Original Article

Airway stent intervention in a high-volume center: safe procedures and educational perspectives

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Background: Airway intervention, including stenting, can rapidly improve a patient's respiratory condition, but the procedure requires highly specialized techniques and expertise. Therefore, educating young endoscopists and passing on the techniques are major issues. However, the best way to educate new doctors on these techniques remains unclear. This study analyzed our educational system for airway intervention and its outcomes.

Methods: Patients who underwent airway intervention regarding airway stents under general anesthesia in our department between January 2010 and September 2023 were included. The outcomes of interventions related to airway stents in our hospital were evaluated retrospectively, including from an educational perspective.

Results: A total of 96 patients (76 undergoing stenting for airway stenosis, 8 stenting for airway-esophageal fistula, and 12 stent removal) were analyzed. The median experience level of the main physician was 5 (range, 1–17) years, and that of the supervising physician was 18 (range, 5–23) years. The median number of physicians who participated in the interventions was four. A rigid bronchoscope was used in 86.5% of cases. The procedure success rate was 95.8%. Intraoperative complications occurred in 8.3% and postoperative complications in 10.5% of cases, and there was 1 procedure-related death (1.3%). In the analysis of factors related to the development of complications, the years of experience of the main physician had no influence.

Conclusions: These findings indicate that our method of airway intervention is safe. Young endoscopists were able to master the technique by gaining experience under the supervision of experts.

Keywords: Airway stenosis; tracheoesophageal fistula; stent; intervention; education

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Introduction

Central airway stenosis due to benign or malignant diseases and airway-esophageal fistula can cause severe dyspnea and significantly worsen the quality of life (QOL) and activities of daily living (ADL) of patients (1,2). Most of these patients are not indicated for definitive surgery, and chemotherapy or radiotherapy are selected for them. However, these therapies have no immediate effect on respiratory distress (3,4). Nevertheless, it is very important to palliate patients' symptoms even in the terminal stages of malignancy (5-7).

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The most immediate and effective treatment for airway stenosis and airway-esophageal fistula is airway intervention, including airway stenting (8-10). However, while there are already many reports on the effectiveness of airway stenting (1,2,11,12), performing airway stenting requires highly specialized techniques and expertise (13,14). Unfortunately, the number of facilities where airway interventions can be performed is limited, and there are few opportunities for beginners to gain sufficient experience (9,10). We consider educating future generations and passing on these skills to be very important factors for continuing airway interventions. Our institution is a high-volume center for airway interventions in Japan and has performed such procedures many times since they were first introduced in 1987.

We herein report our experience with airway stenting, discuss whether or not it is appropriate to educate younger endoscopists on this technique, and evaluate the risk factors for complications with the procedure. We present this article in accordance with the STARD reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-89/rc).

Methods

Patients

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This retrospective analysis was approved by the Institutional Review Board of Seirei Mikatahara General Hospital (approval No. 23-15, 2023). The requirement for informed consent from each patient was waived due to the retrospective nature of the study, with patient information obtained from a database. The study consort diagram is shown in *Figure 1*. Of the 143 patients who received airway intervention under general anesthesia from January 2010 to September 2023 in our department, 96 were included in the study after excluding the 47 whose course did not involve airway stents.

Highlight box

Key findings

- Young endoscopists were able to master the interventional technique by gaining experience under the supervision of experts.

What is known and what is new?

- Airway intervention requires highly specialized techniques and expertise.
- Even young endoscopists were able to perform airway interventions safely with the supervision of experts.

What is the implication, and what should change now?

- Our methods should be used to pass on airway intervention techniques to the younger generation.

Preoperative planning

Preoperative thin-slice computed tomography (CT) is used to fully evaluate the location of the stenosis or fistula, the condition of the entire airway, and the extent of the lesion in order to select the stent diameter and type. A three-dimensional tracheobronchial image is also generated from the CT image. Additional preoperative bronchoscopy is performed if a more accurate assessment of the airway lumen is required. This preoperative information is used to determine the type of stent to be used. The Dumon Y-stent (Novatech, La Ciotat, France) is our first choice for intervention around the tracheal bifurcation and is always available for lumen diameters of 14, 15, and 16 mm. In addition, we are prepared to use a metallic stent (Ultraflex®; Boston Scientific, Marlborough, MA, USA) or a hybrid stent (AERO®; Merit Medical Endotek, South Jordan, UT, USA) if the Dumon stent cannot be delivered. In principle, we do not use percutaneous cardiopulmonary support, such as extracorporeal membrane oxygenation (ECMO). The use of ECMO is considered in the following cases: patients cannot maintain the supine position due to dyspnea, patients have severe stenosis from the tracheal bifurcation to the bilateral main bronchus, patients have complete atelectasis in one lung, patients are already intubated and their airway becomes obstructed when the endotracheal tube is removed, patients are scheduled for effective treatment of their primary disease and absolutely need stenting.

