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The Clinical, Radiological, and Bronchoscopic Findings and Outcomes in Patients with Benign Tracheobronchial Tumors

Byung Woo Jhun, Kyung-Jong Lee, Kyeongman Jeon, Sang-Won Um, Gee Young Suh, Man Pyo Chung, O Jung Kwon, and Hojoong Kim

Division of Pulmonary and Critical Care Medicine, Department of Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea.

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Corresponding author: Dr. Hojoong Kim, Division of Pulmonary and Critical Care Medicine, Department of Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, 81 Irwon-ro, Gangnam-gu, Seoul 135-710, Korea.
Tel: 82-2-3410-3425, Fax: 82-2-3410-3429
E-mail: hjk3425@skku.edu

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Purpose: We evaluated the characteristics of and treatment outcomes in patients with benign tracheobronchial tumors. **Materials and Methods:** We reviewed the records of patients with benign tracheobronchial tumors who underwent bronchoscopic intervention with mechanical removal and Nd: YAG laser cauterization, and evaluated the characteristics and treatment outcomes of 55 patients with hamartomas, leiomyomas, papillomas, typical carcinoids, or schwannomas seen between April 1999 and July 2012. **Results:** The most common tumors were hamartoma (n=24), leiomyoma (n=16), papilloma (n=7), typical carcinoid (n=5), and schwannoma (n=3). Forty-one patients (75%) had symptoms. On chest computed tomography, 35 patients (64%) had round or ovoid lesions, accompanied by atelectasis (n=26, 47%) or obstructive pneumonia (n=17, 31%). Fatty components (n=9, 16%) and calcifications (n=7, 13%) were observed only in hamartomas, leiomyomas, and typical carcinoids. At bronchoscopy, the typical findings were categorized according to tumor shape, surface, color, and visible vessels. Fifty (91%) patients underwent complete resection. Forty patients (73%) achieved successful bronchoscopic removal defined as complete resection without complications or recurrence. Recurrences occurred in four papillomas, one leiomyoma, and one typical carcinoid. The proportions of tumor types (p=0.029) differed between the successful and unsuccessful removal groups, and a pedunculated base (p<0.001) and no spontaneous bleeding (p=0.037) were more frequent in the successful removal group. **Conclusion:** We described clinical, radiological, and typical bronchoscopic findings in patients with benign tracheobronchial tumors; these findings might help to differentiate such tumors. Bronchoscopic intervention was a useful treatment modality, and tumor type, pedunculated base, and vascularity may influence successful tumor removal.

Key Words: Benign tracheobronchial tumors, bronchoscopy, intervention

INTRODUCTION

Benign tracheobronchial tumors are rare, accounting for nearly 2% of all types of lung tumor.[1] They generally present as asymptomatic pulmonary nodules on radiological examination and occasionally cause respiratory or systemic symptoms due

to airway obstruction, bleeding, or the compression of other structures.[2-4] A definitive diagnosis of a tracheobronchial tumor can usually be made after tumor resection, although combinations of radiological examinations and either endoscopic or percutaneous needle biopsies can provide diagnostic information.[5,6]

Surgical resection as an initial management strategy might not be suitable in young patients that involve a high probability of having benign disease, in whom the lung parenchyma should be conserved, or in elderly patients with reduced residual lung function or of poor general condition due to underlying disease. Initially, bronchoscopic tumor removal should be undertaken in appropriate candidates only. Since Shah, et al.[7] reported the endoscopic characteristics and beneficial role of laser resection in 185 patients with benign tracheobronchial tumors, only small case series or limited clinical data on the characteristics or management of benign endobronchial tumors have been reported due to their rarity.[8-14] Therefore, we evaluated clinical, radiological, and bronchoscopic findings in patients with relatively common benign tracheobronchial tumors and assessed the treatment outcomes of rigid bronchoscopic intervention including mechanical removal with or without using neodymium-doped yttrium aluminum garnet (Nd: YAG) laser cauterization.

MATERIALS AND METHODS

Patients and data collection

We retrospectively reviewed the medical records of consecutive patients who underwent rigid bronchoscopic intervention for tumor removal between April 1999 and July 2012 at Samsung Medical Center, a referral hospital in Seoul, South Korea. We evaluated patients who were diagnosed with histologically proven benign endobronchial tumors, including hamartomas, leiomyomas, papillomas, and schwannomas. We also included patients with low-grade neoplasms that exhibited a benign course clinically, such as typical carcinoid.

