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Original Article

Tracheobronchial surgical interventions

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ABSTRACT

Background: Surgical treatment is almost always necessary for lesions that cause stenosis or obstruction of the tracheobronchial system. Sleeve resection is a surgical method that ensures airway continuity and reduces the loss of lung tissue by creating a primary anastomosis following the resection of the affected segment.

Materials and Methods: In this study, 65 patients who underwent tracheobronchial sleeve resection and bronchoplasty at the Ankara Atatürk Sanatorium Training and Research Hospital between 1974 and 1997 were retrospectively evaluated. Patient data were obtained from medical records and surgical reports, and compared with the previous studies.

Results: Of the 65 patients, 34 were male and 31 were female (mean age, 32.56 years; range, 5–65 years). Tracheal resection and reconstruction were performed in 25 patients because of stenosis and neoplasm, whereas bronchial sleeve resection and bronchoplasty were performed in 40 patients because of benign neoplasm, bronchial adenoma, bronchial carcinoma, endobronchial foreign body, and bronchial rupture.

Conclusions: Resection of a small bronchial segment instead of pneumonectomy offers a curative treatment alternative for centrally localized, benign endobronchial lesions with low malignancy potential. In bronchial carcinomas, the results obtained from the complete removal of tumor tissue with sleeve lobectomy in a selected group of patients have shown that this surgical method may be an alternative to pneumonectomy. In patients with bronchial cancer, pneumonectomy should not be performed if sleeve lobectomy is possible. The high postoperative quality of life and low mortality and morbidity emphasize the superiority of this surgical method over pneumonectomy.

Keywords: pneumonectomy, bronchial anastomosis, bronchoplasty

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Introduction

The continuity of the trachea and the bronchial tree is vital for survival. The disruption of continuity due to lesions or traumatic rupture within the respiratory transmission system, which is responsible for air conduction, leads to respiratory insufficiency.

Surgical treatment is almost always necessary for lesions that cause stenosis or obstruction of the tracheobronchial system. Sleeve resection is a surgical method that ensures airway continuity and reduces the loss of lung tissue by creating a primary anastomosis following the resection of the affected segment. In 1947, Price Thomas performed the first bronchoplasty on a patient with an adenoma in the right main bronchus and no alternative to pneumonectomy. Thomas performed sleeve resection and primary bronchial anastomosis because the patient was a pilot by profession [1].

With this method, surgical treatment options can be provided to patients considered inoperable because of limited respiratory function, while preserving maximum lung tissue.

Materials and Methods

In this study, 65 patients who underwent tracheobronchial sleeve resection and bronchoplasty at the Ankara Atatürk Sanatoryum Training and Research Hospital between 1974 and 1997 were retrospectively evaluated. Patient data were obtained from medical records and surgical reports, and compared with the previous studies. Our study was carried out following the ethical principles determined by the 1964 Helsinki Declaration and subsequent amendments. Ethical approval for this study was obtained from a relevant institute (1/18, 27.02.2012 Ankara Atatürk Sanatorium Training and Research Hospital).

Statistical Analyses

Statistical analyses were performed using the SPSS version 15 package program. The variables were analyzed using visual (e.g., histograms and probability plots) analytical methods (Kolmogorov-Smirnov test) to determine whether they showed normal distribution. Descriptive analyses were presented as means for normally distributed variables and as medians and interquartile ranges for nonnormally distributed and ordinal variables.

Results

Of the 65 patients, 34 were male and 31 were female (mean age, 32.56 years; range, 5-65 years). Tracheal resection and reconstruction were performed in 25 patients because of stenosis and neoplasm, whereas bronchial sleeve resection and bronchoplasty were performed in 40 patients because of benign neoplasm, bronchial adenoma, bronchial carcinoma, endobronchial foreign body, and bronchial rupture (Table 1).

Patients were referred based on the underlying pathology, with the most common complaint identified as shortness of breath (Table 2).

Two patients with tracheal tumors were treated with a preliminary diagnosis of asthma for two years before presenting to our clinic.

The most common finding on physical examination was decreased respiratory sounds. Subcutaneous emphysema was observed in 2, 5, and 1 patient with penetrating tracheal injury, traumatic rupture, and tracheal tumor, respectively. Clubbing was identified in 13 patients and flail chest was detected in 2 patients with bronchial rupture. Patients were initially evaluated using posteroanterior and lateral chest X-rays (Table 3).

Table 1. Indications for tracheobronchial sleeve resection and bronchoplasty.

Indication	n
Tracheal stenosis	8
Tracheal neoplasm	14
Bronchial neoplasm	24
Bronchial rupture	12
Endobronchial foreign body	5
Penetrating tracheal injury	2
Total	65

Table 2. Patients' complaints.