Airway intervention method

After induction of general anesthesia, the airway is basically secured with a laryngeal mask. The airway is observed with a flexible bronchoscope. If a metallic or hybrid stent is used, stenting is performed with a flexible bronchoscope and roentgen fluoroscopy. If a Dumon stent is used, or if a metallic stent is used in combination with resection or cauterization of tumors in the airway, the laryngeal mask is removed, and a rigid bronchoscope is inserted to secure the airway. After insertion of the rigid bronchoscope, multiple sheets of gauze should be packed in the oral cavity to prevent air leakage. Tumors in the airway are cauterized

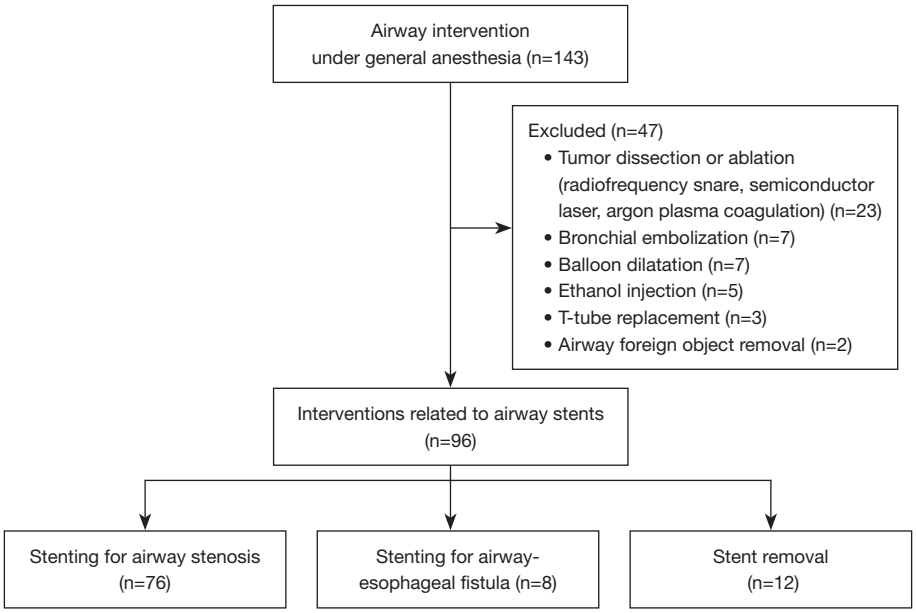
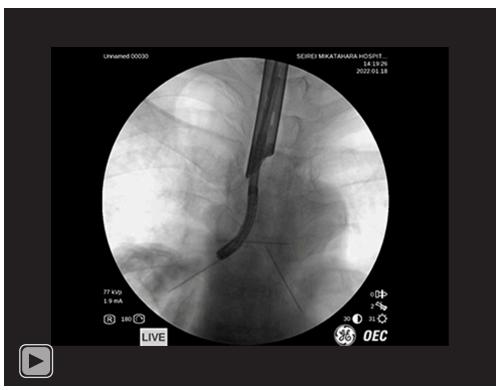


Figure 1 The study consort diagram.



Video 1 The video shows the "pull-back method" in the basic case of airway stenosis.

with a high-frequency snare or semiconductor laser to make stenting easier. The exhaled oxygen level should be kept below 40% before cauterization to prevent ignition. When using a Dumon Y-stent, the stent is released into the left main bronchus and pulled proximally with the forceps so that the right side of the stent opens into the right main bronchus (called the "pull-back method", *Video 1*). If the right main bronchus is severely stenosed, the lumen of the right main bronchus is pre-dilated, after which the Y-stent is released into the right main bronchus and pulled back to extend the stent leg into the left main bronchus. In this study, success was defined as placement of the stent in the diseased area of the airway as planned.

