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Removal of Retrievable Self-Expandable Metallic Tracheobronchial Stents: An 18-Year Experience in a Single Center

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Abstract

Purpose The purpose of the study was to retrospectively evaluate the technical outcomes of removal of retrievable self-expandable metallic stents (REMSs) and identify predictors of technical failure in 81 patients with benign and malignant tracheobronchial strictures.

Materials and Methods A total of 98 REMSs were removed under fluoroscopic guidance in 81 patients with benign ($n = 48$) or malignant ($n = 33$) tracheobronchial strictures. Primary and secondary technical success rates and complication rate were evaluated. Technical outcomes with regard to underlying diseases were also evaluated. Logistic regression models were constructed to identify predictors of primary technical success.

Results Primary and secondary technical success rates were 86.7 and 94.9 %, respectively. Stent removal-related complication rate was 7.1 % (7/98) and all were bleeding after stent removal. All bleeding complications were minor and managed conservatively. Primary technical success rate for benign strictures was significantly lower compared with that for malignant strictures (80.9 vs. 97.1 %, $P = 0.029$), but secondary technical success rate (93.7 vs. 97.1 %, $P = 0.652$) did not differ between the two groups. Granulation tissue formation was identified as an independent predictor of primary technical success (odds ratio 0.249, 95 % CI 0.071–0.874, $P = 0.030$).

Conclusion Removal of REMSs in patients with benign and malignant tracheobronchial strictures is safe and technically feasible. Bronchoscopic guidance may be required when the removal using a hook wire fails. The presence of granulation tissue was the negative predictor of primary technical success.

Keywords Tracheobronchial stricture · Tracheobronchial stent · Stent removal

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Introduction

Self-expandable metallic stents (SEMSs) are safe, easy, and effective for palliation of malignant tracheobronchial strictures. However, if the stent is no longer required or stent-related complications (i.e., stent migration and obstruction) occur, stent removal should be considered [1–6]. SEMSs can also be used to treat selected benign tracheobronchial strictures, but stent removal is mandatory to avoid stent-induced complications such as granulation tissue (GT) formation, mucus plugging, recurrent respiratory infection, stent migration, or stent fracture [7–10]. Hence, stent retrievability is extremely important in patients with both benign and malignant tracheobronchial strictures [1].

However, tumor ingrowth and tissue hyperplasia frequently occur after stent placement and make stent removal 'difficult,' especially if bare stents are used [11]. Thus, retrievable self-expandable metallic stents (REMSs) with nylon drawstrings attached to the proximal inner margin have been developed [1]. REMSs can be removed using a hook wire to capture the drawstrings of the stent [2, 12, 13].

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The main advantage of this technique is that it may minimize airway injuries because the proximal end of the stent is in a collapsed state and enters into a sheath while it is being removed. A previous study with this REMS has shown promising initial results in a small sample size [12]. However, studies with a larger sample size are required to evaluate comprehensive and detailed outcomes of stent removal using a retrieval hook wire under fluoroscopic guidance. Therefore, our purpose was to retrospectively evaluate the technical outcomes of the removal of REMSs and identify the predictors of technical failure in 81 patients with benign and malignant tracheobronchial strictures.

Materials and Methods

Patient Population

This retrospective study was approved by the institutional review board, and the requirement to obtain written informed consent was waived. Between November 1997 and November 2015, 274 consecutive patients with benign or malignant tracheobronchial strictures underwent placement of REMSs at our institution. A total of 98 REMSs were removed under fluoroscopic guidance in 81 patients with benign ($n = 48$) or malignant ($n = 33$) tracheobronchial strictures. The diagnoses of benign and malignant tracheobronchial strictures were established by bronchoscopic biopsy and/or chest computed tomography (CT). The characteristics of the patient population are summarized in Table 1.

Indications for Stent Removal

A total of 36 REMSs were electively removed in our study. Twenty-six REMSs were electively removed 52–212 days (median 150.5 days) after temporary stent placement in 17 patients with benign tracheobronchial strictures. In cases of benign etiology, stents were electively removed either 2 or 6 months after placement. We initially removed the stent 2 months after the placement; however, due to frequent restenosis, we later decided to remove stents 6 months after the placement [8]. Ten stents were also electively removed 7–164 days (median 70 days) in nine patients with malignant tracheobronchial strictures. The causes of elective removal in the patients with the malignant stricture were scheduled removal following radiation and/or chemotherapy after stent placement ($n = 5$), tracheostomy ($n = 4$), and tracheal resection ($n = 1$).

