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Original Article / *Özgün Makale*

Use of airway stents to treat malignant tracheobronchial fistulas: Our six-year experience

Malign trakeobronşiyal fistüllerin tedavisinde hava yolu stentlerinin kullanımı: Altı yıllık deneyimimiz

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ABSTRACT

Background: This study aims to investigate the indications, safety, complications, and long-term outcomes of airway stenting in the treatment of malignant tracheobronchial fistulas.

Methods: The medical records of a total of 34 patients (24 males, 10 females; mean age: 55.4+13 years; range, 23 to 76 years) with malignant tracheobronchial fistulas treated with airway stenting between February 2014 and August 2020 were retrospectively analyzed. Data including demographic features, diagnosis, symptoms, treatment, complications and outcomes were recorded.

Results: Thirty-eight airway stents were inserted in 34 patients with malignant tracheobronchial fistulas, including 19 patients with malignant tracheobronchial esophageal fistulas and 15 patients with bronchopleural fistulas. The clinical success and the technical success rates were 91% and 100%, respectively. No perioperative death or severe complications occurred. Chronic complications (>24 h) occurred in eight (23%) patients with malignant tracheobronchial fistula. Median follow-up was 3.5 (range, 1.4 to 5.5) months in patients with malignant tracheobronchial esophageal fistulas and 18 (range, 9.5 to 26.5) months in patients with bronchopleural fistulas. Mortality rates were 79% and 61%, respectively.

Conclusion: Airway stent insertion provides a secure and effective treatment for patients with malignant tracheobronchial fistulas.

Keywords: Airway stent, malignant bronchopleural fistula, malignant tracheobronchial esophageal fistula.

ÖZ

Amaç: Bu çalışmada malign trakeobronşiyal fistül tedavisinde hava yolu stentlemenin endikasyonları, güvenliliği, komplikasyonları ve uzun dönem sonuçları incelendi.

Çalışma planı: Şubat 2014 - Ağustos 2020 tarihleri arasında hava yolu stentleme ile tedavi edilen malign trakeobronşiyal fistülü olan toplam 34 hastanın (24 erkek, 10 kadın, ort. yaş: 55.4+13 yıl; dağılım, 23 ile 76 yıl) tıbbi verileri retrospektif olarak incelendi. Demografik özellikler, tanı, semptomlar, tedavi, komplikasyonlar ve sonuçlar dahil olmak üzere veriler kaydedildi.

Bulgular: Malign trakeabronkoözofageal fistüllü 19 hasta ve bronkoplevral fistüllü 15 hasta dahil olmak üzere, malign trakeobronşiyal fistüllü 34 hastaya 38 hava yolu stenti takıldı. Klinik başarı ve teknik başarı oranları sırasıyla %91 ve %100 idi. Perioperatif ölüm veya ciddi komplikasyon izlenmedi. Malign trakeobronşiyal fistüllü 34 hastanın sekizinde (23%) kronik komplikasyonlar (24 saat) görüldü. Medyan takip süresi, malign trakeabronkoözofageal fistüllü hastalarda 3.5 (dağılım, 1.4-5.5) ay ve bronkoplevral fistüllü hastalarda 18 (dağılım, 9.5-26.5) ay idi. Mortalite oranları, sırasıyla %79 ve %61 idi.

Sonuç: Hava yolu stent takılması, malign trakeobronşiyal fistüllü hastalar için güvenli ve etkili bir tedavi sağlar.

Anahtar sözcükler: Hava yolu stenti, malign bronkoplevral fistül, malign trakeabronkoözofageal fistül.

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Malignant tracheobronchial fistulas (MTBFs) are potentially fatal, and immediate intervention is required to ensure airway patency. Most adults with malignant tracheobronchial esophageal fistulas (MTBEFs) have lung or esophageal cancer or metastasis.[1] However, most malignant bronchopleural fistulas (MBPFs) are caused by pulmonary resection for lung cancer.[2] Patients with MTBFs have a decreased long-term survival, and a poor prognosis and quality of life.[3-5] Early diagnosis and treatment of the fistula can increase the survival and the quality of life (QoL) of the patient.[5,6] Treatment options include surgical resection with fistula anastomosis or repair, stenting, radiotherapy, or combined treatments.[7-9] Surgical treatment of the fistula and airway reconstruction may allow full recovery; however, such treatment is infrequent due to the high risk of complications. Palliative therapy (tracheobronchial tree airway stent [AS] insertion) prolongs survival, improves QoL, and may allow oncological treatment.[5,10,11] However, few definitive treatment recommendations have been developed for patients with MTBEFs and MBPFs, and there is a limited number of clinical studies have focused on AS insertion.

In the present study, we aimed to evaluate the efficacy, tolerance, and safety of palliative stenting for MTBF patients and to investigate its impact on survival.