Main physician and supervisor

Before a novice endoscopist becomes a main physician for stent intervention, he or she must have experienced at least ten airway stenting procedures as an assistant and understand the stenting procedure. In addition, one to three supervising endoscopists with at least five years of rigid bronchoscopic stenting experience always participate in airway interventions. The supervisor checks the interventional technique of the operator, and if the operator fails to achieve stenting two to three times, the supervisor takes over the procedure.

Perioperative complication factors of stenting for airway stenosis

The age, performance status (PS), hemoglobin, serum albumin level, C-reactive protein, presence of symptoms before stenting, type of stenosis (intrinsic or extrinsic compression), stenosis diameter, site of stenosis (tracheal bifurcation or not), years of experience of the main physician in airway intervention, number of participants involved in the intervention, intraoperative stenting redo, and operation time were analyzed as the factors that may be involved in the development of perioperative complications.

In this study, postoperative complications were defined as complications that occurred within 30 days after stenting.

Statistical analyses

The patients with airway stenosis were divided into the two groups according to the presence or absence of complications, and univariate and multivariate analyses were performed for the above factors. A logistic regression analysis was used for the multivariate analysis. P values of <0.05 were considered statistically significant.

All statistical analyses were performed using the StatView software program (SAS Institute Inc., Cary, NC, USA).

Results

Patient characteristics

The characteristics of the 96 patients are shown in *Table 1* and *Table 2*. There were 75 male patients (78.1%), and the median age was 68 (range, 20–98) years old. The PS was ≥2 in 20 (20.8%) patients, 3 of whom were intubated and on ventilators due to severe airway stenosis. In cases of airway stenosis, the most common cause was primary lung cancer (n=46, 60.5%). Of the cases of lymph node metastasis from other carcinoma, testicular tumor and breast cancer were found in one patient each. Of the cases of tracheobronchial tumor, tracheal squamous cell carcinoma was found

Table 1 Characteristics of patients with airway stenosis and airway-esophageal fistula

Characteristic	Stenting for airway stenosis	Stenting for airway-esophageal fistula
Number	76	8
Sex		
Male	58 (76.3)	8 (100.0)
Female	18 (23.7)	0
Age (years)	70 [20–98]	63 [54–74]
Performance status		
0	33 (43.4)	1 (12.5)
1	23 (30.3)	5 (62.5)
2	11 (14.5)	0
3	3 (3.9)	2 (25.0)
4	4 (5.3)	0
Unknown	2 (2.6)	0
Causative diseases		
Lung cancer	46 (60.5)	1 (12.5)
Esophageal cancer	10 (13.2)	7 (87.5)
Thyroid cancer	2 (2.6)	0
Lymph node metastasis of other carcinomas	2 (2.6)	0
Tracheobronchial tumor	5 (6.6)	0
Mediastinum tumor	7 (9.2)	0
Idiopathic tracheomalacia	2 (2.6)	0
Burn-induced airway constriction	2 (2.6)	0
Types of airway stenosis		
Direct invasion	36 (47.4)	
Compressive stenosis	30 (39.5)	
Tracheobronchial tumor	5 (6.6)	
Tracheomalacia	2 (2.6)	
Scarring central airway stenosis	2 (2.6)	
Anastomotic stenosis	1 (1.3)	
Main lesion		
Trachea	33 (43.4)	3 (37.5)
Tracheal bifurcation	14 (18.4)	0
Right main bronchus	17 (22.4)	0
Left main bronchus	12 (15.8)	5 (62.5)
Shortest diameter of stenosis (mm)		
Total	4.3 [0–16]	
Trachea	5.3 [2–16]	
Tracheal bifurcation	3.0 [1–14]	
Right main bronchus	2.5 [0–7.5]	
Left main bronchus	0.5 [0–7.5]	
Symptoms before stenting		
Yes	59 (77.6)	6 (75.0)
Dyspnea	42	4
Wheezing	5	0
Cough	6	2
Disorder to expectorating	3	0
Bloody sputum	3	0
No	17 (22.4)	2 (25.0)
Preoperative examination		
Hemoglobin (g/dL)	11.6 [7.8–15.8]	9.6 [7.3–11.9]
Albumin (g/dL)	3.5 [2.0–4.5]	2.7 [2.4–3.4]
C-reactive protein (mg/dL)	1.9 [0–18.1]	7.0 [1.8–13.7]

Data are presented as n or n (%) or median [range].