The data collected included clinical characteristics, chest radiography and computed tomography (CT), bronchoscopic findings, bronchoscopic intervention, histopathology, treatment outcomes, complications, and recurrence during the study period. Follow-up data were collected lastly on August 30, 2012. We also included published data on patients with hamartoma[15] and leiomyoma[16,17] seen at our institution. The Institutional Review Board at Samsung Medical Center approved the study protocol. Informed consent was waived because of the retrospective nature of the study.

Bronchoscopic intervention and treatment outcomes

The bronchoscopic findings were described according to tumor shape (round or polypoid), surface (smooth, rough, or lobulated), color (pinkish or whitish), visible vessels (present or not), spontaneous bleeding (present or not), and base (pedunculated or wide), as modified from other references.[7,15,18]

Rigid bronchoscopy was performed under general anesthesia using intravenous propofol. After inducing general anesthesia, the patient was intubated with a rigid bronchoscope (Karl-Storz, Tuttlingen, Germany), and then a flexible bronchoscope (EVIS BF 1T240, Olympus, Tokyo, Japan) was introduced through the rigid bronchoscope and the tumor was evaluated. The tracheobronchial tumors were removed mechanically, using the blade of the rigid tube, bronchial snare, or rigid forceps with or without Nd: YAG laser cauterization. For small tumors, flexible bronchoscopic removal was performed using biopsy forceps or a bronchial stone basket. Nd: YAG laser (Laser-Sonics Model 1000, Milpitas, CA, USA) treatment was applied using a G56D non-contact fiber (LaserSonics, Milpitas, CA, USA). The removal technique depended on the discretion of an experienced bronchoscopist (HK).

Successful removal was defined as complete resection via bronchoscopic intervention without complications or recurrence during the follow-up period and unsuccessful removal was defined as partial resection via bronchoscopic intervention, complication associated with bronchoscopic intervention, subsequent surgical resection, or recurrence during the follow-up period. Complications associated with the procedure were defined as events that interrupted bronchoscopic interventions or events that required further surgical or non-surgical intervention. We compared the characteristics of the successful and unsuccessful removal groups to identify factors that might influence treatment outcomes.

Statistical analysis

The data are presented as medians and ranges or interquartile range (IQR) for continuous variables and as numbers (percentages) for categorical variables. The data were compared using the Mann-Whitney U test for continuous variables and the chi-square or Fisher's exact test for categorical variables. All statistical analyses were performed using IBM SPSS Statistics ver. 20.0 (IBM, Chicago, IL, USA), and two-sided p-values <0.05 were considered indicative of statistical significance.

RESULTS

Patient characteristics

Fifty-five patients with hamartomas, leiomyoma, papilloma, typical carcinoid, and schwannoma were included in the analysis. The most common tumor types were hamartoma (n=24, 43%), leiomyoma (n=16, 29%), papilloma (n=7, 13%), typical carcinoid (n=5, 9%), and schwannoma (n=3, 6%) (Table 1). The clinical characteristics of the study patients are shown in Table 2. The median patient age was 53 (range 17-75) years. Twenty-nine (53%) patients were male and 15 (27%) were current or ex-smokers. Nine (16%) of all study patients had at least one underlying lung disease. Forty-one patients (75%) had at least one pulmonary or systemic symptom or sign, such as cough (n=27, 49%), sputum (n=20, 36%), dyspnea (n=11, 20%), hemoptysis (n=6, 11%), fever (n=6, 11%), or wheezing (n=3, 6%). Forty-eight patients underwent flexible bronchoscopic examination before the rigid bronchoscopic intervention, and a histopathological tumor diagnosis was confirmed in 19 (40%) of these: six leiomyomas, five hamartomas, five papillomas, two typical carcinoids, and one schwannoma.

