximately 2 days (p = 0.747) (Table 1).

Table 1.

General Statistical Values

	Surgery (n=40)	Stent (n=13)	p
Age	47.11±14.23	53.54±19.62	0.212
Gender (M/F)	29 (72.5%)/ 11	11 (84.6%)/2	0.480
DM	5 (15.2%)	3 (23.1%)	0.669
Obesity	4 (12.9%)	2 (16.7%)	1.000
Anemia	13 (37.1%)	5 (41.7%)	0.781
Stenosis Etiology			
Intubation	29 (78.4%)	10 (83.3%)	0.508
Trauma	7 (18.9%)	1 (8.3%)	
Tumor	1 (2.7%)	1 (8.3%)	
Impaired Cartilage	20 (60.6%)	8 (61.5%)	0.953
Steroid Usage (+)	19 (57.6%)	9 (69.2%)	0.522
Steroid Usage (-)	14 (42.4%)	4 (30.8%)	0.460
Steroid Usage - IV	4 (12.1%)	4 (30.8%)	
Steroid Usage - Inhaler	5 (15.2%)	1 (7.7%)	
Steroid Usage - IV&Inh	10 (30.3%)	4 (30.8%)	
ICU in patients history	26 (83.9%)	9 (69.2%)	0.414
ICU (day)	19.06±18.61	14.92±17.91	0.422
Prolonged Intubation	25 (67.6%)	5 (38.5%)	0.065
Leukocytosis & Changing Antibiotic	28 (75.7%)	8 (61.5%)	0.329
Stenotic Diameter	6.28±2.20	6.69±2.96	0.970
McCaffrey			
1	0 (0%)	0 (0%)	0.269
2	16 (48.5%)	3 (25%)	
3	16 (48.5%)	9 (75%)	
4	1 (3%)	0 (0%)	
Brichet			
Simple	7 (19.4%)	0 (0%)	0.167
Complex	29 (80.6%)	13 (100%)	
Myer			
1	1 (3.1%)	1 (7.7%)	0.239
2	21 (65.6%)	5 (38.5%)	
3	10 (31.3%)	7 (53.8%)	

According to the Brichet classification, 80.6% of surgical patients have complex stenosis; This rate was found to be 100% in patients who received stents. 97% of surgical patients fall into McCaffrey stage 2, 3 and 97% fall into Myer stage 2, 3. When the intensive care unit stay times of patients with preserved and impaired cartilage structure integrity were compared (16.81±17.45, 18.68±19.92); It was found to be longer in patients with damaged cartilage structure, with a difference of approximately 2 days (p = 0.747) (Table 2).

When patients complying with Myer classification 2 and 3 were compared in terms of ICU hospitalization duration, a significant difference was detected in ICU hospitalization duration for stent, surgery and all patients.

Table 2.

ICU stay duration (days) according to Myer classification

	Myer 2	Myer 3	P
All patients	15.75±16.49	22.31±20.68	0.368
Surgery	18.58±17.26	27.38±22.17	0.287
Stenting	5.00±6.285	18.43±20.35	0.246

In the preoperative period, 8 (15%) of the patients had a tracheostomy cannula, 2 had a tracheal tumor, and 1 patient had a lung lesion causing tracheal stenosis. The distance of the lesions detected in the bronchoscopic examination and tomographic examinations performed on all patients to the vocal cords is shown below (Table 3).

Table 3.

Distance of the stenosis from the vocal cords and average stenotic length (millimeters)

	Surgery n=27	Stenting n=11	P
Distance to vocal cords	24.48 ±9.00	29.18 ± 5.44	0.071
Stenotic length	16.52 ± 9.55	25.64 ± 24.43	0.339

The distance between the vocal cord and the stenotic area in the patients was measured as 13-45 mm. No significant difference was found between the distance in surgical patients (24.48 ± 9.00) and the distance in stenting patients (29.18 ± 5.44) (p = 0.071). Surgical resection was performed in 40 patients, and the resected materials measured between 15 mm and 50 mm in pathological evaluation, with an average of 27.02 mm. The stenotic

segment length in the stent group (25.64 ± 24.43 mm) was found to be longer than the surgery patients (16.52 ± 9.55 mm) (p = 0.339) (Table 3).