Table 2 Characteristics of patients undergoing stent removal

Characteristic	Stent removal (n=12)
Sex, n	
Male	9
Female	3
Age (years), median [range]	60 [45–79]
Performance status, n	
0	7
1	5
Diseases causing airway stenosis before stenting, n (%)	
Lung cancer	8 (66.7)
Esophageal cancer	1 (8.3)
Tracheal tumor[†]	1 (8.3)
Malignant mediastinal tumor	1 (8.3)
Tracheomalacia	1 (8.3)
Reasons of removal, n (%)	
Patient preference	4 (33.3)
Stent migration	4 (33.3)
Tumor progression	2 (16.7)
Granulation	1 (8.3)
Atelectasis	1 (8.3)

[†], adenoid cystic carcinoma.

in two patients, adenoid cystic carcinoma in one, and airway metastasis from lung cancer in two. Of the cases of mediastinum tumor, malignant epithelial mediastinal tumor was found in four patients, malignant lymphoma in two, and thymic carcinoma in one. Regarding the type of stenosis in airway stenosis, 46 patients (60.5%) had intrinsic stenosis and 30 patients (39.5%) had extrinsic stenosis. Among the patients with intrinsic stenosis, 15 had combined stenosis.

The most common site of stenosis was the trachea (n=33, 43.4%), and 59 patients (77.6%) had symptoms associated with airway stenosis before intervention. In airway-esophageal fistula, the most common cause was esophageal cancer (n=7, 87.5%). Fistulas were most common in the left main bronchus (n=5, 62.5%), and 6 (75.0%) patients were symptomatic before intervention. In patients who underwent stent removal, all were stented for airway stenosis. The most common reasons for stent removal were patient preference (n=4, 33.3%) and stent migration (n=4, 33.3%). Only one patient with airway stenosis due to malignant lymphoma was on standby ECMO before intervention; however, it was not used as the result.

Procedures

The details of the airway interventional procedures are shown in *Table 3*. The median experience level of the main physician was 5 (range, 1–17) years, and that of the supervising physician was 18 (range, 5–23) years. In 44 patients (45.8%), the main physician was an endoscopist with 4 years or less of experience.

The median number of physicians who participated in interventions was 4 (range, 2–7). In airway stenosis, 31 patients (40.8%) underwent tumor resection with a high-frequency snare or semiconductor laser, and 7 patients (9.2%) underwent ballooning before stenting. In stent removal, 5 patients (41.7%) underwent stenting with a new stent intraoperatively after removal of the old stent. All were scheduled preoperatively and not emergency procedures.

A rigid bronchoscope was used in 83 (86.5%) cases. In two cases of airway stenosis, the rigid bronchoscope could not be inserted: in one because of cervical retroflexion due to the massive thyroid cancer with deformity and edema throughout the neck, and in the other because of malignant mediastinal tumor surrounding the trachea, which prevented the bronchoscope from passing the tracheal stenosis lesion. Intraoperative stenting errors occurred in 21 cases (27.6%) of airway stenosis and 1 case (12.5%) of fistula. In these patients, a simple redo of the stenting procedure or changing the stent from a wide one to a narrow one allowed eventual stent placement. The success rate of the procedure was 95.8%. Failure of the procedure occurred in 4 cases (5.3%) of airway stenosis: 1 with tracheobronchial injury, 1 with failure of rigid bronchoscope insertion, and 2 with strategic withdrawal due to their poor prognosis.

Complications and clinical outcomes

Perioperative complications and outcomes are shown in *Table 4*. Intraoperative complications occurred in 8 patients (8.3%). In airway stenosis, there were four patients with intraoperative ventilatory failure (due to blood clots in two, airway edema in one, and tumor obstruction in the stent in one) and one each with tracheal injury, laryngeal edema, and tooth defect. In cases of stent removal, there was one patient with ventilatory failure due to procedure-related blood clots after removal, which was managed