PATIENTS AND METHODS

This two-center, retrospective study was conducted at Yedikule Training and Research Hospital, Department of Chest Disease and Pulmonology and Medipol University, Faculty of Medicine, Department of Interventional Pulmonology between February 2014 and August 2020. A total of 34 patients (24 males, 10 females; mean age: 55.4+13 years; range, 23 to 76 years) who were treated with AS for MTBEF and MBPF were included. Digital medical records of these centers were searched for patients with MTBEF and MBPF who underwent AS insertion. Data including demographic details, diagnoses, bronchoscopic findings, treatment modalities, indication for stenting, the success of stenting, procedure and stent-related complications, duration of follow-up, and survival time were recorded. All cases (or their families) were informed about the procedures, possible results and complications.

Location of fistulas

Fistulas were classified according to their location (L) in eight groups: *(i)* L- I, upper third of the trachea; *(ii)* L- II, middle third of the trachea; *(iii)* L- III, lower third of the trachea; *(iv)* L- IV, main carina; *(v)* L- V, right main bronchus; *(vi)* L- VI, left main bronchus; *(vii)* L- VII, distal part of right main bronchus; *(viii)* L- VIII, distal part of left main bronchus.

Stenting technique

We used a bronchoscope to decide the type and shape of the stent to be placed. The location, diameter, and length of the fistulas (a); the status of airway stenosis and the percentage (b) if present; and whether mechanical debulking, argon plasma coagulation (APC), or cryotherapy (c) would be of assistance were recorded. The patients were intubated with a rigid bronchoscope (RB) (Efer Endoscopy, La Ciotat; Paris, France) of appropriate size followed by loading of the stent into a specifically designed introducer and which was deployed using the applicator. Stents used were silicone stents (Volutam; Medical Epsilon, Istanbul, Türkiye) and covered airway self-expanding metallic stents (SEMS; Leufen, Medical GmbH, Berlin, Germany). Stent shapes included Y-shaped, I-shaped, J-shaped, and Oki stents. The Oki and Y stents were modified according to the fistula localization and length by tailoring or drilling. Some patients with MTBEF were referred to our center following insertion of self-expanding esophageal metallic stents by gastroenterologists.

Follow-up

Respiratory failure requiring mechanical ventilation, arrhythmia, hemorrhages, and death within 24 h after the procedure were considered to be acute complications. All patients underwent surveillance bronchoscopies at one month of the procedure or earlier according to the patient's symptoms for detecting chronic complications, such as stent fracture, granulation tissue formation, migration and mucostasis. The primary outcomes of the present study were the assessment of clinical and technical success of AS and their complications. Technical success was described as successful insertion of the stent at the appropriate site in a single bronchoscopic session. Clinical success was defined as dramatic improvement in symptoms and/or successful repair of fistula, within one month after stent placement without complications or death.

Statistical analysis

Statistical analysis was performed using the R software version 3.5.1/2018-7-01 (Bell Laboratories, Lucent Technologies, New Jersey, USA). Descriptive data were expressed in mean ± standard deviation (SD),

Table 1. Demographic and clinical details of the patients with MTBF

	Patients with MTBEF (n=19)					Patient with MBPF (n=15)				
Variables	n	%	Mean±SD	Median	IQR	n	%	Mean±SD	Median	IQR
Age (year)			55.6±6.9					55.2±6.4		
Sex										
Male	13	68				11	73			
Etiology of disease										
Lung cancer	3	15				-	-			
Stages of the tumor										
I	-					1				
II	-					6				
III	2					8				
IV	1					-				
Histological tumor types										
Adenocancer	1	5				6	40			
Epidermiod cancer	2	10				9	60			
Esophageal cancer	16	84				-	-			
Stages of the tumor										
I	-					-				
II	-					-				
III	15					-				
IV	4					-				
Histological tumor types										
Adenocarcinoma	6	38								
Epidermoid cancer	10	62								
Comorbidities										
Chronic pulmonary disease	2	10				3	20			
Cardiovascular disease	2	10				2	13			
Cerebrovascular disease	1	5				-	-			
Diabetes mellitus	-	-				1	6			
Previous treatment modalities										
Surgery	4	21				15	100			
CT	16	84				5	26			
RT	5	26				-	-			
CT and RT	9	47				9	60			
Symptoms										
Dyspnea	5	26				3	20			
Cough	16	84				13	86			
Sputum	7	37				9	60			
Hemoptysis	2	10				1	6			
Dysphagia	12	63				-	-			
Chest pain	7	37				5	26			
Length of the fistula (mm)			12.3±3.2					6.9±2.2		
Degree of endobronchial stenosis				50	37-75				23	0-50
Site of fistula										
Trachea	12	63				2	13			
Left bronchus	3	15				4	27			
Right bronchus	3	15				9	60			
Carina	1	5				-	-			

MTBF: Malignant tracheobronchial fistula; MTBEF: Malignant tracheobronchial esophageal fistula; MBPF: Malignant bronchopleural fistula; SD: Standard deviation; IQR: Interquartile range; CT: Chemotherapy; RT: Radiotherapy.

median (min-max) or number and frequency, where applicable. The Student t-test and Mann-Whitney U test were used to continuous data, respectively. Categorical data were compared using the chi-square and Fisher exact test. The date of stenting was considered as zero-day, last check date or date of death was considered as last day on survival analysis. The Kaplan-Meier survival analysis was performed for univariate survival analysis. Cut-off values for continuous variables were identified using the receiver operating characteristic (ROC) analysis. Variables that were associated with survival at p<0.15 in the univariate analysis were included in multivariate analysis. The Cox proportional risk model was used for multivariate analysis of these factors that were likely to affect the survival. A p value of <0.05 was considered statistically significant.