In our study, the complication rate after surgery was found to be 22.5%, and the complication rate after stent procedure was 53.6%. Restenosis was observed in 7 of 9 patients who had post-surgical complications, and 5 of these patients underwent dilatation with a rigid bronchoscope and 2 underwent stenting. Temporary unidirectional vocal cord paralysis was detected in 1 patient, and esophageal stenosis was detected in a patient operated for TEF. Of the 7 patients who had complications after the stent procedure, stenosis was detected in 5 due to newly formed hyperplastic granulation tissue in the proximal or distal part of the stent, and migration was detected in 2. In 1 of 5 patients with stenosis, coagulum was observed in the stent lumen and was removed (Table 4). A patient who developed restenosis after being operated on at an external center underwent resection, and a Montgomery T-tube was placed in a patient who had a tracheostomy at the time of admission.

Table 4.

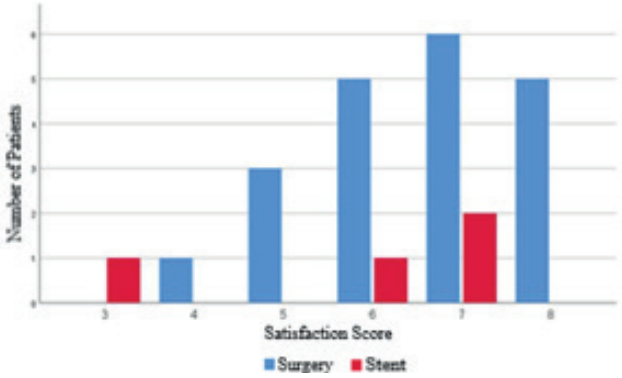
List of Complications

List of Complications
Post Surgery Complications
– Stenosis in anastomosis line (7)
– Temporary unilateral vocal cord paralysis (1)
– Esophageal stenosis (1)
Post Stenting Complications
– Hyperplastic granulation tissue in proximal and distal of the stent (5)
– Migration (2)
– Coagulum in the stent

A satisfaction survey consisting of 8 questions was prepared for all patients to be asked over the phone. Patients were asked about recurrence, rehospitalization, wheezing or stridor, shortness of breath that wakes them up from sleep, post-discharge medication use, post-procedure effort capacity, post-treatment compliance and psychosocial well-being, and a total of 8-point patient satisfaction survey was administered, with each question receiving 1 point. With the data taken from the hospital database, 29 interviews were made and 5 exitus were detected in the patients reached. The satisfaction average of the remaining 24 patients was calculated as 6.41 out of 8, 6.55 for patients who underwent surgery and 5.75 for patients who underwent stenting (p=0.477) (Graph 2).

Graph 2.

Satisfaction Survey Results



One patient who underwent surgery died due to hypertensive pulmonary edema and systemic infection (2.5%), and a terminal cancer patient who received a stent for palliation died within 30 days postoperatively due to immobilization and pneumonia (7.6%).

4. DISCUSSION

According to the Brichet classification, 80.6% of surgical patients have complex stenosis; This rate was found to be 100% in patients who received stents. 97% of surgical patients fall into McCaffrey stage 2, 3 and 97% fall into Myer stage 2, 3. When the intensive care unit stay times of patients with preserved and impaired cartilage structure

integrity were compared; It was found to be longer in patients with damaged cartilage structure, with a difference of approximately 2 days (p = 0.747) (Table 2).

When patients complying with Myer classification 2 and 3 were compared in terms of ICU hospitalization days, a significant difference was detected in ICU hospitalization times for stent, surgery and all patients. (Table 2).

When the surgery and stent group patients were examined separately; It was determined that antibiotics were changed in 75% of patients given steroids. This rate is 57.9% in patients not given steroids; It can be interpreted as increased antibiotic change rates in tracheal stenosis patients given steroids, but the current difference could not be shown statistically due to the limited number of patients (p = 0.217) (Table 1).

In another study with a large series, the average age was measured as 47.4 years, with an age range of 4-86 years.[9,10] In our study, the average age was found to be 48.4, with 16.9% aged >65 and 3.7% aged >80 years. The average age of stent-treated patients was (53.5) higher than surgical patients (47.1) (Table 1).