Table 1. Types of Benign Tracheobronchial Tumor

Characteristics	No. (%) or median (range)
Patients	55 (100)
Tumor types	
Hamartoma	24 (43)
Chondroid hamartoma	16 (29)
Chondrolipomatous hamartoma	4 (7)
Lipomatous hamartoma	4 (7)
Leiomyoma	16 (29)
Papilloma	7 (13)
Typical carcinoid	5 (9)
Schwannoma	3 (6)

Table 2. Clinical Characteristics of Patients with Benign Tracheobronchial Tumors

Characteristics	No. (%) or median (range)
Age, yrs	53 (17-75)
Sex, male	29 (53)
Current or ex-smoker	15 (27)
Pulmonary function test	
FEV_1, %	93 (55-119)
FEV_1/FVC <0.7	9/51 (18)
Underlying pulmonary disease	
Asthma	4/55 (7)
Bronchiectasis	2/55 (3)
History of lung cancer	1/55 (2)
Chronic obstructive pulmonary disease	1/55 (2)
Pneumoconiosis	1/55 (2)
Underlying systemic disease	
History of extrathoracic malignancy	4/55 (7)
Laryngeal papillomatosis	2/55 (4)
Symptoms or sign	
Cough	27/55 (49)
Sputum	20/55 (36)
Dyspnea (≥MMRC dyspnea scale II)	11/55 (20)
Hemoptysis	6/55 (11)
Fever	6/55 (11)
Wheezing	3/55 (6)
Pathologic diagnosis by FB before resection	19/48 (40)

FEV_1, forced expiratory volume in 1 second, percentage of predicted value; FVC, forced vital capacity; MMRC, modified Medical Research Council; FB, flexible bronchoscopy.

Chest computed tomography findings

The chest CT findings in the patients with benign tracheobronchial tumors are shown in Table 3. All patients underwent chest CT upon diagnosis of a benign tumor. Thirty-five patients (64%) had round or ovoid lesions in the tracheobronchial tree and the median size was 12.0 (range 1.5-38.0) mm (Figs. 1B-5B). Atelectasis (n=26, 47%) or obstructive pneumonia (n=17, 31%) frequently accompanied the tumor (Fig. 5B), while fatty components (n=9, 16%) and calcifications (n=7, 13%) were rare (Fig. 1B). Common tumor locations were the trachea (n=12, 21%), followed by the right main bronchus (n=7, 13%).

Bronchoscopic findings and treatment outcomes

Upon bronchoscopy, all of the study patients had an exophytic mass or nodular lesion in the tracheobronchial tree. Typical bronchoscopic findings of hamartomas consisted of a round shape, smooth or rough surface, pinkish color, and no visible vessels on the tumor surface; spontaneous bleeding was absent (Fig. 1A). The leiomyomas were round, with a smooth surface, pinkish color, and visible vessels on the tumor surface; spontaneous bleeding was rare (n=1) (Fig. 2A). The papillomas were polypoid, with a lobulated surface, whitish color, and no visible vessels on the tumor surface; spontaneous bleeding was absent (Fig. 3A). Typical carcinoid was round, with a lobulated surface, pinkish color, and visible vessels on the tumor surface; spontaneous bleeding was frequent (n=3, 60%) (Fig. 4A). Schwannomas were round, with a smooth surface, whitish color, and no visible vessels on the tumor surface; spontaneous bleed-

ing was absent (Fig. 5A). Pedunculated tumor bases were observed in each tumor type.

For all tumor types, bronchoscopic interventions were performed with or without using Nd: YAG laser cauterization. Mechanical removal alone without Nd: YAG laser cauterization was possible in 18 patients (33%), mostly hamartomas. Overall, 50 (91%) of 55 patients achieved complete resection. Complications associated with bronchoscopic intervention were bleeding that interrupted the bronchoscopic procedure (n=2), pneumothorax (n=2), and broncho-mediastinal fistula at the carina (n=1). However, there were no fatal complications. Six (11%) patients demonstrated recurrence at a median of 13 (range 2-36) months after the intervention, as seen on follow-up chest CT or bronchoscopy: papilloma (n=4) at 13 (12-36) months, leiomyoma (n=1) at 17.0 months, and carcinoid tumor (n=1) at 2.0 months. Ultimately, 42 (76%) patients achieved successful removal via bronchoscopic intervention, while the remaining 13 (24%) were unsuccessful due to recurrence (n=6), partial resection (n=1), complications, or subsequent surgical resection (n=6). The median follow-up period for the study patients was 15 (range 1-146, IQR 4-49) months. In regards to tumor type, the median follow-up period was 12.2 (range 1-146, IQR 1-36.7) months for hamartoma, 12.5 (range 1-81, IQR 3.5-43.4) months for leiomyoma, 38.7 (range 5-92, IQR 24.8-72.3) months for papilloma, 72.2 (range 22-91, IQR 24.8-88.7) months for typical carcinoid, and 9.4 (range 3-27,

Table 3. Chest Computed Tomography Findings in Patients with Benign Tracheobronchial Tumors