Tracheal neoplasm and stenosis	(n=25)	Bronchial cancer	(n=8)
Shortness of breath	25	Cough	8
Cough	23	Side pain	4
Bloody sputum	5	Bloody sputum	2
Hoarseness	5	Sputum	6
Wheezing	3	Shortness of breath	2
		Fire	1
Bronchial adenoma and benign lesions	(n=15)	Bronchial rupture	(n=12)
Cough	15	Shortness of breath	12
Side pain	9	Side pain	12
Fever	10	Endobronchial foreign body	(n=5)
Sputum	12	Cough	5
Bloody sputum	5	Sputum	2
Shortness of breath	5	Fever	2

Table 3. Radiological findings of the patients (findings detected on chest X-rays).			
Tracheal neoplasm and stenosis	(n=25)	Bronchial cancer	(n=8)
Normal	20	Atelectasis	4
Pneumomediastinum	1	Apical mass	2
Upper mediastinal enlargement	4	Mass in the lower zone	1
		Normal	1
Bronchial adenoma and benign lesions	(n=15)	Bronchial rupture	(n=12)
Pneumonia	8	Pneumothorax	8
Atelectasis	6	Hemopneumothorax	4
Normal		Rib fracture	3
Endobronchial foreign body	(n=5)	Subcutaneous emphysema	5
Normal	3		
Pneumonia + atelectasis	2		

After chest X-rays, advanced diagnostic methods were applied to patients based on the etiological causes. All patients underwent preoperative bronchoscopy. Patients with tracheal neoplasm or stenosis underwent tracheal laminography, and in one case, an MRI was performed. All patients underwent thoracic computed tomography (CT) scans, except those with acute trauma and endobronchial foreign bodies. After establishing a definitive diagnosis, treatment was performed using surgical methods (Table 4).

Twelve patients who underwent sleeve lobectomy had the most common lesion localization in the right upper lobe (Table 5).

Furthermore, in 12 patients who underwent sleeve resection without lobectomy, the most common sites of involvement were the main and intermediate bronchi (Table 6).

All 8 patients who underwent surgery for bronchial carcinoma had a preoperative histopathological diagnosis. A preoperative histopathological diagnosis was established in 8 of 14 patients (57%) with carcinoid tumors. The histopathological diagnoses are listed in table 7.

Table 4. Surgical methods applied to patients.		
	n	%
Tracheal resection and reconstruction	23	35
Primary tracheal anastomosis	2	3
Sleeve lobectomy	12	18
Sleeve resection + cranioplasty	3	5
Bronchotomy + primary anastomosis	3	5
Sleeve resection (without lobectomy)	22	34
Total	65	

Table 5. Lesion localization in patients undergoing sleeve lobectomy.		
	n	%
Right upper lobe	7	58
Left upper lobe	2	17
Middle lobe bronchus	2	17
Right lower lobe bronchus	1	8

Table 6. Lesion localization in patients undergoing sleeve resection without lobectomy and bronchotomy + mass excision.		
	n	%
Right main bronchus	10	45
Left main bronchus	8	36
Bronchus intermedius	2	9
Left lower lobe bronchus	1	5
Right lower lobe bronchus	1	5

Table 7. Histopathological diagnoses of patients undergoing sleeve resection for tracheal and bronchial neoplasms.			
			n
Tracheal Neoplasms		Adenocystic carcinoma	8
		Epidermoid carcinoma	1
		Mucoepidermoid carcinoma	1
		Invasive fibrous tumor of the trachea	1
		Plasma cell granuloma	1
	Secondary tumors	Thyroid follicular carcinoma	1
		Thyroid papillary carcinoma	1
Bronchial neoplasms	Carcinoid tumor		14
	Epidermoid carcinoma		5
	Adenocarcinoma		2
	Mucoepidermoid carcinoma		1
	Endobronchial hamartoma		1

Among patients who underwent tracheal surgery, 11 underwent cervical incision, 11 underwent right thoracotomy, and 3 underwent median sternotomy. End-to-end anastomosis was performed in all patients who underwent resection.

Standard posterolateral thoracotomy was performed in all patients who underwent bronchial sleeve resection. The postoperative hospital stay for tracheobronchial sleeve resection was 28 days (7–58 days). Complications occurred in 26.2% (n = 17) of the 65 operated patients. All patients underwent postoperative bronchoscopy performed during follow-up (Table 8).

