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Original Article / *Özgün Makale*

Is there any change in disease presentation and surgical outcomes in patients with pulmonary aspergilloma? An evaluation of the time trend

Pulmoner aspergillomalı hastalarda hastalık sunumu ve cerrahi sonuçlarda değişiklik var mı? Zaman trendinin değerlendirilmesi

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ABSTRACT

Background: This study aims to investigate the changes in the clinical and radiological presentations of pulmonary aspergilloma in patients undergoing surgery and to evaluate changes in the surgical outcomes over time.

Methods: Between January 2000 and January 2020, a total of 88 patients (69 males, 19 females; mean age: 45.4±11.2 years; range, 17 to 70 years) who underwent surgery for pulmonary aspergilloma were retrospectively analyzed. Surgeries performed were divided into two groups based on their chronological order: first period (from 2000 to 2010, n=44) and second period (from 2010 to 2020, n=44).

Results: The most frequent underlying disorder was tuberculosis (72.7%), whereas 10 patients did not have any predisposing conditions for pulmonary aspergilloma. Regarding the aspects of radiological imaging and operative findings, 22 patients had simple aspergilloma and 66 patients had complex aspergilloma. Complications and mortality rates were 33.0% and 5.7%, respectively. A statistical downward was observed in the second period compared to that in the first period regarding the rate of patients with tuberculosis history (61.4% *vs*. 84.1%, p=0.01). There were more patients who did not have any predisposing conditions for pulmonary aspergilloma in the second period and in the simple aspergilloma group (p=0.04 and p<0.001, respectively). Simple aspergilloma was often observed in the second period than that in the first period (31.8% *vs*. 18.2%). There was no significant difference between the periods regarding the type of surgical resection (p=0.506), whereas in the simple aspergilloma group, more patients underwent wedge resection (p<0.001). There were no significant differences between the periods and radiological groups in terms of complications and mortality. Patients who underwent pneumonectomy had significantly higher rates of complications and mortality (p=0.01 and p=0.03, respectively).

Conclusion: Although pulmonary aspergilloma patients who underwent surgery in the last 10 years had a lower history of tuberculosis than those who were operated in the previous 10 years, there was no change in postoperative complications and mortality rates. An increase in simple aspergilloma prevalence may reduce the rate of surgical morbidity.

Keywords: Pulmonary aspergilloma, surgery, time trend, tuberculosis.

ÖZ

Amaç: Bu çalışmada pulmoner aspergilloma nedeniyle cerrahi uygulanan hastalarda klinik ve radyolojik görünümün değişimi incelendi ve zaman içerisinde cerrahi sonuçlarda meydana gelen değişiklikler değerlendirildi.

Çalışma planı: Ocak 2000 - Ocak 2020 tarihleri arasında, pulmoner aspergilloma nedeniyle cerrahi yapılan toplam 88 hasta (69 erkek, 19 kadın; ort. yaş: 45.4±11.2 yıl; dağılım, 17-70 yıl) geriye dönük olarak incelendi. Yapılan ameliyatlar yapıldıkları tarihe göre birinci periyot (2000'den 2010'a, n=44) ve ikinci periyot (2010'dan, 2020'ye, n=44) olarak iki gruba ayrıldı.

Bulgular: En sık altta yatan hastalık tüberküloz iken (%72.7), 10 hastada pulmoner aspergilloma için herhangi bir yatkınlaştırıcı durum yok idi. Radyolojik görüntüleme ve ameliyat sırası bulgular açısından, 22 basit aspergilloma ve 66 kompleks aspergillomalı hasta vardı. Komplikasyon ve ölüm oranları sırasıyla %33.0 ve %5.7 idi. İkinci periyotta, tüberküloz öyküsü olan hasta sayısı açısından ilk periyota kıyasla istatistiksel olarak bir düşüş vardı (%61.4'e kıyasla %84.1, p=0.01). Altta yatan bir yatkınlaştırıcı hastalığı olmayan hastalar ikinci periyotta ve basit aspergilloma grubunda daha fazlaydı (sırasıyla, p=0.04 ve p<0.001). Basit aspergilloma ikinci periyotta birinci periyota kıyasla daha fazla gözlendi (%31.8'e kıyasla %18.2). Cerrahi rezeksiyon tipi açısından periyotlar arasında anlamlı bir fark yok iken (p=0.506), basit aspergilloma grubunda daha fazla hastaya kama rezeksiyon uygulandı (p<0.001). Periyotlar ve radyolojik gruplar arasında komplikasyon ve mortalite açısından anlamlı bir farklılık yoktu. Pnömonektomi yapılan hastalar anlamlı olarak daha yüksek komplikasyon ve ölüm oranlarına sahipti (sırasıyla, p=0.01 ve p=0.03).