The remaining 62 REMSs were removed because of stent-related complications such as stent migration

Table 1 Characteristics of study population

Characteristics	No.
Total number of patients	81
Total number of procedures	98
Age (year)	47.9 ± 18.7
Sex	
Male	36 (44.4)
Female	45 (55.6)
Stricture length (mm)	35.0 ± 14.4
Stricture location	
Trachea	44 (54.3)
Left main bronchus	30 (37.0)
Right main bronchus	7 (8.6)
Underlying cause	
Benign	48 (59.3)
Tuberculosis	23 (28.4)
Postintubation	9 (11.1)
Posttracheostomy	7 (8.6)
Postoperative	6 (7.4)
Trauma	2 (2.5)
Radiation fibrosis	1 (1.2)
Malignant	33 (40.7)
Lung cancer	14 (17.3)
Thyroid cancer	8 (9.9)
Esophageal cancer	7 (8.6)
Tracheal cancer	3 (3.7)
Lymphoma	1 (1.2)

Data are summarized as mean ± standard deviation or as number of patients (percentile)

($n = 26$), GT formation ($n = 14$), mucus plugging ($n = 14$), stent fracture ($n = 3$), severe pain ($n = 2$), tumor overgrowth ($n = 1$), stent misplacement ($n = 1$), and patient's strong demand ($n = 1$). The indications for stent removal are summarized in Table 2.

Stent Design

Details of the REMS have been previously described in earlier studies [7, 12]. In brief, a REMS (Taewoong, Seoul, Korea) was woven from a single thread of nitinol wire 0.2 mm in diameter in a tubular configuration and was bonded to the external surface of polyurethane (Chronoflex; Cardiotech International, Woburn, MA), silicone (NuSil, Carpinteria, California), or polytetrafluoroethylene (AG Fluoropolymers, Wilmington, DE) covered membrane to prevent tissue hyperplasia. The tracheal stent was flared distally, 16 or 20 mm in diameter when fully expanded, and 40–90 mm long; the bronchial stent was flared

Table 2 Indications for airway stent removal

	Benign ($n = 63$)	Malignant ($n = 35$)	Total ($n = 98$)
Elective removal	26 (41.3)	10 (28.6)	36 (36.7)
Non-elective removal	37 (58.7)	25 (71.4)	62 (63.3)
Stent migration	18 (28.6)	8 (22.9)	26 (26.5)
GT formation	13 (20.6)	1 (2.9)	14 (14.3)
Mucus plugging	5 (7.9)	9 (25.7)	14 (14.3)
Stent fracture	0 (0.0)	3 (8.6)	3 (3.1)
Severe pain	0 (0.0)	2 (5.7)	2 (2.0)
Tumor overgrowth	0 (0.0)	1 (2.9)	1 (1.0)
Stent misplacement	1 (1.6)	0 (0.0)	1 (1.0)
Patient's strong demand	0 (0.0)	1 (2.9)	1 (1.0)

Data are summarized as number of procedures (percentile)

GT granulation tissue

proximally and distally, 10 or 12 mm in diameter, and 30–40 mm long. A stent at least 10 mm longer than the stricture was selected for placement so the both parts would rest on the upper and lower margins of the stricture, respectively. To make a stent removable, a 2-mm-diameter nylon loop was hooked inside of each bend of the proximal end of the stent and another two nylon threads were passed through each of the nylon loops to form a larger loop (drawstring) to fill the circumference of the inside of the proximal end of the stent.

Stent Retrieval Set and Removal Technique

The stent retrieval set consisted of a 13-Fr sheath, a 10-Fr dilator, and a 0.6-mm hook wire made of stainless steel (S&G Biotech Inc., Seongnam, Korea). The distal end of the hook wire was constructed in a question-mark configuration to hook the drawstring of the stent. The distal 20-mm portion of the hook wire was positioned at an approximate 30° angle to the axis (Fig. 1A). To make the stent removable, 2-mm-diameter nylon loops were hooked through each bend in the upper end of the stent and nylon threads were passed through each of the nylon loops to form larger loops (drawstrings) that filled the inner circumference of the proximal stent (Fig. 1B).