Characteristics					No. (%) or median (range)
Sizes, mm					12.0 (1.5-38.0)
Shapes					
Round or ovoid					35 (64)
Polypoid					12 (22)
Lobulated					4 (7)
Undetectable					4 (7)
Abnormal CT findings					
Atelectasis					26 (47)
Obstructive pneumonia					17 (31)
Fatty component					9 (16)
Calcification					7 (13)
Locations in the tracheobronchial tree					
Right		Trachea		Left	
RUL	5 (9)	Upper	4 (7)	LUL	8 (14)
RM	7 (13)	Mid	4 (7)	LM	5 (9)
RBI	5 (9)	Lower	4 (7)	Lingular	1 (2)
RML	3 (5)			LLL	5 (10)
RLL	4 (8)				

CT, computed tomography; RUL, right upper lobe; RM, right main; RBI, right bronchus intermedius; RML, right middle lobe; RLL, right lower lobe superior segment; LUL, left upper lobe; LM, left main; LLL, left lower lobe.

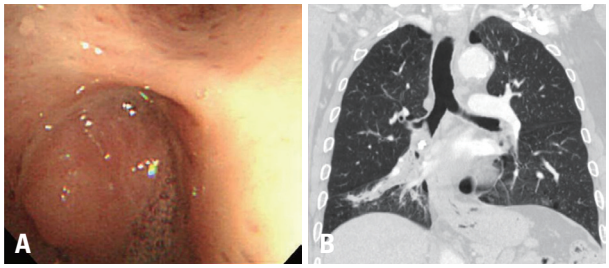

Fig. 1. Bronchoscopic examination of a hamartoma shows a round shape, smooth and rough surface, pinkish color, and no visible vessels on the tumor surface. Spontaneous bleeding was absent (A). Chest computed tomography shows a 25-mm calcified ovoid nodule at the distal bronchus intermedius and atelectasis of the right middle lobe (B).

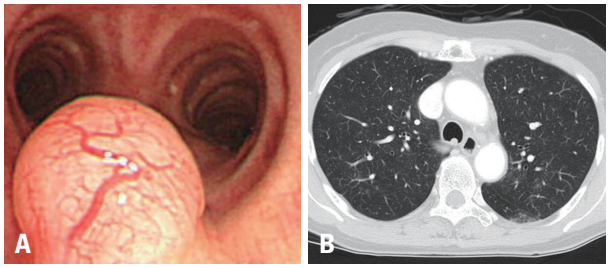

Fig. 2. Bronchoscopic examination of a leiomyoma reveals a round shape, smooth surface, pinkish color, and visible vessels on the tumor surface. Spontaneous bleeding was rarely observed (A). Chest computed tomography shows a 5.5-mm polypoid nodule at the membranous portion of the distal trachea (B).

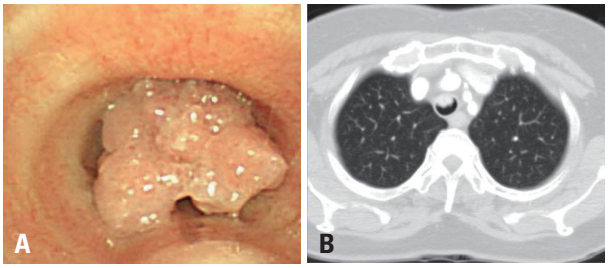

Fig. 3. Bronchoscopic examination of a papilloma shows a polypoid shape, lobulated surface, whitish color, and no visible vessels on the tumor surface. Spontaneous bleeding was absent (A). Chest computed tomography reveals a 15-mm lobulated lesion at the anterior wall of the upper trachea (B).

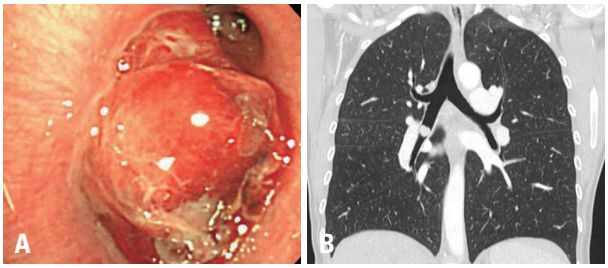

Fig. 4. Bronchoscopic examination of a typical carcinoid shows a round shape, lobulated surface, pinkish color, visible vessels on the tumor surface. Spontaneous bleeding was frequent (A). Chest computed tomography shows a 20-mm round nodule at the right bronchus intermedius (B).