Table 3 Procedures

Factors	Stenting for airway stenosis (n=76)	Stenting for airway-esophageal fistula (n=8)	Stent removal (n=12)
Main physician's experience, years	5 [1–17]	4 [1–16]	15 [2–17]
Supervising physician's experience, years	18 [5–23]	19.5 [11–23]	18.5 [13–23]
Number of physicians participating in stenting	4 [2–7]	4.5 [3–6]	4.5 [2–6]
Procedures stenting			
Stenting only	38 (50.0)	7 (87.5)	
Stenting with tumor resection	31 (40.8)	1 (12.5)	
Stenting with ballooning	7 (9.2)	0	
Procedures removal			
Stent removal only			7 (58.3)
Stent removal and exchange			5 (41.7)
Use of rigid bronchoscopy			
Yes	66 (86.8)	5 (62.5)	12 (100.0)
No	8 (10.5)	3 (37.5)	0
Failed to insert rigid bronchoscopy	2 (2.6)	0	0
Type of stent (inserted or removal)[†]			
Dumon-Y	44	4	7
Dumon-I	12	1	2
Metallic stent	16	0	2
Hybrid stent	0	3	1
Stenting error (intraoperative)	21 (27.6)	1 (12.5)	
Once	15	1	
Twice	6	0	
Three times	1	0	
Success of procedure	72 (94.7)	8 (100.0)	12 (100.0)
Operation time, min	86.5 [22–325]	66.5 [30–89]	59 [15–270]

Data are presented as n, median [range] or n (%). [†], four patients with failure of procedure in airway stenosis were excluded.

by suctioning the blood clots and tumor fragments. Postoperative complications occurred in 8 patients (10.5%) and these were found only in stenting for airway stenosis; respiratory failure in 2, pneumonia in 2, atelectasis in 2, stent migration in 1, and pneumomediastinum in 1. There was 1 (1.3%) procedure-related death. The patient was a 64-year-old woman scheduled to undergo Dumon Y-stent insertion for airway stenosis due to multiple mediastinal lymph node metastases from breast cancer. Her stenting was cancelled due to a large tracheal injury that occurred when the stent was inserted into the tracheal lumen. She was unable to be weaned from the ventilator because the injured membranous trachea failed to heal and died 92 days postoperatively.

Factors associated with complications

The analyses of intra- and postoperative complications are shown in *Table 5* and *Table 6*, respectively. In both situations, there were no significant risk factors associated with the development of complications according to either univariate or multivariate analyses, including the main physician's level

Table 4 Complications and clinical outcomes

Factors	Stenting for airway stenosis (n=76)	Stenting for airway-esophageal fistula (n=8)	Stent removal (n=12)
Intraoperative complications, n (%)			
Yes	7 (9.2)	0	1 (8.3)
No	69 (90.8)	8 (100.0)	11 (91.7)
Postoperative complications, n (%)			
Yes	8 (10.5)	0	0
No	68 (89.5)	8 (100.0)	12 (100.0)
Improvement of symptoms[†], n (%)			
Yes	46 (78.0)	4 (66.7)	6 (100.0)
No	13 (22.0)	2 (33.3)	0
Death related to intervention, n (%)	1 (1.3)	0	0

[†], the subjects were patients with symptoms before these interventions (airway stenosis, n=59; airway-esophageal fistula, n=6; stent removal, n=6).

Table 5 Analysis of intraoperative complication factors in airway stenosis stenting

Factors	Univariate		Multivariate	
	OR (95% CI)	P value	OR (95% CI)	P value
Age ≥70 (*vs.* <70 years)	0.46 (0.11–1.98)	0.30		
PS ≥2 (*vs.* 0–1)	0.41 (0.05–3.60)	0.42		
Hemoglobin <11.6 (*vs.* ≥11.6 g/dL)	2.55 (0.59–11.09)	0.21		
Albumin <3.5 (*vs.* ≥3.5 g/dL)	2.71 (0.62–11.80)	0.18		
CRP >1.9 (*vs.* ≤1.9 mg/dL)	0.78 (0.19–3.16)	0.72		
Symptoms before stenting: yes (*vs.* no)	2.51 (0.29–21.62)	0.40		
Type of stenosis: extrinsic compression (*vs.* intrinsic)	3.20 (0.57–17.90)	0.19	2.43 (0.39–15.13)	0.34
Site of stenosis: tracheal bifurcation (*vs.* not)	0.74 (0.18–3.03)	0.68		
Main physician's experience: <5 (*vs.* ≥5 years)	2.32 (0.54–10.10)	0.26	4.65 (0.49–43.48)	0.18
Number of participants in the intervention: <4 (*vs.* ≥4)	0.28 (0.06–1.22)	0.19		
Intraoperative stenting redo: yes (*vs.* no)	3.98 (0.95–16.65)	0.06	4.20 (0.76–23.16)	0.10
Operation time: >80 (*vs.* ≤80 min)	7.31 (0.87–61.77)	0.07		

OR, odds ratio; CI, confidence interval; PS, performance status; CRP, C-reactive protein.

of experience in airway intervention.