Table 8. Postoperative complications.

	n	%
Atelectasis	14	22
Wound infection	4	6
Postoperative empyema	2	3
Osteomyelitis	1	2
Tracheoesophageal fistula	1	2
Granulation at the anastomosis line	2	4
Vocal cord paralysis	2	4
Total	26	43

A patient with bronchial carcinoma died on postoperative day 7 because of massive hemoptysis. The mortality rate was 8% in patients who underwent tracheal resection. One patient who underwent tracheal resection died because of postoperative cardiac arrest, and another patient died because of bleeding. Granulation tissue developed at the anastomotic site in two patients and was cleared bronchoscopically. One patient developed tracheoesophageal fistula in the third postoperative month. Reoperation was performed. Two patients developed left vocal cord paralysis.

Two of our patients with traumatic bronchial rupture underwent thoracomyoplasty because of postoperative empyema. In one patient with a right main bronchial rupture, osteomyelitis developed in postoperative month 4, and vertebral resection was performed. Local recurrence or distant metastasis was not observed in any patient with carcinoid tumors.

Discussion

The bronchoplastic technique and sleeve resection, first described by Paulson et al [2], is a conservative surgical method that minimizes the loss of healthy lung tissue. The aim of this study was to preserve normal lung tissue and respiratory function. Resection of a small bronchial segment instead of pneumonectomy offers a curative treatment alternative for centrally localized, benign endobronchial lesions with low malignancy potential. In bronchial carcinomas, the results obtained from the complete removal of tumor tissue with sleeve lobectomy in a selected group of patients have shown that this surgical method may be an alternative to pneumonectomy [3-12,13]. Frist et al [14] reported that the 5-year survival rates in patients with bronchial carcinoma undergoing sleeve lobectomy were as follows: Stage 1, 58% + 25%; Stage 2, 69% ± 18%; and Stage 3, 38% ± 13%. Weisel et al compared the outcomes of sleeve lobectomy in 70 patients (27 patients due to reduced pulmonary reserve, 43 patients as elective surgery) with the outcomes of pneumonectomy performed in an equal number of patients during the same period and reported no significant difference in the 5-year survival rate between the two groups [14].

There are different ideas regarding the application of preoperative radiotherapy to make surgery more suitable in malignant cases. Jensic et al [15] recommended preoperative radiotherapy followed by sleeve lobectomy after 4–6 weeks. In a sleeve lobectomy series of 115 patients, 62 patients underwent surgery after preoperative radiotherapy of 4,000 rad, with a 5-year survival rate of 33%. Frist et al [14], Lowe et al [16], and Weissberg [17] stated that preoperative radiotherapy poses a risk for anastomosis and contraindicates sleeve resection if there is mediastinal lymph node metastasis. In a study conducted by Jensic [5], the 5-year survival rate was 36% in patients without lymph node metastasis (–), 9.5% in patients with lymph node metastasis (+), and the recurrence rate was 10%. In our study, inadequate pulmonary reserve and localization of the lesion constituted the indication for sleeve resection in patients with bronchial cancer, and none of our patients received preoperative radiotherapy.

For benign endobronchial lesions or those with a low potential for malignancy, sleeve resection is the best surgical method to preserve the distal lung tissue. Patients who may be candidates for sleeve resection should be preoperatively evaluated with bronchoscopy to identify the localization of the lesion and histopathological diagnosis. In malignant cases, CT and positron emission tomography should be used to identify mediastinal and hilar lymph nodes. With appropriate indication and surgical methods, mortality and morbidity are low and the outcomes are excellent. The 5-year survival rate is reported to be between 86% and 100% in various series [16,18]. In this study, 8 (53.3%) of 15 patients who underwent sleeve resection and bronchotomy along with primary anastomosis for benign endobronchial lesions and bronchial adenomas were asymptomatic.

In cases where surgery is indicated for bronchial rupture, the prevailing idea is to perform bronchial anastomosis within the first 24-48 hours [15,19-25]. Therefore, promptly diagnosing the rupture and initiating treatment is crucial. Successful outcomes have been reported with bronchoplastic methods applied in the late period for patients in whom the diagnosis of bron-

chial rupture could not be established early. Nonoyama et al reported a case in which he performed primary bronchial anastomosis for left main bronchial rupture, achieving full expansion of the lung after 9 years [26].

The most common complication after surgery is atelectasis; therefore, respiratory physiotherapy and bronchial hygiene should be carefully monitored. On the first and second days, bronchoscopy is recommended for aspiration and anastomosis control [4,10], whereas some surgeons prefer to avoid bronchoscopy as much as possible [9]. Bronchoscopic control after administering low-dose corticosteroids for 5-8 days to control edema and secretions was recommended [27].