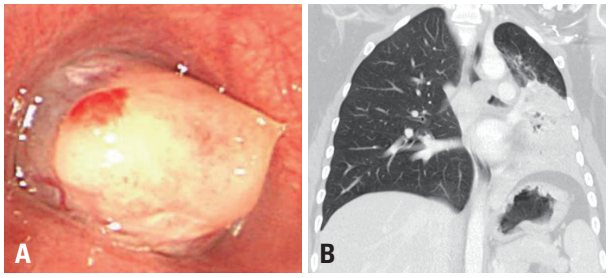

Fig. 5. Bronchoscopic examination of a schwannoma reveals a round shape, smooth surface, whitish color, and no visible vessels on the tumor surface. Spontaneous bleeding was absent (A). Chest computed tomography shows a 21-mm oval nodule occupying the proximal portion of the left main bronchus, leading to left lung atelectasis (B).

IQR 3.2-9.37) months for schwannoma.

Comparison of the clinical, radiologic, and bronchoscopic findings and treatment outcomes according to tumor type

The clinical, radiological, and bronchoscopic findings and treatment outcomes according to tumor type are shown in Table 4. The median age of the patients with typical carcinoid or schwannoma was younger than that for other tumor types, although a leiomyoma was identified in a 17-year-old female. The proportion of females was high in most tu-

Table 4. Clinical, Radiological, and Bronchoscopic Findings and Treatment Outcomes of Patients with Benign Tracheobronchial Tumors According to Tumor Type

Characteristics	Hamartoma	Leiomyoma	Papilloma	Typical carcinoid	Schwannoma
Patients	24 (100)	16 (100)	7 (100)	5 (100)	3 (100)
Age	56 (37-75)	56 (17-70)	56 (25-69)	35 (23-50)	36 (21-52)
Sex, male	17 (71)	7 (44)	3 (43)	1 (20)	1 (33)
Size, mm	12.3 (5.0-35.0)	12.0 (1.5-29.0)	9.0 (3.0-20.0)	20.0 (7.0-38.0)	15.0 (11.2-21.0)
Abnormal CT findings					
Atelectasis	15 (63)	4 (25)	1 (14)	4 (80)	2 (67)
Obstructive pneumonia	10 (42)	3 (39)	1 (14)	2 (40)	3 (33)
Calcification	6 (25)	0	0	1 (20)	0
Fatty component	8 (33)	1 (6)	0	0	0
Location					
Trachea	1 (4)	5 (31)	6 (86)	0	0
Main bronchi	4 (17)	5 (31)	1 (14)	3 (60)	3 (100)
Lobar or segmental bronchi	19 (79)	6 (38)	0	2 (40)	0
Typical bronchoscopic findings of tumor					
Shape	Round	Round	Polypoid	Round	Round
Surface	Smooth or rough	Smooth	Lobulated	Lobulated	Smooth
Color	Pinkish	Pinkish	Whitish	Pinkish	Whitish
Visible vessel	Absence	Presence	Absence	Presence	Absence
Other bronchoscopic findings and procedures					
Spontaneous bleeding	0	1 (6)	0	3 (60)	0
Pedunculated base	20 (83)	14 (88)	4 (57)	4 (80)	2 (67)
Use of Nd: YAG laser cauterization	13 (54)	11 (69)	6 (86)	4 (80)	3 (100)
Outcomes					
CR without complication	21 (88)	14 (88)	7 (100)	2 (40)	2 (67)
CR with complication	1 (4)	1 (6)	0	1 (20)	1 (33)
PR without complication	1 (4)	0	0	0	0
Subsequent surgical resection	1 (4)	1 (6)	0	2 (40)	0
Complications					
Bleeding	0	0	0	2 (40)	
Pneumothorax	1 (4)	0	0	0	1 (33)
Broncho-mediastinal fistula	0	1 (6)	0	0	0
Recurrence	0	1 (6)	4 (57)	1 (20)	0
Death during follow up period	0	0	1 (14)	0	0

Nd: YAG, neodymium-doped yttrium aluminum garnet; CR, complete resection; PR, partial resection.
Data are shown as No. (%) or median (range).

mor types, with the exception of hamartomas. Tumor size did not seem to differ according to tumor type.