Case presentation

Stenting for airway stenosis (*Figure 2A*)

The case is a 70-year-old man with a massive lung cancer lesion (sarcomatoid carcinoma) caused extensive stenosis of the trachea (8 cm longitudinally). He was in severe respiratory condition with wheezing. He was unable to speak, so informed consent for stent placement was obtained in writing. We considered covering from the trachea to the tracheal bifurcation to be necessary and planned to use a Dumon-Y stent. The main physician had 4 years of experience with rigid bronchoscopic intervention, and the

Table 6 An analysis of postoperative complication factors in airway stenosis stenting

Factors	Univariate		Multivariate	
	OR (95% CI)	P value	OR (95% CI)	P value
Age ≥70 (*vs.* <70 years)	0.12 (0.01–1.03)	0.053		
PS ≥2 (*vs.* 0–1)	1.04 (0.19–5.68)	0.96		
Hemoglobin <11.6 (*vs.* ≥11.6 g/dL)	1.59 (0.33–7.66)	0.56		
Albumin <3.5 (*vs.* ≥3.5 g/dL)	1.69 (0.35–8.13)	0.51		
CRP >1.9 (*vs.* ≤1.9 mg/dL)	0.47 (0.08–2.75)	0.40		
Symptoms before stenting: yes (*vs.* no)	0.85 (0.16–4.65)	0.85		
Type of stenosis: extrinsic compression (*vs.* intrinsic)	6.60 (0.73–60.12)	0.09	6.60 (0.71–61.09)	0.10
Site of stenosis: tracheal bifurcation (*vs.* not)	4.90 (0.57–42.08)	0.15		
Main physician's experience: <5 (*vs.* ≥5 years)	1.06 (0.25–4.59)	0.94	1.83 (0.28–11.90)	0.53
Number of participants in the intervention: <4 (*vs.* ≥4)	0.62 (0.14–2.70)	0.52		
Intraoperative stenting redo: yes (*vs.* no)	0.86 (0.16–4.64)	0.86	0.44 (0.04–4.56)	0.49
Operation time: >80 (*vs.* ≤80 min)	1.32 (0.29–5.95)	0.72		

OR, odds ratio; CI, confidence interval; PS, performance status; CRP, C-reactive protein.

supervisor had 21 years of experience. Because wheezing worsened in the supine position, general anesthesia was induced in the sitting position. A 16-mm-diameter Y-stent was released into the left main bronchus, and the stent was deployed by the pull-back method. The procedure was successful the first time, and stenting re-do was not required. The patient's dyspnea improved significantly and he was able to speak after the procedure. He was admitted to hospice care and died two weeks later.

Stenting for airway-esophageal fistula (*Figure 2B*)

A 71-year-old man was being treated with chemoradiotherapy for esophageal cancer. With the shrinkage of the tumor, he developed a tracheoesophageal fistula in the tracheal invasion area and was referred to our hospital for airway stenting. The fistula resulted in aspiration pneumonia. The fistula was located just above the tracheal bifurcation, and considering the stability of the stent, we planned to insert a Dumon Y-stent. The main physician had 4 years of experience with rigid bronchoscopic intervention, and the supervisor had 11 years of experience. The rigid bronchoscope was carefully inserted while avoiding the fistula, and a 16-mm-diameter Y-stent was released into the left main bronchus. The stent was deployed by the pull-back method. The procedure was successful the first time, and stenting re-do was not required. The aspiration pneumonia improved after stenting, and the patient was able to receive further treatment.

Stent removal (*Figure 2C*)

A 71-year-old man was being treated with chemoradiotherapy for malignant epithelial mediastinal tumor at another hospital. He was referred to our department for treatment of dyspnea. Bronchoscopy revealed fracture of the tracheal cartilage and deformed stenosis of the trachea. A 16 mm diameter Dumon Y-stent was placed under rigid bronchoscopy and his dyspnea resolved. He achieved a complete response with late-line atezolizumab and was referred back to our department for stent removal three years after the initial procedure. The main physician had 2 years of experience with rigid bronchoscopic intervention, and the supervisor had 15 years of experience. The stent was removed safely. The fractured tracheal cartilage had been repaired. The tracheal lumen was completely open, and did not collapse even when negative pressure was applied. No subjective symptoms or disease progression have been observed in the seven months since the removal.