Sonuç: Son 10 yılda pulmoner aspergilloma nedeniyle ameliyat edilen hastalar, önceki 10 yılda ameliyat edilenlere kıyasla daha az tüberküloz öyküsüne sahip olmasına rağmen, ameliyat sonrası komplikasyon ve mortalite oranlarında değişiklik olmadı. Basit aspergilloma prevalansındaki artış cerrahi morbidite oranını azaltabilir.

Anahtar sözcükler: Pulmoner aspergilloma, cerrahi, zaman trendi, tüberküloz.

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Patients with pulmonary aspergillomas (PAs) should undergo surgical treatment, when the disease is observed, as there is no effective alternative medical therapy and the risk of sudden life-threatening hemoptysis.[1] However, there are also reports recommending surgery only in patients with recurrent and/or massive hemoptysis.[1-3] Therefore, there is still debate over the effectiveness of surgical treatment in influencing prognosis and relieving complaints, particularly in asymptomatic patients with aspergilloma diagnosis or suspicion.[4] The place of surgery has not yet been established due to the high rates of mortality and morbidity. Surgery, which is currently the mainstay of treatment for aspergilloma, has been widely recognized as a technical challenge. Conversely, spontaneous recovery or regression of symptoms is extremely rare in aspergilloma, and surgical treatment of PA is commonly recommended to control symptoms, prevent recurrent and life-threatening hemoptysis, and prolong survival in patients with adequate pulmonary function.[5-7]

Although the incidence of pulmonary tuberculosis has decreased, nine million new tuberculosis cases are diagnosed worldwide each year, and the cavitation rates after pulmonary tuberculosis are estimated to be between 30 and 35% based on tomography examination.[8] This indicates that PA is still a major problem. In contrast, postoperative outcomes have been shown to improve due to a decreased incidence of aspergilloma growing in tuberculosis cavitations.[9,10] However, very few studies have investigated the differences between the periods.[2,10]

In the present study, we aimed to evaluate the factors affecting mortality and morbidity in patients who underwent surgery for PA over the past two decades and to investigate the changes in both clinical presentation and postoperative outcome of PA in the passing years.

PATIENTS AND METHODS

This observational single centre, retrospective study was conducted at Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital, Department of Thoracic Surgery between January 2000 and January 2020. A total of 88 patients (69 males, 19 females; mean age: 45.4±11.2 years; range, 17 to 70 years) who underwent surgery for PA were included. The diagnosis of PA was based on clinical and radiological examinations, surgical and pathological findings, and the presence of an isolated fungal ball. Transthoracic fine-needle aspiration biopsy was performed only in patients who were suspected of having a malignancy (n=9). None of the patients received antifungal therapy either preoperatively or postoperatively. Two patients who underwent emergency surgery due to massive hemoptysis and who were observed with invasive pulmonary aspergillosis in the postoperative pathological examination were excluded from the study. Since the invasive forms of pulmonary aspergillosis usually occur in the setting of severe immunosuppression, such as in human immunodeficiency virus infection or hematological malignancy, these patients were excluded. All patients included in the present study were immunocompetent when operated. Surgeries performed were divided into two groups based on their chronological order: first period (from 2000 to 2010, n=44) and second period (from 2010 to 2020, n=44).

Surgical technique and details

All patients who underwent elective surgery involving thoracotomy or video-assisted thoracoscopic surgery (VATS) had an adequate pulmonary function for pulmonary resection (postoperative predicted the first second of forced expiration [FEV1] value ≥40%). Patients who underwent emergency surgery had a pulmonary function test, as they were on the surgery waiting list.

Intrapleural or extrapleural mobilization of the lung was performed at the beginning of surgery depending on the pleural adhesion density. During surgery, extrapleural dissection of the parietal pleura was confined to a limited area due to the risk of postoperative hemorrhage. In such cases, dissection was advanced toward the mediastinal surface, which had less dense adhesions, followed by pneumolysis.