On chest CT, although atelectasis and obstructive pneumonia were observed in all tumor types, calcification was observed only in six hamartomas and one typical carcinoid, and a fatty tumor component was observed only in eight hamartomas and one leiomyoma. Hamartomas occurred mainly in the distal lobar or segmental bronchus (n=19, 79%), while most papillomas occurred in the trachea (n=6, 86%). Typical carcinoid did not occur in the trachea and all schwannomas occurred in the main bronchi.

Upon bronchoscopy, bronchoscopic findings were categorized according to tumor shape, surface, color, and visible vessels. Spontaneous tumor bleeding was common in typical carcinoid (n=3, 60%). During bronchoscopic intervention, complete resection was achieved for 22 (92%) hamartomas, 15 (94%) leiomyomas, seven (100%) papillomas, three (60%) typical carcinoids, and three (100%) schwannomas. Partial resection was achieved for one hamartoma without tumor regrowth during the follow-up period. Subsequent surgical resection was required for two typical carcinoids (40%) due to bleeding, as well as one leiomyoma (6%) and one hamartoma (4%) due to a wide tumor base. Recurrence occurred in four papillomas (57%), one leiomyoma (6%), and one carcinoid (20%). The four recurrent papillomas needed repeated bronchoscopic interventions, while the recurrent leiomyoma and typical carcinoid required surgery; no recurrence occurred during follow-up.

Comparison of patients with successful and unsuccessful removal

We also compared the differences in the characteristics and treatment outcomes between patients who had successful and unsuccessful removal (Table 5). The proportions of tumor types (p=0.029) differed between the two groups. A pedunculated tumor base (p<0.001) was more frequent in the successful removal group, while spontaneous tumor bleeding (p=0.037) was more frequent in the unsuccessful removal group. There was no significant difference between groups in terms of tumor size, location, or use of Nd: YAG laser cauterization during bronchoscopic intervention.

DISCUSSION

This retrospective study described the clinical, radiological, and bronchoscopic findings and treatment outcomes of bronchoscopic intervention in patients with various benign tracheobronchial tumors. This case series revealed the bronchoscopic findings typical of various benign tracheobronchial tumors and suggested that consideration of both bronchoscopic findings and other clinical characteristics facilitates

Table 5. Comparison of the Characteristics and Outcomes between Patients with Successful and Unsuccessful Removal

Characteristics	Successful removal	Unsuccessful removal	p value
Patients	42 (100)	13 (100)	
Age	55 (17-75)	46 (19-68)	0.045
Sex, male	20 (48)	9 (69)	0.173
Size, mm	11.4 (1.5-35.0)	15.0 (7.0-38.0)	0.124
FEV_1 (%)	93 (55-119)	97 (59-115)	0.673
Tumor types			0.029
Hamartoma	21 (50)	3 (23)	
Leiomyoma	14 (33)	2 (15)	
Papilloma	3 (7)	4 (31)	
Typical carcinoid	2 (5)	3 (23)	
Schwannoma	2 (5)	1 (8)	
Location			0.383
Trachea	8 (19)	4 (31)	
Main bronchus	12 (29)	5 (38)	
Distal segmental bronchus	22 (52)	4 (31)	
Bronchoscopic findings and procedure			
Pedunculated base	39 (93)	5 (39)	<0.001
Spontaneous bleeding	1 (2)	3 (23)	0.037
Use of Nd: YAG laser cauterization	28 (67)	9 (69)	0.863

FEV_1 (%), forced expiratory volume in 1 second, percentage of predicted value; Nd: YAG, neodymium-doped yttrium aluminum garnet.
Data are shown as No. (%) or median (range).

differentiation of benign tumors.