RESULTS

Of a total of 34 patients, 15 had MBPF and 19 had MTBEF. All MBPFs developed following surgery for lung cancer (Table 1). Seven patients presented following right pneumonectomy, two following left pneumonectomy, three following right upper lobectomy, one following left upper lobectomy, and two following left lower lobectomy. Four (26%) of the patients with MBPF had mucosal tumor infiltration at the fistula side.

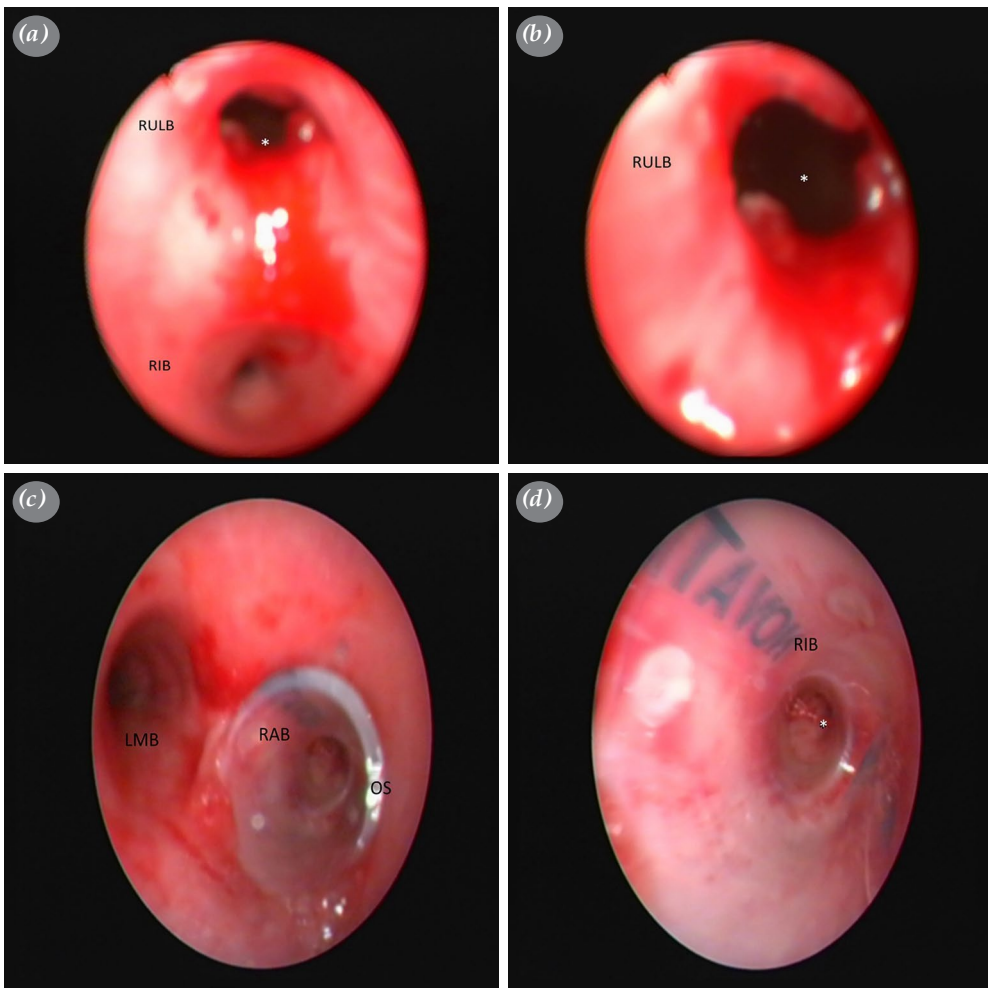

Figure 1. Rigid bronchoscopic view of BPF; **(a)** and **(b)** A fistula of approximately 10 mm was observed in the right upper lobe bronchus (RULB) localization. **(c)** and **(d)** Oki stent was inserted in the right bronchial system after the modification of right upper lobe-limb with 3.0 prolene sutures and the fistula was completely repaired.

BPF: Bronchopleural fistulas; RULB: Right upper lobe bronchus; RIB: Right intermediate lobe bronchus; RAB: Right main bronchus; LMB: Left main bronchus; OS: Oki stent.