In our institution, wedge resection is performed, if PA has a small/peripheral location in the lung and the underlying lung tissue is relatively healthy; otherwise, lobectomy is performed, if it is not located peripherally and confined to a single lobe. If a peripheral PA is located in the apical portion of the upper lobe or superior segment of the lower lobe, wedge resection is chosen rather than segmentectomy. Our limit in wedge resection is the area where healthy parenchyma appears. Although parenchyma-preserving surgery is performed in lung resections at our hospital, pneumonectomy is performed in cases with PA in the presence of a central disease, involvement of more than one lobe, and if the affected lung tissue is completely damaged or the remaining lung tissue becomes extremely fibrotic and small. All patients are extubated in the operating room and, then, moved to the surgical intensive care unit.

In the second period, some changes are made to the patients' surgical details and management. The bronchial stump has always covered the parietal pleura flap or pericardial fat in patients who have undergone lobectomy or pneumonectomy for the past 10 years. Since prolonged air leak (PAL) and residual apical space may be the main problem, all efforts are directed to prevent them. Pleural tenting is started in patients undergoing upper lobectomy for the past 10 years. While separating the intralobar fissure, automatic linear staplers are used. Preoperative parenchyma leaks are repaired very carefully and supported by pleural flaps, when deemed necessary. Fiberoptic bronchoscopy (FOB) has been commonly used to identify the proper placement of a double-lumen endotracheal tube for good lung isolation during surgery since 2012. Most importantly, preoperative respiratory exercise programs are developed for patients, ensuring that they enter the operation room with the best respiratory function.

Radiological findings, diagnoses, and the types of aspergilloma

The indications for pulmonary surgery included symptomatic or asymptomatic "air-crescent" lesions, destruction of the lung, indeterminate lung mass, or a lung lesion with clinical hemoptysis. Preoperative diagnosis of aspergilloma was established in 62 patients based on the radiological appearance of a fungus ball characteristically surrounded by a crescent-shaped radiolucent area (Monod sign). The diagnosis was based on pathological examination in the remaining 26 patients; 18 patients underwent surgery with the preliminary diagnoses of cavitary (n=14) or mass (n=4) lung lesions, and the remaining eight patients underwent surgery for various reasons: three had bronchiectasis, two had destroyed lung, two had squamous cell lung carcinoma, and one had bullous lung disease.

The type of aspergilloma was determined as either simple aspergilloma (SA) or complex aspergilloma (CA) based on chest imaging examinations, thoracotomy findings, and pathological records in accordance with the radiological aspergilloma classification described by Belcher and Plummer in 1960.[11] Simple aspergilloma is a thin-walled cavity with little or no surrounding parenchymal disease, while CA is a thick-walled cavity with gross surrounding parenchymal disease (Figure 1).

Complication analysis

Prolonged air leak was defined as an air leak lasting longer than seven days. Patients with PAL or residual pleural space or those who were readmitted to the hospital due to empyema underwent routine FOB to rule out bronchopleural fistula (BPF). In the postoperative period, patients who met at least three of the following criteria were considered to have postoperative respiratory failure: *(i)* respiratory rate >25 breaths per min, *(ii)* active use of accessory respiratory muscles, *(iii)* paradoxical abdominal movement, *(iv)* partial