Awareness of the typical bronchoscopic findings for benign tracheobronchial tumors is important for predicting the probability of benign disease and it might help physicians to decide treatment modalities, especially when a precise histopathological diagnosis has not been established. Although a preoperative diagnosis might be possible based on a combination of radiological examinations and either bronchoscopic forceps or percutaneous needle biopsy, diagnosis is more often made only after tumor resection.[5,6] Radiological examinations can provide useful information concerning the extent of lesions or the involvement of adjacent structures, which is important for planning resection; however, many benign tumors share similar radiological features and cannot be distinguished from one another reliably based on radiological features alone. In a previous study, Ko, et al.[19] reported the chest CT and pathology findings of 17 patients with benign tracheobronchial tumors, including hamartomas, leiomyomas, lipomas, schwannomas, inflammatory polyps, amyloidomas, and papillomas. Although those tumors were unique histologically and calcifications or fatty components were observed in hamartomas and lipomas, radiological changes in the patients were not distinguishable among the different tumor types. Stevic, et al.[4] also reported the clinical and chest CT findings of 65 tracheobronchial lesions, including 50 patients with malignant tumors and 15 patients with benign tumors. The benign tumors included lipomas, hamartomas, papillomas, mucous gland adenomas, leiomyomas, and myofibroblastic tumors, and the common chest CT findings were atelectasis, consolidation, mass-like lesion, and hyperlucency. However, the CT findings of benign tumors did not differ significantly from those of malignant tumors. Additionally, the use of a bronchoscopic forceps biopsy or needle biopsy for diagnosis is likely to be limited in some types of benign tumors.[20-22] One study reported that only 17 of 113 (15%) patients with endobronchial hamartomas could be diagnosed preoperatively because it was difficult to obtain sufficient tissue for a pathological diagnosis.[21] In a recent study of 28 cases of carcinoid tumor, the initial diagnosis of carcinoid tumor was made in 14 tumors (50%) following CT-guided needle biopsy and in 11 tumors (39%) following surgical lobectomy.[22] In our study, only 19 of 48 (40%) patients who underwent flexible bronchoscopic examination were diagnosed before tumor resection. Therefore, given the limitations of radiological findings and biopsies in benign tracheobronchial tumors and the benefit of conservative excision, determination of the typical bronchoscopic findings of benign tracheobronchial tumors might provide additional information for choosing the initial treatment modality.

In our series, rigid bronchoscopic intervention resulted in a high complete resection rate without fatal complications, even without using Nd: YAG laser cauterization in some cases. Fifty of 55 (91%) patients underwent complete resection with bronchoscopic intervention (Table 4) and 40 (73%) patients achieved successful removal (Table 5). Removal was successful in 14 of 18 (78%) patients who underwent bronchoscopic intervention using mechanical removal alone without Nd: YAG laser cauterization. Particularly, our study included some young patients who necessitated lung parenchyma conservation and elderly patients with reduced residual lung function and poor general condition due to underlying disease, including a 17-year-old female with a leiomyoma and a 52-year-old female with a schwannoma who was receiving palliative chemotherapy for advanced breast cancer. In both cases, tumor removal via bronchoscopic intervention was successful without complications or recurrence.

Regarding the use of bronchoscopic intervention, reports indicate that it should be considered in younger patients as a first-line therapy and in elderly patients or patients with severe underlying diseases or malignancies.[23] Bronchoscopic laser resection and bronchoscopic surveillance are acceptable approaches for the management of pedunculated tumors with no extratracheal component, particularly if the patient is inoperable.[2] Therefore, our results suggest a beneficial role of rigid bronchoscopic intervention in patients with benign tracheobronchial tumors as a useful initial diagnostic and treatment modality.

We also evaluated possible factors associated with poor outcomes to help identify appropriate candidates for successful removal via bronchoscopic intervention (Table 5). Our data showed that successful removal was influenced by tumor type, pedunculated tumor base, and low tumor vascularity. Although there was a significant difference in the median age of the two groups, this might be because of the higher proportions of typical carcinoids and schwannomas in the relatively young patients. Therefore, our results might help to predict successful bronchoscopic tumor removal and to choose appropriate candidates for bronchoscopic tumor removal.

There are some limitations to this study. First, because we included only patients who underwent rigid bronchoscopic interventions, it is possible that patients with benign disease

who underwent tumor removal via flexible bronchoscopy alone or surgical resection without bronchoscopic intervention might have been excluded, influencing the tumor characteristics observed. Second, the median follow-up duration of 15 months might be insufficient for evaluating treatment outcomes, given the relatively slow progression of benign tumors. Therefore, further studies of benign tracheobronchial tumors with more cases and long-term follow-up are required. Finally, we did not directly compare the bronchoscopic appearance of benign and malignant tumors, which are not distinguishable according to chest CT. Therefore, to evaluate the characteristics of benign tracheobronchial tumors more accurately, comparative studies between benign and malignant tracheobronchial tumors are needed.

In conclusion, in this study, we described the clinical, radiological, and typical bronchoscopic findings in patients with various benign tracheobronchial tumors, which might help to differentiate benign tumors. Rigid bronchoscopic intervention was a useful treatment modality, and the type of tumor and tumor characteristics such as a pedunculated base and vascularity might influence successful tumor removal.

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