Discussion

Airway intervention for airway stenosis and airway-esophageal fistula, especially stenting, is an extremely

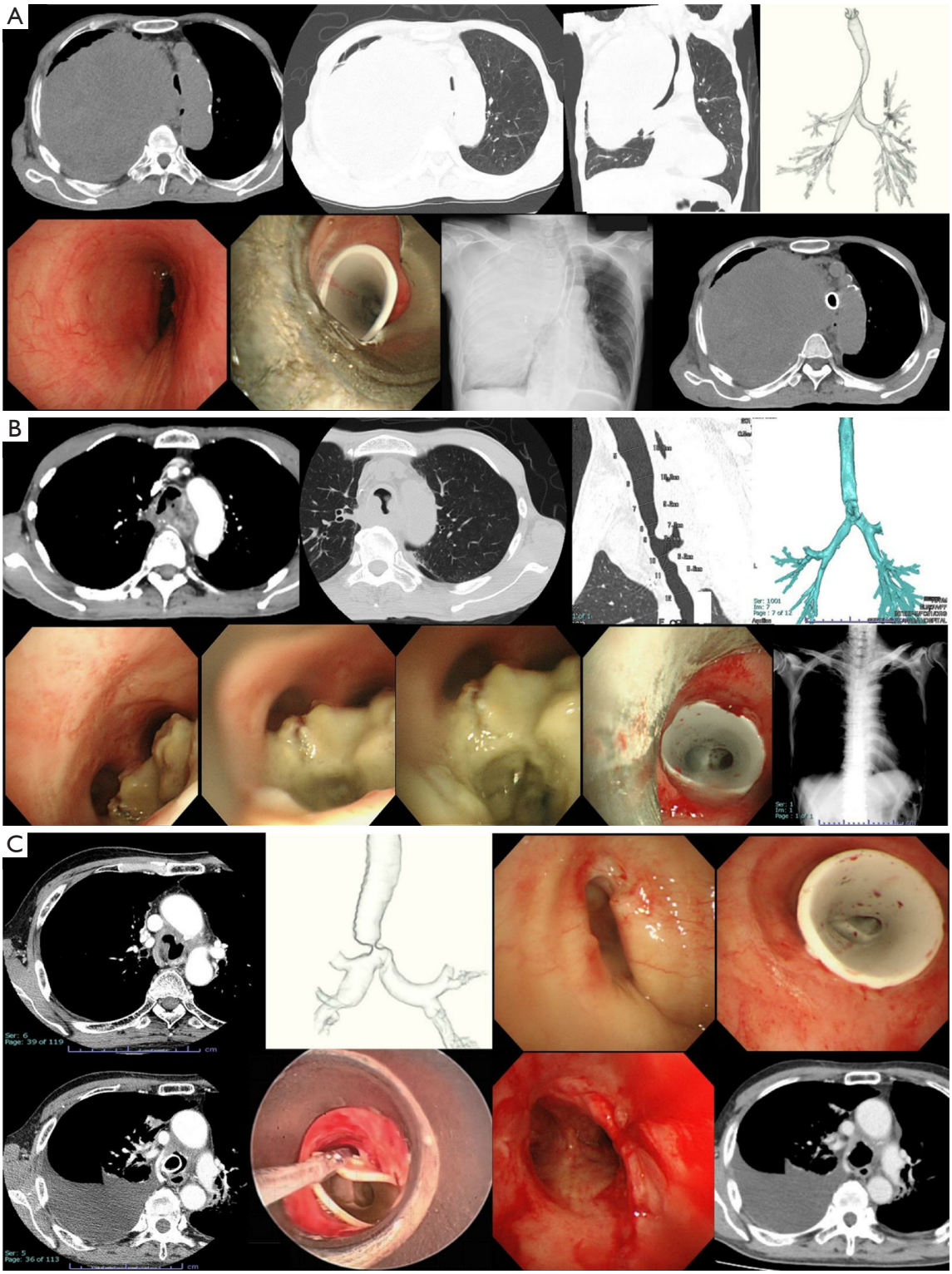


Figure 2 The cases related to airway stents performed by young trained endoscopists. (A) Stenting for airway stenosis. (B) Stenting for airway-esophageal fistula. (C) Stent removal. (A,B) The upper panels show before stenting and the lower panels show after stenting. (C) The upper panels show the initial stenting for airway stenosis and the lower panels show stent removal.

important treatment that can rapidly improve patients' symptoms regardless of benign or malignant (1-8,11,12). However, most of these patients are in a poor respiratory condition and have a high risk of complications associated with airway intervention, which requires specialized skill and experience to perform (13,14).