Other complications observed in bronchial sleeve resections include anastomotic insufficiency, stenosis at the anastomotic site, and bronchopleural and bronchovascular fistulas. The routine practice for securing the integrity of the anastomotic site is to wrap it with a pleural or pericardial flap [3,4,9,14,16,28,29]. In this study, we did not observe complications such as anastomotic insufficiency or stenosis at the anastomotic site; however, tracheoesophageal fistula developed in one patient, requiring surgical intervention. Therefore, we evaluated the points to be considered in terms of surgical technique in bronchial sleeve resections based on our experience.

Careful incision and opening of the mediastinal pleura facilitate closure of the anastomosis. Particularly, the meticulous dissection and removal of the peribronchial and surrounding lymph nodes allow for the easy execution of bronchial resection and anastomosis. Before performing bronchial resection, a sling suture should be placed in the anatomical plane proximal and distal to the lesion. These sutures assist in aligning the bronchi in the same plane during anastomosis. After bronchial resection, both the removed segment and the remaining ends should be inspected for lesions, and if necessary, further resection should be performed. The secretion in the distal bronchus should be aspirated with a thin probe, and it must be ensured that no secretion remains. Especially in bronchial adenomas, the thick and viscous distal mucus that has been obstructed for a long time should be aspirated repeatedly with gentle massaging of the lung. Anastomosis should be performed in the same plane, and the sutures of the posterior wall should have knots outside the lumen. There should be no difficulty in resuturing for air leakage from the back. After completion of the anastomosis, air leakage should be checked using normal saline. The lung should be expanded, and the anatomical condition of the bronchi should be evaluated. Similarly, the pulmonary artery should be examined for any twisting or bending in the lobular expansion position. The mediastinal pleura should be brought over the anastomosis and sutured loosely to allow for air and fluid leakage.

Although the first bronchial sleeve resection was performed in 1947, tracheal resection and reconstruction were rarely reported till the 1960s.

Initially, it was proclaimed that resecting more than two or three tracheal rings would be unsafe. However, in 1970, Grillo successfully performed primary anastomosis after resecting 50% of the trachea [30,31].

The most common indications for tracheal resection and reconstruction are intubation-related strictures, neoplasms and traumas, and rarely tracheomalacia, acquired tracheoesophageal fistula, and congenital anomalies [31]. It provides an excellent chance of cure for benign tumors and tumors with low malignancy potential and a high chance of palliation and cure in squamous cell carcinoma and adenoid cystic carcinoma along with radiotherapy.

In 1990, Grillo reported an operative mortality rate of 5% in 132 patients who underwent tracheal resection and reconstruction for tracheal tumors [32]. In this study, tracheal resection and reconstruction were performed in 9 and 14 patients because of stenosis and neoplasms, respectively. Two patients died during the postoperative period, with the cause of death being innominate vein bleeding in one patient and cardiac arrest in another. Stenosis occurred in the anastomotic line in 2 of the other 23 patients. One of these patients underwent endobronchial stent placement. In one patient operated for adenoid cystic carcinoma, recurrence was observed 5 years later, and endoscopic excision was performed, whereas seven patients are still asymptomatic.

Silk was previously used for anastomosis in tracheal and bronchial resections. When it was observed that silk knots penetrated into the bronchus and formed granulation tissue, the use of absorbable suture materials was attempted. Currently, the technique of anastomosis with synthetic absorbable suture material, with knots left outside using individual sutures, is widely accepted [3,4,9,12,14,33]. In the literature, especially in series

focusing on bronchial rupture, polypropylene has been commonly used for anastomosis [19,24,25,34]. Some doctors even recommend continuous suture technique with polypropylene for anastomosis (25,34). In this study, a synthetic absorbable suture material (polyglactin 910) was used for anastomosis in 90% of the patients.

To conclude, patients with obstructive lesions or ruptures in the trachea and large bronchi should be thoroughly examined clinically, radiologically, and endoscopically. After definitive diagnosis, primary anastomosis should be considered first following tracheal lesion resection. In benign and low-grade malignant endobronchial lesions, the primary goal should be to preserve healthy lung tissue along with lesion resection. In bronchial ruptures, the possibility of elective bronchoplasty should be considered after stabilizing the patient's vital signs and other systemic indicators. In patients with bronchial cancer, pneumonectomy should not be performed if sleeve lobectomy is possible. The high postoperative quality of life and low mortality and morbidity emphasize the superiority of this surgical method over pneumonectomy.

Declaration of conflicting interests

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Ethics approval

The study was approved by Ankara Atatürk Sanatorium Training and Research Hospital Ethical Committee (No: 1/18, 27.02.201)

Authors' contribution

DBK; conceptualized and designed the study, collected, analyzed and interpreted the patient data, wrote the paper, SŞEG; collected the literature data, revised the final version of the manuscript, and co-wrote the paper. All authors read and approved the final manuscript.

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