The stent removal techniques are described in detail elsewhere [1, 12]. In brief, topical anesthesia of the pharynx and larynx was routinely performed before the procedure with an aerosol spray of lidocaine hydrochloride (Dai Han, Seoul, Korea). Neither sedatives nor general anesthesia were used. Under bronchoscopic guidance, a 180-cm, 0.035-in. exchange guide wire (Radifocus M; Terumo, Tokyo, Japan) was inserted through the patient's mouth, then across the stent into the distal trachea or bronchus. The bronchoscope was removed while the guide wire was in place. A sheath with a dilator was passed down
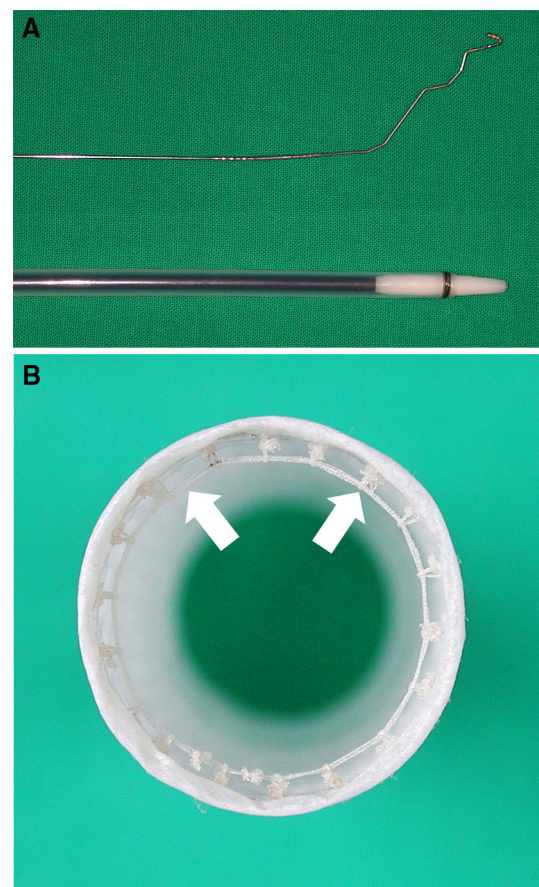
Fig. 1 A From *top* to *bottom*, a hook wire and a stent retrieval set consisting of a dilator and sheath. **B** Drawstrings (*arrows*) at the proximal end of the stent

over the guide wire into the proximal stent lumen. After the dilator was removed from the sheath, a hook wire was introduced into the sheath and advanced until the hook passed through the sheath into the stent lumen. Three

techniques were used for stent removal: standard, proximal mesh, and eversion technique. The standard technique was performed by pulling the hook out of the stent so that it grasped the drawstring, withdrawing the hook wire through the sheath to collapse the proximal stent when it reached the sheath tip, and pulling the sheath, hook wire, and stent out of the tracheobronchial tree (Fig. 2). If the drawstrings were invisible on bronchoscopy because of granulation tissue at the proximal portion of the stent, balloon dilation was performed before the removal procedure (Fig. 3). If the standard technique failed, the stent was removed by one of the two alternative techniques. For example, if the hook failed to grasp the drawstring but grasped the proximal mesh of the stent, the stent was removed by pulling it out in its expanded state (proximal mesh technique). If the hook failed to grasp the drawstring or proximal mesh of the stent, the distal mesh of the stent was grasped and the stent was pulled out (eversion technique). Bronchoscopy and plain radiography were performed to evaluate complications and patency immediately after stent removal.

Definition and Analysis of Data

Primary technical success was defined as successful stent removal using the standard technique. Secondary technical success was defined as successful stent removal using one of the following techniques: standard, proximal mesh, or eversion technique. Major bleeding was defined as bleeding that required treatment for cessation, and minor bleeding was defined as bleeding that ceased spontaneously without any treatment.

The Student's t test was used to compare continuous variables, and Fisher's exact test or a Chi-square test was used for categorical variables. To identify predictors of primary technical success, univariate and multivariate logistic regression models were constructed. Only variables with a P value of less than 0.10 on univariate analysis were entered into the multivariate logistic regression test. A P value of less than 0.05 was considered indicative of a statistically significant difference. All statistical analyses were performed using SPSS version 22 (IBM Corp, Armonk, NY).