Preoperative planning is extremely important for safe and high-quality stenting. The location, extent, and morphology of the stenosis or fistula must be carefully assessed with preoperative CT. A variety of stents are used, including silicone stents, metallic stents, and hybrid stents, and it is also important to choose the right one for each case (15). Among them, the Dumon stent is the standard and used worldwide regardless of benign or malignant airway diseases because of its superior durability, superior disease versatility, position adjustability after implantation, removability, and reduced cost compared to metallic stents (16,17). In our department, the Dumon stent is the first choice for airway stenosis and airway-esophageal fistula. However, there are cases in which the Dumon stent cannot be used, so we also prepare metallic and hybrid stents as a backup in all cases. Metallic and hybrid stents are relatively easy to deliver using a flexible bronchoscope, and success rates have been reported to be 98% to 100% (18-21). In our study, the success rate of interventions with these stents was 100%. However, most of them are only linear stents, so migration is more likely to occur than with Y-stents (18-22). In addition, it is difficult to cover a wide area around the tracheal bifurcation with metallic stents. In particular, the ability to apply the Y-stent under rigid bronchoscopy is required for intervention of tracheal bifurcation lesions, which are more likely to cause a severe respiratory condition than other lesions.

In airway intervention, the skill of the endoscopist has a significant impact on the outcome (9,10,12,13). From this perspective, it seems optimal that only expert endoscopists perform the procedure. However, passing on the skills and knowledge of airway intervention to the future generations is a major challenge. At present, indications for intervention and stent selection depend on the individual's skill and experience, and there are no standard guidelines. Therefore, we consider it is necessary to provide opportunities for young endoscopists to learn and master standardized procedures performed in high-volume centers. It is also important to participate in simulator-based training organized by academic societies and learn the techniques.

One indicator of whether or not procedures are being performed safely is the complication rate, which in the present study was 8.3% for intraoperative complications and 10.5% for postoperative complications. Although there is no standard complication rate, and reported data show a wide disparity in such rates from 3.9% to 42% (22-26), the complication rate is generally reported to be ≥20% in European and American guidelines (14). Furthermore, it has been reported that complication rates also vary significantly among facilities (24). The balance between the quality of interventions and the training of young endoscopists within an institution is extremely important. In this study, we demonstrated that the stentings performed by young endoscopists were not associated with the development of complications when supervised by experienced instructors. The complication rate was also lower than in previous reports (23-26). To our knowledge, this is the first report to investigate airway stenting from an "educational" perspective.

Cases of stent removal were included in this study, although the number of such cases was small. Previously, in stenting for malignant airway stenosis caused, the stent could not be removed in most cases due to a poor prognosis, although there are complications (granulation, infection, migration, etc.) associated with long-term stenting (15,22,23), except in cases of malignant lymphoma (27,28). However, in recent years, the increasing use of treatment regimens involving immune checkpoint inhibitors and their long-lasting anti-tumor effects (29) is expected to increase the number of cases in which the stent can be removed. In case 3 described above, a patient who benefited from immune checkpoint inhibitors was reported (30). Although stent removal should be considered based on the patient's prognosis and desire for removal, our results demonstrate that removal can be performed safely using a rigid bronchoscope.

Several limitations associated with the present study warrant mention. First, it was a single-center retrospective study. However, it is difficult to conduct a randomized controlled trial of airway interventions, including airway stenting, because of the varied patient conditions. Second, there was a lack of data on the long-term prognosis. Our institution accepts patients for airway intervention from all over the region, and after the intervention, we request that patients receive treatment at the referring institution. Therefore, we could not evaluate the long-term prognosis in this study. Finally, the number of events (complications) was low. Although this is favorable, it resulted in a large confidence interval of the hazard ratio regarding whether or not younger endoscopists' procedures were involved in

the complications. The further accumulation of cases is therefore needed

Conclusions

This study showed that our method of intervention regarding airway stents is safe. Young endoscopists were able to master the interventional technique by gaining experience in stenting under the supervision of experts.

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Footnote

Reporting Checklist: The authors have completed the STARD reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-89/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-89/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by the Institutional Review Board of Seirei Mikatahara General Hospital (Approval No. 23-15, 2023). The requirement for informed consent was waived because of the retrospective observational design.

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