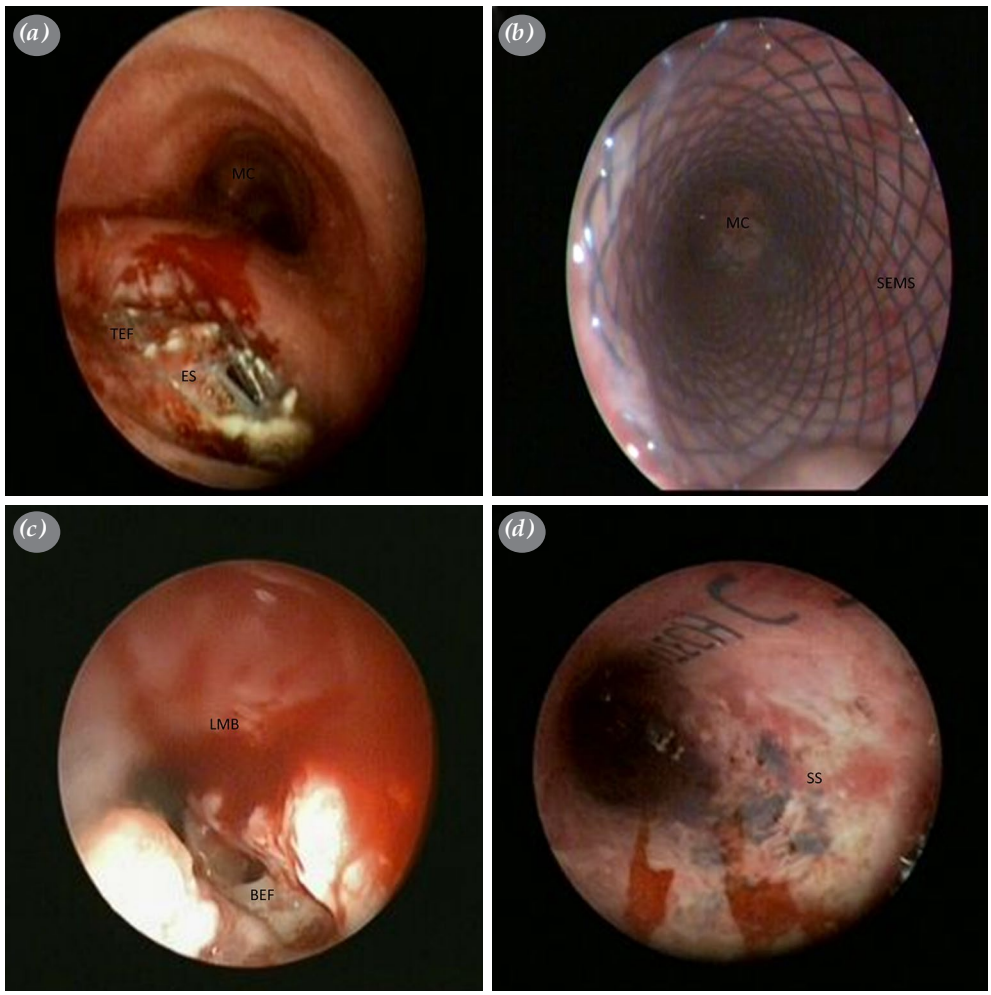

Figure 2. Rigid bronchoscopic view of TEF; **(a)** A fistula of approximately 20 mm was observed in the posterior wall of the distal part of the trachea. **(b)** A SEMS was placed in the fistula location. **(c)** A 15 mm long fistula with tumoral infiltrations was observed in the posterior wall of the left main bronchus entrance. **(d)** Tumoral infiltrates in the left main bronchus were coagulated with APC and a Y-shaped SS of 15×12×12 mm diameter was inserted.

TEF: Tracheoesophageal fistulas; ES: Esophageal stent; MC: Main carina; SEMS: Covered airway self-expanding metallic stent; APC: Argon plasma coagulation; LMB: Left main bronchus; BEF: Bronchoesophageal fistulas; SS: Silicone stent.

The MTBEF patients included 16 cases of esophageal cancer and three cases of lung cancer. Seven patients with MTBEF who had AS inserted were previously treated with esophageal stents. Four (21%) patients had a history of surgery. Mucosal tumor infiltration at the fistula side was observed in 15 (79%) patients.

A total of 38 ASs were inserted with a technical success rate of 100% (Figures 1 and 2, Video 1). Stents were inserted in a single session in 88% of the patients and the remaining in two sessions (12%). Thirteen of the stents were SEMS and 25 were silicon stents (Table 2).

The clinical success rate was 95% in patients with MTBEF (n=1 migration) and 86% in patients with MBPF (n=2 migration). The median survival time was 3.5 (range, 1.7 to 8.5) months in patients with MTBEF and 18 (range, 7.2 to 51) months in patients with MBPF (Figure 3). The 3, 6, and 12-month survival rates were 64%, 27%, and 18% in patients with MTBEF, and 83%, 66%, and 38% in patients with MBPF, respectively.

Factors significantly affecting survival in patients with MTBEF using the univariate analysis were the diameter of the fistula (p=0.08), stage of the tumor (p=0.02), degree of airway obstruction (p=0.11), and

Video 1. The video demonstrates the treatment of 2-cm long TEF in the posterior wall of the distal trachea with an I-shaped SS
TEF: Tracheoesophageal fistula; SS: Silicone stent.