Results

Technical Outcomes

Primary technical success rate was 86.7 % (85/98). Eight of 13 REMSs with primary technical failure were removed by proximal mesh technique ($n = 4$) or eversion technique ($n = 4$). Consequently, secondary technical success rate was 94.9 % (93/98). In three of five patients with technical failure, GT narrowed the space resulting in the manipulation of the hook wire and capturing of the drawstring impossible. In the remaining two patients, the drawstrings became untied during

Fig. 2 Schematic representation of the technical steps in the standard technique for stent removal. **A** After stent placement. **B** Insertion of a guide wire through the stent into the left bronchus. **C** Insertion of a sheath and a dilator over the guide wire into the stent lumen. **D** Insertion of a hook wire after removal of the dilator from the sheath. **E** Grasping of the drawstrings with the hook wire. **F** Withdrawal of the hook wire through the sheath to collapse the proximal stent when it reaches the sheath tip, and pulling the sheath, hook wire, and stent out of the tracheobronchial tree
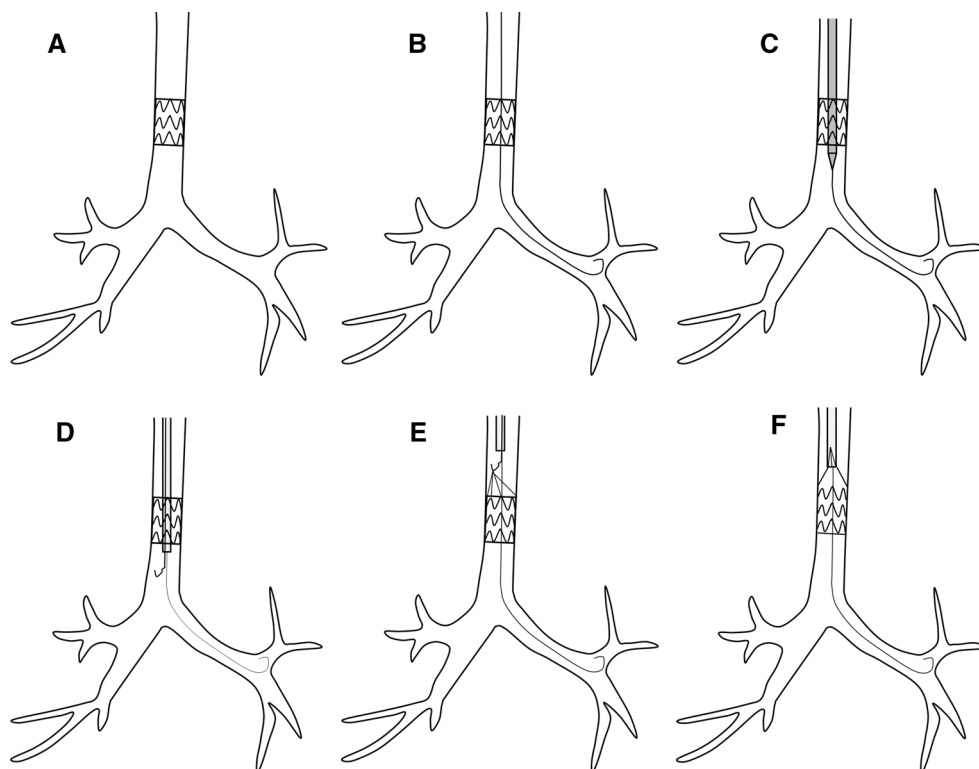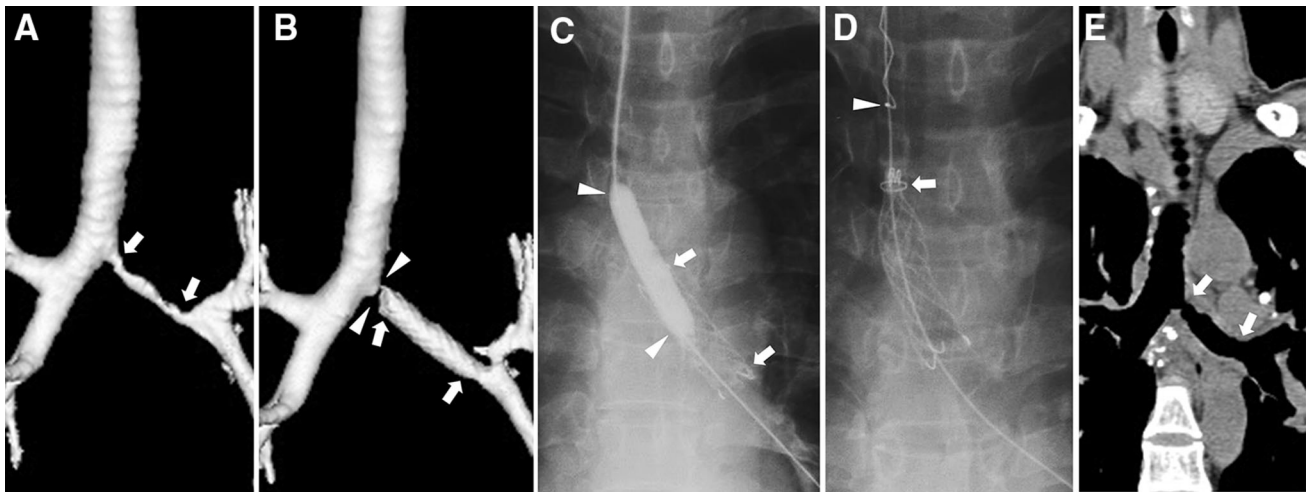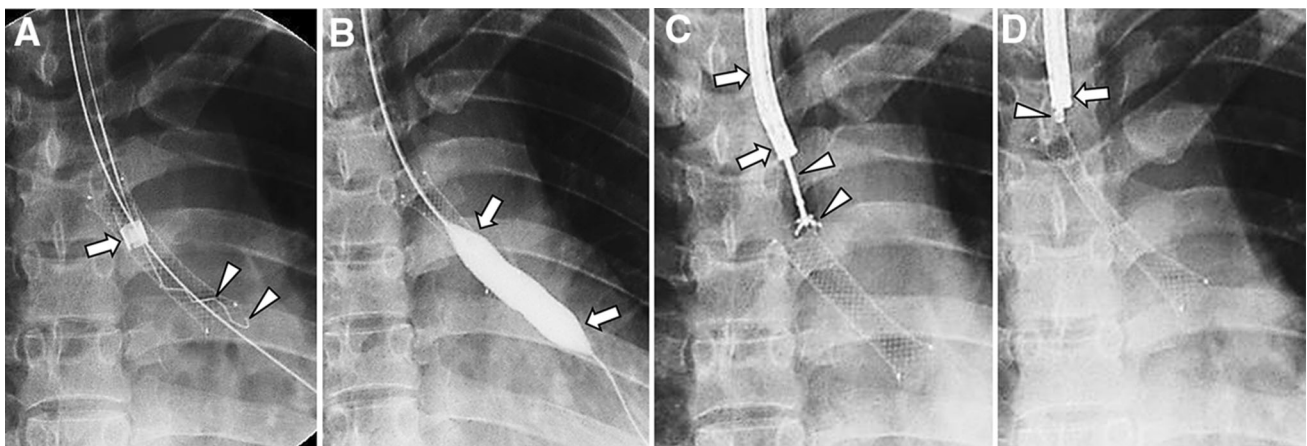
Fig. 3 A 26-year-old man who underwent bronchial stent placement for a tuberculous stricture. **A** Three-dimensional (3D) surface-rendered reconstructed CT image obtained 6 days before stent placement shows a severe left main bronchial stricture (*arrows*). **B** 3D reconstructed CT image obtained 68 days after stent placement shows a severe focal stricture (*arrowheads*) at the proximal end of the stent (*arrows*). **C** Balloon dilation (*arrowheads*) was performed in the narrowed distal portion of the stent (*arrows*). **D** Proximal end of the stent collapses while hook wire (*arrowhead*) was introduced through the sheath (*arrow*) next to the initial wire. The stent was then pulled out of trachea. **E** Reconstructed CT image 1 month after stent removal shows improvement of the stricture (*arrows*)