The first case series regarding tracheal damage after intubation was published in 1995.[11] The incidence of tracheal damage after endotracheal intubation is 5-19 per 10000.[12] There are publications indicating the incidence of tracheal laceration after double-lumen intubation (12/10000).[13] In the publication of Spaggiari et al., the incidence of damage as a result of 800 double-lumen intubations performed in 4 years was 0.37%.[14] Özdemir et al. Of the 42 patients treated for benign stenosis, 23 (54.7%) underwent bronchoscopic intervention (laser, dilation, cryotherapy or stent placement), and 19 (45.3%) underwent surgery, and 6-month results showed success rates of 43.4% and 94.7%.[15] We performed surgery on 74% of our patients and stents on 16%, and achieved similar success results.

In a study published in 1996 on complications after tracheal stent, 17.5% migration, 6.3% granulation, and 6.3% mucostasis were found.[16] In a study dated 2016 investigating the results of bronchoscopic treatment; No complications were observed after treatment for simple tracheal stenosis, except for 16% mucostasis; In complex stenoses, 41% migration, 33.1% granulation at the proximal or distal end, and 43% mucostasis have been reported.[17] In our study, when the patients who received stents were examined, we found 61.5% complex stenosis. When our complication rate after stent application (53.6%) was compared with the literature, no significant difference was detected.

Several risk factors have been shown to increase complication rates. These; reoperation, DM, long resections (>4 cm), laryngotracheal resections, age younger than 17 and the presence of preoperative tracheostomy. In the study published by Marulli et al. in 2007, the total anastomotic complication rate was 8.1% and the separation rate was 5.4%.[18] In Grillo's publication of 503 patients, post-surgical morbidity was 32%, and the most common complications were granulation tissue formation (9.7%), wound infection (3%), glottic dysfunction (2.2%), dehiscence and restenosis (5.7%).[1] In our study, we found the postoperative morbidity rate to be 22.5%. We detected stenosis in the anastomosis line in 17.5%, temporary unidirectional vocal cord paralysis in 2.5%, and esophageal stenosis in 2.5%.

Segmental tracheal resection is the most preferred method in the treatment of postintubation stenosis. In the nonoperative techniques (endoscopic dilatation and stent placement) we applied in 13 cases in our clinic; We found that patient

satisfaction was lower compared to patients who underwent surgery (surgery 6.55, stent 5.75). It was noted that the stent group was in the older age group and required frequent rehospitalization.

The segment length to be removed in tracheal surgery is one of the major problems. As the length increases, the risk of tension and complications in the anastomosis line increases. When the resection length is examined in our study, the average length is 27.02 millimeters (between 15-50 mm). In Grillo et al.'s 1995 study, resection lengths were between 10-75 mm, and in Uluşan et al.'s 2017 study, the average resection length was 25 mm.[1,19] Ashiku et al. They examined 73 patients between 1971 and 2002 and the average resection length was found to be 26 mm (10-50 mm).[20] When compared with current values, it was found compatible with our study data.

Another controversial issue is steroid usage, which negatively affects anastomotic healing. When the effect of steroids on intensive care unit stays was investigated, hospitalization times were observed to be longer in the group using steroids for all patients and surgical patients; When looking at patients who received stents, this period was found to be shorter for those using steroids. It should not be forgotten that the choice of steroid may affect the duration of stay, and it should be used considering its effect on surgical site healing. In our study, it was determined that antibiotics were changed in 21 of 28 patients (75%) who were given steroids, and this rate was 57.9% in patients who were not given steroids; It can be interpreted as an increased antibiotic revision rate in tracheal stenosis patients given steroids, but it could not be shown statistically due to the limited number of patients.

In the literature reviews, postoperative morbidity was found to be 5-15%, mortality was 1-5%, and morbidity was found to be 3% in experienced centers.[1, 21, 22] In our study, we found the post-surgical complication rate to be 22.5% and found it to be compatible with the literature.

During the study, we experienced difficulties such as the study being retrospective and the number of cases not being sufficient to allow detailed analysis. Due to the characteristics of our center, the majority of patients with cardiac comorbidities were admitted. In our study investigating tracheal stenosis treatment preferences and results, we found that the most important factor was the surgeon's experience and appropriate patient selection. Etiology, ICU stay, DM, anemia, steroid usage, leukocytosis and antibiotic therapy, form and localization of stenosis, cartilage structure integrity and surgical techniques are important factors that affect the research but there is no significant values that would affect our preference orientation.

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