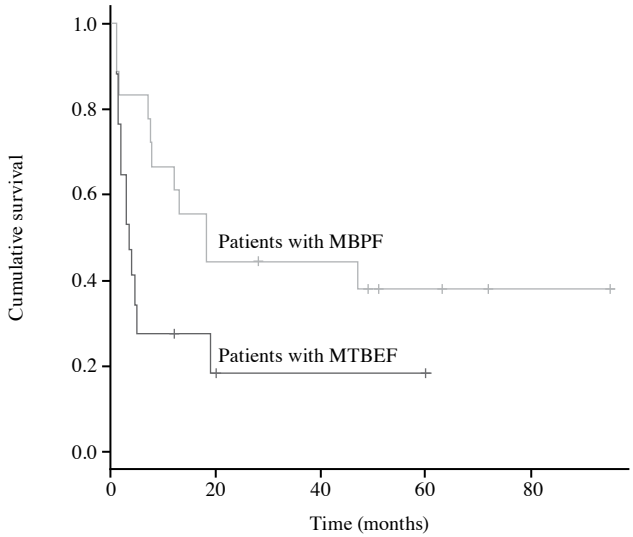

Figure 3. Survival curves of patients with MTBF.
MTBF: Malignant tracheobronchial fistulas; MBPF: Malignant bronchopleural fistulas; MTBEF: Malignant tracheobronchial esophageal fistula.

the presence of esophageal stent (p=0.02). Multivariate analysis showed that the stage of the tumor (p=0.04) and the presence of esophageal stent (p=0.02) were both independent predictors of survival (Table 3). Factors significantly affecting survival in patients with MBPF using the univariate analysis were histological tumor type (p=0.02), degree of airway obstruction (p=0.14), stage of the tumor (p=0.03), diameter of the

Table 2. Characteristics of stents implanted in patients with MTBF

	Patients with MTBEF (n=19)		Patient with MBPF (n=15)	
	n	%	n	%
Stent location				
Type II	2	10	-	-
Type III	9	47	-	-
Type IV	2	10	2	13
Type V	2	10	9	60
Type VI	-	-	-	-
Type VII	3	16	3	20
Type VIII	1	5	1	7
Stent shape				
Y-shaped stent	13	65	8	44
J-shaped stent	-	-	4	22
I-shaped stent	6	35	3	16
Small Y-shaped (Occi) stent	1	5	3	16
Stent type				
Silicon stent	12	60	13	72
Covered metallic stent	8	40	5	28
Presence of esophagea stent	7	37	-	-
Additional procedures				
Argon plasma coagulation	10	53	4	27
Cryotherapy	7	37	3	20
Mechanical dilation	3	16	-	-

MTBF: Malignant tracheobronchial fistula; MTBEF: Malignant tracheobronchial esophageal fistula; MBPF: Malignant bronchopleural fistula.

Table 3. Characteristics of the study population that affect survival after AS insertion procedures for patients with MTBEF

	Months		3rd months	6th months	12th months	Univariate	Multivariate
Characteristics	Median	%95 CI	%	%	%	*p*	*p*
Age (year)						0.3	
<65	3.7	2-4.6	63	26	13		
≥65	3	1-16	57	42	0		
Type of underlying malignancy						0. 2	
Non-small cell lung cancer	4.5	3-12	71	42	28		
Esophageal cancer	3.2	1.3-8.7	70	40	26		
Histological tumor types						0. 2	
Adenocarcinoma	4	1.5-12	50	25	12		
Epidermoid cancer	3.5	2.5-32	60	40	0		
Stages of the tumor (Esophageal cancer)						**0. 02**	**0.04 (0.02-0.9)**
III	4	1.8-13	69	35	23		
IV	2	1-2.8	33	0	0		
Location of the fistula						0.6	
Trachea	3.7	2.2-4	62	16	0		
Right main bronchus	2.5	1-3.4	50	0	0		
Left main bronchus	3	2-10	66	33	0		
Carina	10	1.5-49	50	25	25		
Degree of airway obstruction						**0.11**	**0.6 (0.1-4.1)**
<25%	1.7	1.1-3.5	50	25	0		
≥25%	4	2-15	61	30	0		
Length of the fistula (mm)						**0.08**	**0.4 (0.1-1.7)**
<13	4	1.8-18	62	46	0		
≥13	3	1.7-4.5	44	11	0		
Presence of previous esophageal stent						**0.02**	**0.02 (1.3-56)**
Available	4.7	2-18	70	40	26		
Not available	2	1-3.5	42	28	0		
Previous treatment modalities						0.8	
Surgery	2	1-4	50	0	0		
CT	8.2	4.5-10	77	33	16		
RT	3.2	1.3-18	66	33	0		
CT and RT	2	1.2-19	40	20	0		
SP	2.5	2-8	55	0	0		
Stent type						0.7	
SS	4	1.7-15	55	33	16		
MS	3.2	1.6-4.3	62	37	0		
Stent shape						0.5	
Y-shaped stent	4	1.7-15	76	53	20		
I-shaped stent	3.2	1.5-3.8	50	25	0		

MTBEF: Malignant tracheobronchial esophageal fistula; AS: Airway stent; CI: Confidence interval; CT: Chemotherapy; RT: Radiotherapy; SP: Supportive treatment; SS: Silicon stent; MS: Metallic stent.

fistula (p=0.08), and the site of the fistula (p=0.09). Multivariate analysis revealed that no factor was an independent predictor of survival (Table 4).