Fig. 4 A 27-year-old woman who underwent bronchial stent placement for a tuberculous stricture. The stent removal failed using standard and modified techniques because the untied drawstring and granulation tissue formation at the distal potion of the stent. **A** Radiograph obtained during stent removal using an eversion technique showing a sheath (*arrow*) with a hook wire (*arrowheads*) over a guide wire into the stent lumen. **B** Balloon dilation (*arrows*) was performed in the narrowed distal portion of the stent. **C**, **D** Stent removal was performed by grasping the metallic loops of the proximal edge of the stent with use of a bronchoscope (*arrows*) and a rigid alligator forceps (*arrowheads*)

the initial attempt of the removal. In these five patients with failure of fluoroscopic removal, the REMSs were successfully removed using forceps under bronchoscopic and fluoroscopic guidance (Fig. 4). GT was observed in 28.6 % (28/98). Stent indwelling time was significantly longer in cases with GT that that without GT (95 vs. 70 days, $P = 0.050$). When comparing benign and malignant group, secondary technical success rate was not significantly different (93.7 vs. 97.1 %, $P = 0.652$), but primary technical success rate was significantly lower in benign group (81.0 vs. 97.1 %, $P = 0.029$)

(Table 3). The information regarding underlying diseases is summarized in Table 4.

Complications

Bleeding immediately developed in 7.1 % (7/98) after the removal. All cases of bleeding were minor and managed conservatively with ($n = 4$) or without ($n = 3$) bronchoscopic epinephrine injection therapy. Five cases of bleeding occurred after the removal using standard technique,

Table 3 Comparisons between benign and malignant condition

	Benign	Malignant	P value
Total number of patients	48	33	
Total number of procedures	63	35	
Age (year)	40.8 ± 18.6	58.2 ± 13.7	<0.001
Sex			0.002
Male	14 (29.2)	21 (63.6)	
Female	34 (70.8)	12 (36.4)	
Stricture length (mm)	28.8 ± 9.6	44.7 ± 14.5	<0.001
Stricture location			0.015
Trachea	26 (41.3)	25 (71.4)	
Left main bronchus	30 (47.6)	8 (22.9)	
Right main bronchus	7 (11.1)	2 (5.7)	
Indications of removal			0.207
Elective	26 (41.3)	10 (28.6)	
Non-elective	37 (58.7)	25 (71.4)	
Stent dwell time (week)	11.9 ± 9.1	6.9 ± 6.6	0.002
GT formation			0.015
Present	23 (36.5)	5 (14.3)	
Absent	40 (63.5)	30 (85.7)	
Secondary technical success	59 (93.7)	34 (97.1)	0.652
Primary technical success	51 (81.0)	34 (97.1)	0.029
Removal technique			N/A
Standard	51 (81.0)	34 (97.1)	
Proximal mesh	4 (6.3)	0 (0.0)	
Eversion	4 (6.3)	0 (0.0)	
Bronchoscopic removal	4 (6.3)	1 (2.9)	
Complications[a]	3 (4.8)	4 (11.4)	0.244

Data are summarized as mean ± standard deviation or as number of patients (percentile) for age and sex, and as number of procedures (percentile) for others

GT granulation tissue, *N/A* not applicable

[a] All complications were minor bleeding and managed conservatively

and two cases of bleeding occurred after the removal using eversion technique. There was no significant difference of complication rates between benign ($n = 3$) and malignant ($n = 4$) group (4.8 vs. 11.4 %, $P = 0.244$) (Table 5).

Predictors of Primary Technical Success

In the univariate analyses, age, benign condition, stricture length, and GT showed P values of <0.1. Of note, a majority of cases with primary technical failure were benign strictures (12/13, 92.3 %), and benign strictures were significantly shorter than malignant strictures (28.8 ± 9.6 vs. 44.7 ± 14.5 mm, $P < 0.001$). Thus, stricture length was considered to be statistically insignificant. Therefore, those factors except stricture length entered into the multivariate model. The multivariate model identified

the presence of GT as the independent predictor of primary technical success (odds ratio 0.249, 95 % CI 0.071–0.874, $P = 0.030$). Benign condition demonstrated the trend, but did not reach statistical significance (odds ratio 0.169, 95 % CI 0.020–1.413, $P = 0.101$) (Table 6).

Interestingly, the presence of GT was significantly associated with removal techniques; in the cases without GT, standard, proximal mesh, and eversion technique were performed in 95.6 % (65/68), 4.4 % (3/78), and 0 %, respectively. On the contrary, in the cases with GT, those were performed in 80.0 % (20/25), 4.0 % (1/25), and 16.0 % (4/25), respectively; in other words, when a granulation tissue was present, eversion technique was more frequently used (16.0 vs. 1.3 %). However, calculation of P value was impossible due to small sample size in each category.

Discussion

Our present study provides evidence that the removal of a REMS using a retrieval hook wire under fluoroscopic guidance is technically feasible and safe. The secondary technical success rate was 94.9 % (93/98), and the primary technical success rate was 86.7 % (85/98). The stent removal-related complication rate was 7.1 % (7/98). Although primary technical success rate was lower in the benign group (81.0 vs. 97.1 %, $P = 0.029$), secondary technical success and complication rate were comparable to the malignant group. The regression analysis showed that the presence of GT was the only independent predictor of primary technical success (odds ratio 0.249, 95 % CI 0.071–0.874, $P = 0.030$). When GT was present, eversion technique was more frequently used (16.0 vs. 1.3 %), but without statistical significance.

Stent removal with use of a REMS and hook wire device has been used previously for urethral, upper or lower gastrointestinal, and airway strictures [12, 14–18]. Our study showed that the removal of a REMS with use of a hook wire is safe and technically feasible. Theoretically, standard removal technique can minimize airway injuries because the removed stent is collapsed and enters into a sheath, thereby reducing a chance of mucosal tear from the mesh of the stent. According to the studies on bronchoscopic removal of covered airway stents [3, 19, 20], airway injuries (mucosal tear, bleeding) were observed in 5.6–16.7 % of procedures, and stent fracture during the removal occurred in 5.6–8.3 %, which are comparable to our results. Yoon et al. [15] reported technical outcomes of the removal of a REMS using a hook wire for esophageal and gastrointestinal strictures in 113 patients, and the results were promising; technical success rate was 97.7 %, and the complication rate was 6.3 %. Considering our

Table 4 Technical outcomes of stent removal regarding underlying diseases

Underlying diseases	Location (T:LMB:RMB)	Stricture length (mean, mm)	STS	PTS	Complication	GT formation
Benign (n = 63)	26:30:7	28.7	59 (93.7)	51 (81.0)	3 (4.8)	23 (36.5)
Tuberculosis (n = 32)	5:24:3	30.1	30 (93.8)	26 (81.2)	2 (6.2)	18 (56.2)
Postintubation(n = 12)	12:0:0	30.6	10 (83.3)	10 (83.3)	0 (0.0)	2 (16.7)
Posttracheostomy (n = 7)	7:0:0	30.0	7 (100)	5 (71.4)	1 (14.3)	1 (14.3)
Postoperative (n = 8)	2:2:4	25.0	8 (100)	7 (87.5)	0 (0.0)	0 (0.0)
Trauma (n = 3)	0:3:0	16.7	3 (100)	2 (66.7)	0 (0.0)	2 (66.7)
Radiation fibrosis (n = 1)	0:1:0	30.0	1 (100)	1 (100)	0 (0.0)	0 (0.0)
Malignant (n = 35)	25:8:2	44.1	34 (97.1)	34 (97.1)	4 (11.4)	5 (14.3)
Lung (n = 15)	9:4:2	46.3	15 (100)	15 (100)	1 (6.7)	1 (6.7)
Thyroid (n = 8)	8:0:0	46.3	7 (87.5)	7 (87.5)	0 (0.0)	0 (0.0)
Esophagus (n = 7)	3:4:0	38.6	7 (100)	7 (100)	0 (0.0)	2 (28.6)
Trachea (n = 3)	3:0:0	43.3	3 (100)	3 (100)	2 (66.7)	1 (33.3)
Lymphoma (n = 2)	2:0:0	50.0	2 (100)	2 (100)	1 (50.0)	1 (50.0)

T trachea, *LMB* left main bronchus, *RMB* right main bronchus, *STS* secondary technical success, *PTS* primary technical success, *GT* granulation tissue

Table 5 Detailed information of complicated cases

No./age/sex	Underlying disease	Indications of removal	Location	Technique	Stent dwell time (day)	GT	Complication	Treatment	Outcomes
1/62/F	Tuberculosis	Stent migration	RMB	Standard	3	N	Minor bleeding	Observation	Recovered
2/36/F	Tuberculosis	GT formation	LMB	Eversion	49	Y	Minor bleeding	Observation	Recovered
3/41/M	Posttracheostomy	GT formation	Trachea	Eversion	56	Y	Minor bleeding	Observation	Recovered
4/53/M	Tracheal cancer	Elective removal	Trachea	Standard	66	Y	Minor bleeding	EPI injection	Recovered
5/68/M	Lung cancer	Severe pain	LMB	Standard	7	N	Minor bleeding	EPI injection	Recovered
6/52/F	Tracheal cancer	GT formation	Trachea	Standard	52	Y	Minor bleeding	EPI injection	Recovered
7/18/F	Lymphoma	Mucus plugging	Trachea	Standard	24	N	Minor bleeding	EPI injection	Recovered