There were no major acute complications. Three patients had minor complications: two had mild hemorrhage and the other had hypercarbic respiratory failure requiring non-invasive mechanical ventilation for 4 h. Chronic complications (>24 h) occurred in nine (26%) of 34 patients with fistulas. Additionally, four patients needed stent reinsertion: three for stent migration and one for mucostasis (Table 5). Chronic complications were not correlated with the stent type, stent shape, fistula location, or fistula size.

DISCUSSION

Various endoscopic procedures have been used for MTBF closure in patients who are not indicated for surgery, including application of topical fibrin, sclerosing agents, and metallic or silicone stents; and none of those approaches has been proven to be ideal. The AS insertion (an endoscopic procedure) is an attractive, minimally invasive palliative treatment

Table 4. Characteristics of the study population that affect survival after AS insertion procedures for patients with MBPF

	Months		3rd months	6th months	12th months	Univariate	Multivariate
Characteristics	Median	%95 CI	%	%	%	*p*	*p*
Age (year)						0.4	
<50	49	17-60	75	50	50		
≥50	15	5-49	85	71	57		
Histological tumor types						0.02	**0.07 (0.02-1.3)**
Epidermoid cancer	28	13-63	85	85	71		
Adenocarcinoma	32	4-51	87	75	62		
Small cell cancer	7	1-7.4	66	33	0		
Tumor stage						0.03	**0.9 (0.06-24)**
II	28	15-51	88	77	55		
III	7.1	1.1-22	62	50	25		
Location of the fistula						**0.09**	**0.3 (0.02-8.9)**
Right main bronchus	12	1.5-47	72	63	45		
Left main bronchus	51	17-73	100	80	80		
Carina	45	18-61	100	50	50		
Degree of airway obstruction (%)						**0.14**	**0.8 (0.1-6.8)**
<50	37	8.4-51	91	83	66		
≥50	10	1.3-31	66	50	50		
Length of the fistula (mm)						**0.08**	**0.2 (0.03-1.9)**
<6	38	10-66	87	87	75		
≥6	12	1.3-48	70	60	50		
Previous treatment modalities						0.19	
NT	39	13-77	83	83	66		
CT	29	2.6-60	75	50	50		
CT and RT	12	7-39	87	75	50		
Stent type						0.5	
SS	23	5.8-54	78	71	64		
MS	12	8.2 -45	75	75	50		
Stent shape						0.18	
Y-shaped stent	7.8	1-13	57	42	14		
I-shaped stent	31	9-71	100	66	0		
J-shaped stent	51	47-67	100	66	66		
Oki stent	29	7.5-42	83	66	50		

AS: Airway stent; MBPF: Malingnant bronchopleural fistulas; CI: Confidence interval; NT: No treatment; CT: Chemotherapy; RT: Radiotherapy; SS: Silicon stent; MS: Metallic stent.

Table 5. Complications and outcomes of airway stents

	Patients with MTBEF (n=19)				Patient with MBPF (n=15)			
	n	%	Median	IQR	n	%	Median	IQR
Acute complications								
Mild-to-moderate hemorrhage	1	5			1	7		
Respiratory failure needing NIMV	1	5						
Chronic complications								
Mucostasis	-	5			1	7		
Granulation	3	15			1	7		
Tumor regrowth	-	-			-	-		
Migration	1	5			3	20		
Breakage	-	-			-	-		
AS reinsertion	1	5			3	20		
Follow-up duration after AS insertion (month)			3.5	1.4-5.5			18	9.5-26.5
Mortality ratios	15	79			9	61		

MTBEF: Malignant tracheobronchial esophageal fistula; MBPF: Malignant bronchopleural fistula; IQR: Interquartile range; NIMV: Non-invasive mechanical ventilation; AS: Airway stent.

option for patients with MTBF. In the present study, we evaluated the efficacy and safety of AS placement in 34 patients with MTBF treated in our interventional pulmonology unit over the past six years. The technical success rate was 100% and the clinical success rate 91%. There was no stent-related mortality. Our results suggest that AS insertion is a secure treatment option when managing MTBF.

Malignant tracheobronchial esophageal fistulas can develop secondary to tumoral invasion or after cancer treatment or pressure necrosis caused by a previously implanted stent.[1] These fistulas can be lethal, and many patients are not surgical candidates due to their poor general condition.[8] The AS insertion is an alternative to surgery and can sometimes afford better symptomatic relief. The MTBEF cases lacking airway obstruction receive esophageal stents. If such stents (not ASs) are placed in patients with airway obstructions, airway stenosis can worsen. In such cases, AS should be placed first.[12,13] A combination of an esophageal stent and an AS is more effective than either stent alone.[14,15] All of our MTBEF patients had esophageal or lung cancer. Most previously received chemotherapy and radiotherapy. Of 19 patients with MTBEF, seven were initially treated with ESs.