GT granulation tissue, *LMB* left main bronchus, *RMB* right main bronchus, *EPI* epinephrine

results and aforementioned reports, removal of a REMS with use of a hook wire in patients with benign and malignant tracheobronchial strictures is safe and technically feasible.

Stent placement for the treatment of benign airway strictures has been limited due to numerous stent-related complications and high failure rates of the removal [20–22]. However, in our series, REMSs placed in benign strictures could be successfully removed in 93.7 % with the removal-related complication rate of only 4.8 %, which were comparable to the results in malignant strictures. Furthermore, all observed complications were considered minor, thereby requiring no additional treatment. This result can support extended use of a REMS for benign tracheobronchial strictures.

In our present cohort, GT was the independent predictor of primary technical success (odds ratio 0.249, 95 % CI 0.071–0.874, P = 0.030). Eversion technique was more frequently used when GT existed (16.0 vs. 1.3 %). This can be explained by the fact that an everted stent with reduced diameter can easily pass through the obstructive GT. On the other hand, when performing standard technique, it was difficult to capture the drawstrings because the obstructive GT not only narrowed the space to manipulate the hook wire, but also incorporated the drawstrings. Several case reports showed safety and effectiveness of eversion technique for the removal of esophageal stents with GTs [23–25]. Although two cases of minor bleeding occurred by eversion technique, those were spontaneously ceased without any treatment. Thus, if GT is present and standard technique fails, eversion technique can be considered as the alternative. However, further studies are required to confirm this.

The principal limitation of our study was its nonrandomized and retrospective design, both of which inherently decreased the statistical power. Our single-center

Table 6 Univariate and multivariate analyses to identify predictors of primary technical success

Variables	Success (n = 85)	Failure (n = 13)	Univariate analysis, P value	Multivariate analysis		
				OR	95 % CI	P value
Age (year)	48.0 ± 18.4	35.2 ± 17.1	0.020	1.009	0.967–1.053	0.673
Sex			0.149			
Male	37 (43.5)	3 (23.1)				
Female	48 (56.5)	10 (76.9)				
Underlying cause			0.029			0.101
Benign	51 (60.0)	12 (92.3)		0.169	0.020–1.413	
Malignant	34 (40.0)	1 (7.7)		RD	RD	
Stricture length (mm)[a]	36.1 ± 13.5	24.2 ± 10.5	0.004			
Stricture location			0.250			
Trachea	44 (51.8)	7 (53.8)				
Left main bronchus	32 (37.6)	6 (46.2)				
Right main bronchus	9 (10.6)	0 (0.0)				
Stent dwell time (week)	9.6 ± 8.5	13.1 ± 9.1	0.180			
GT formation			0.008			0.030
Present	20 (23.5)	5 (38.5)		0.249	0.071–0.874	
Absent	65 (76.5)	8 (61.5)		RD	RD	

Data are summarized as mean ± standard deviation or as number of procedures (percentile)

OR odds ratio, *CI* confidence interval, *RD* reference data, *GT* granulation tissue

[a] Although stricture length showed statistical significance in the univariate analysis, this seems to be due to the difference of stricture length between benign and malignant strictures

experience may also suffer from referral bias because of the heterogeneity of the obstructing etiology, which had markedly diverse response to oncologic treatment. In addition, because this was a single-center study, all procedures were performed by clinically experienced interventional radiologists, and a specially designed retrievable stent and retrieval set were used. Because these results may not apply to clinical practices, they need to be verified in other larger multicenter studies. Moreover, this technique is useful only for the removal of REMSs, not for the other commercially available stents.

In conclusion, removal of REMSs with a hook wire in patients with tracheobronchial strictures is safe and technically feasible. Bronchoscopic guidance may be required when the removal using a hook wire fails. Although stent removal in benign strictures showed lower primary technical success rate, secondary technical success rate and complication rate were comparable to the removal in malignant strictures. The presence of GT was the negative predictor of primary technical success.

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