Furthermore, MTBEF are always poorly prognostic.[4,6,16] Most patients die within three to four months from frequent airway aspiration, malnutrition, or life-threatening hemoptysis.[4,6] Stenting enables such patients to breathe normally, facilitates oral nutrition, and improves quality of life and survival.[6,17,18] Freitag et al.[17] found that 30 patients with MTBEF survived for a mean of 110 days after esophageal stent and AS placement, but patients survived for a mean of only 24 days after AS placement alone. Herth et al.[18] found that MTBEF patients survived for a mean of seven months, and survival was longer in those with bilateral stents. The mean survival time of our patients was 3.5 months and was longer in patients with both esophageal stents and ASs (4.7 months) than patients with AS alone (two months), similar to the literature. In our study, the presence of an ES was found to be one of the factors that independently affected survival positively in the multivariate analysis of patients with MTBEF.

Malingnant bronchopleural fistulas can trigger significant morbidity and prolonged hospitalization.[5] The treatment of choice is surgical closure, but this is risky in patients who have poor general health or an infection. In such cases, various endoscopic options have been utilized.[9] In many studies, AS insertion was successful using SEMS or silicon stents, without major complications.[10,11,19] The success rate depends on the fistula diameter (optimal: <8 mm). Our patients had a mean fistula diameter of 6.9±2.2 mm. Most patients underwent chemotherapy and radiotherapy and were not indicated for surgery.

In the literature, MBPF-associated mortality rates range from 1 to 67%.[19-22] Several studies have been published investigating the effect of AS on survival in the treatment of BPF developing after lung cancer surgery.[10,11,19-21] Dutau et al.[19] treated large (>6 mm indiameter) fistulas that developed after pneumonectomy to treat lung cancer. In this study, SEMSs were placed in six patients who were not indicated for surgery, and all exhibited clinical improvement. The mortality rate was 57%. Another study compared surgical treatment and AS placement in fistulas >8 mm in diameter.[21] Although the early mortality rate was lower in the stented group, the two-year survival rates (76% *vs*. 70%, respectively) did not significantly differ. In our study, the six-month (83%) and one-year (66%) survival rates were similar to those reported in the literature.

Silicon stents and SEMSs have been widely used to treat MTBF.[6,10,11,17,18,19-21] However, ASs are foreign bodies that are prone to complications, despite their many benefits.[20] Hemorrhage and airway perforation are acute, but rare complications. Chronic complications include stenosis with granulation tissue formation, mucostasis, and stent migration/fracture.[22] We recorded no perioperative death and no severe acute complication. Minimal-to-moderate hemorrhage developed in two patients, but was easily controlled. Chronic complications were more common in patients with MTBF (33%) than MTBEF (21%). Additionally, migration was observed most frequently in patients with MBPF and granulation in patients with MTBEF. The higher complication rate in the former group of patients may reflect their longer follow-up period. The higher complication rates in patients with MBPF can be attributed to their longer follow-up period.

Silicon stents and SEMSs have unique advantages and disadvantages.[23] The first ones are easily repositioned or removed, minimally associated with granulation, and cost-effective. The latter ones are compatible with the airway anatomy, less prone to migration, and afford better mucociliary clearance.[23] Bronchoscopist experience, fistula location and size, and the bronchial anatomy influence the choice of (a silicone or metal) stent. Although modified silicon

stents are available, a SEMS may be preferred, if the fistula is difficult to close and the bronchial structure is complex. An SEMS expands spontaneously to conform to the bronchial structure. In our study, we placed silicon stents in 66% and SEMSs in 34% of patients. We found no significant differences in complications between the stents. We consider that the extensive experience of our interventional unit, and fistula location and type, encouraged the use of SSs. The lack of any difference between stent types in terms of the development of complications may reflect the low number of cases. The stent should be chosen on the basis of bronchoscopist experience, fistula location and size, and the airway anatomy.

Our study has certain limitations, principally the relatively small sample size and the retrospective nature. Also, this was an observational study and we lacked a control group that was not stented.

In conclusion, our experience indicates that airway stents are safe and palliative, and are useful alternatives, when surgery is impossible or prohibitively risky.

Ethics Committee Approval: The study protocol was approved by the Health Sciences University, Hamidiye Scientific Research Ethics Committee Institutional Review Board (IRB committee A; 19.8.2020. 27817). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

1. Reed MF, Mathisen DJ. Tracheoesophageal fistula. Chest Surg Clin N Am 2003;13:271-89.
2. Sirbu H, Busch T, Aleksic I, Schreiner W, Oster O, Dalichau H. Bronchopleural fistula in the surgery of non-small cell lung cancer: Incidence, risk factors, and management. Ann Thorac Cardiovasc Surg 2001;7:330-6.
3. Morgan RA, Ellul JP, Denton ER, Glynos M, Mason RC, Adam A. Malignant esophageal fistulas and perforations: Management with plastic-covered metallic endoprostheses. Radiology 1997;204:527-32.
4. Gudovsky LM, Koroleva NS, Biryukov YB, Chernousov AF, Perelman MI. Tracheoesophageal fistulas. Ann Thorac Surg 1993;55:868-75.
5. Cardillo G, Carbone L, Carleo F, Galluccio G, Di Martino M, Giunti R, et al. The rationale for treatment of postresectional bronchopleural fistula: Analysis of 52 patients. Ann Thorac Surg 2015;100:251-7.
6. Balazs A, Kupcsulik PK, Galambos Z. Esophagorespiratory fistulas of tumorous origin. Non-operative management of 264 cases in a 20-year period. Eur J Cardiothorac Surg 2008;34:1103-7.
7. Hu Y, Zhao YF, Chen LQ, Zhu ZJ, Liu LX, Wang Y, et al. Comparative study of different treatments for malignant tracheoesophageal/bronchoesophageal fistulae. Dis Esophagus 2009;22:526-31.
8. Burt M, Diehl W, Martini N, Bains MS, Ginsberg RJ, McCormack PM, et al. Malignant esophagorespiratory fistula: Management options and survival. Ann Thorac Surg 1991;52:1222-8.
9. Mehta RM, Singla A, Bhat RS, Godara R, Lokanath C, Cutaia M. An innovative solution for prolonged air leaks: The customized endobronchial silicone blocker. J Bronchology Interv Pulmonol 2018;25:111-7.
10. Andreetti C, D'Andrilli A, Ibrahim M, Ciccone AM, Maurizi G, Mattia A, et al. Effective treatment of post-pneumonectomy bronchopleural fistula by conical fully covered self-expandable stent. Interact Cardiovasc Thorac Surg 2012;14:420-3.
11. Cao M, Zhu Q, Wang W, Zhang TX, Jiang MZ, Zang Q. Clinical application of fully covered self-expandable metal stents in the treatment of bronchial fistula. Thorac Cardiovasc Surg 2016;64:533-9.
12. Simoff MJ, Lally B, Slade MG, Goldberg WG, Lee P, Michaud GC, et al. Symptom management in patients with lung cancer: Diagnosis and management of lung cancer, 3rd ed: American College of Chest Physicians evidence-based clinical practice guidelines. Chest 2013;143(5 Suppl):e455S-e497S.
13. Spaander MC, Baron TH, Siersema PD, Fuccio L, Schumacher B, Escorsell À, et al. Esophageal stenting for benign and malignant disease: European Society of Gastrointestinal Endoscopy (ESGE) Clinical Guideline. Endoscopy 2016;48:939-48.
14. Ke M, Wu X, Zeng J. The treatment strategy for tracheoesophageal fistula. J Thorac Dis 2015;7(Suppl 4):S389-97.
15. Freitag L, Tekolf E, Stamatis G, Greschuchna D. Clinical evaluation of a new bifurcated dynamic airway stent: A 5-year experience with 135 patients. Thorac Cardiovasc Surg 1997;45:6-12.
16. Wang H, Tao M, Zhang N, Li D, Zou H, Zhang J, et al. Airway covered metallic stent based on different fistula location and size in malignant tracheoesophageal fistula. Am J Med Sci 2015;350:364-8.
17. Freitag L, Tekolf E, Steveling H, Donovan TJ, Stamatis G. Management of malignant esophagotracheal fistulas with airway stenting and double stenting. Chest 1996;110:1155-60.

18. Herth FJ, Peter S, Baty F, Eberhardt R, Leuppi JD, Chhajed PN. Combined airway and oesophageal stenting in malignant airway-oesophageal fistulas: A prospective study. Eur Respir J 2010;36:1370-4.
19. Dutau H, Breen DP, Gomez C, Thomas PA, Vergnon JM. The integrated place of tracheobronchial stents in the multidisciplinary management of large post-pneumonectomy fistulas: Our experience using a novel customised conical self-expandable metallic stent. Eur J Cardiothorac Surg 2011;39:185-9.
20. Tayama K, Eriguchi N, Futamata Y, Harada H, Yoshida A, Matsunaga A, et al. Modified Dumon stent for the treatment of a bronchopleural fistula after pneumonectomy. Ann Thorac Surg 2003;75:290-2.
21. Ağababaoğlu İ, Ersöz H, Yıldız ÖÖ, Şimşek G, Sanioğlu SY, Karaoğlanoğlu N. A non-surgical option in large bronchopleural fistulas: Bronchoscopic conical stent application. Turk Gogus Kalp Dama 2020;28:480-7.
22. Folch E, Keyes C. Airway stents. Ann Cardiothorac Surg 2018;7:273-83.
23. Rodriguez AN, Diaz-Jimenez JP, Edell ES. Silicone stents versus metal stents for the management of benign tracheobronchial disease: Con: Metal stents. J Bronchol 2000;7:184-7.