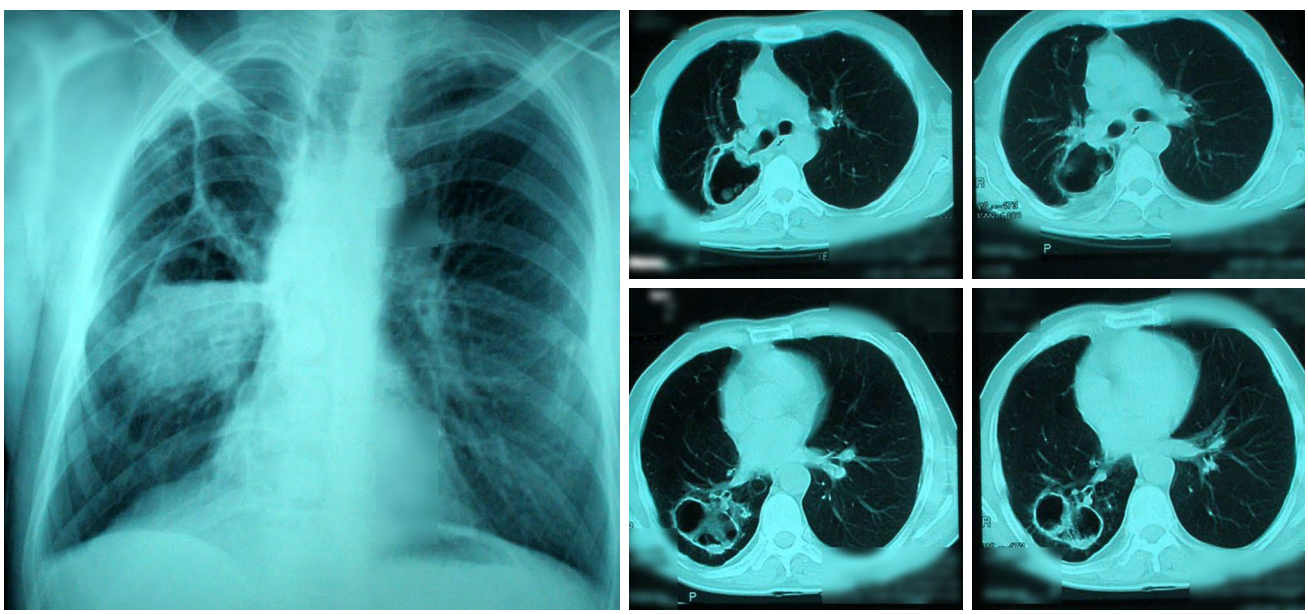

Figure 1. A 46-year-old immunocompetent male patient with a history of pulmonary tuberculosis. It was diagnosed as complex aspergilloma based on chest imaging examinations and thoracotomy findings. Right upper bilobectomy was performed.

pressure of oxygen (PaO_2) <60 mmHg in room air, *(v)* PaO_2/fraction of inspired oxygen (FiO_2) below 250 mmHg with oxygen supplementation, or *(vi)* PaO_2 above 50 mmHg, and *(vii)* abnormal findings on chest radiography (i.e., alveolar consolidation, atelectasis, or interstitial pulmonary edema). In the present study, BPF, empyema, acute postoperative respiratory failure, and hemorrhage requiring thoracotomy were accepted as major complications, whereas PAL, residual pleural space, atelectasis, and wound infection were accepted as minor complications. Surgical mortality was defined as mortality associated with any surgical complication occurring within the first 30 days after surgery or causing prolonged hospitalization.

Statistical analysis

Statistical analysis was performed using the IBM SPSS for Windows version 23.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. The Student t-test was used for comparisons of the groups. The Pearson chi-square test was used for the analysis of qualitative variables, while the Fisher exact test was used if the sample size of the group was small. Non-parametric variables were compared using the Mann-Whitney U test. A p value of <0.05 was considered statistically significant.

RESULTS

Demographic and clinicopathological data of the patients are provided in Table 1. According to the type of aspergilloma, 25% of patients (n=22) had SA, and 75% (n=66) had CA. In the first period, the rate of SA was 18.2% (n=8) and the rate of CA was 81.8% (n=36), whereas in the second period, it was 31.8% (n=14) and 68.2% (n=30), respectively (p=0.140).

Underlying pulmonary disease

Of the patients, 88.6% (n=78) had underlying pulmonary disease. Tuberculosis was the most common underlying disease (n=64, 72.7%). Moreover, five patients had a history of pulmonary surgery within the last 10 years, four had bronchiectasis, two had bullous lung disease, two had cavitary lung cancer, and one had a hydatid cyst as the underlying condition. The remaining 10 patients (11.4%) did not have any predisposing conditions for PA.

The number of patients with underlying pulmonary disease in the first period was statistically higher than that in the second period (95.5% *vs.* 81.8%, respectively; p=0.01). The rate of history of tuberculosis was higher among patients in the first period than that in the second period (84.1% *vs.* 61.4%, respectively; p=0.01).

Symptoms

Of the cases, 83 (94.3%) were symptomatic, while the remaining cases (n=5, 5.7%) were asymptomatic. The most common symptom was hemoptysis (69.3%, n=61). Of these cases, two (3.2%) underwent emergency thoracotomy due to massive hemoptysis.

There was no significant difference between periods and the types of aspergilloma in terms of symptoms (p=0.360 and p=0.595, respectively). Although there was no significant difference in terms of the presence of hemoptysis between the periods (77.3% in the first period, 61.4% in the second period, p=0.106), hemoptysis was more frequent in patients with CA than those with SA (77.3% *vs.* 45.5%, respectively; p=0.005).

Type of surgical resection

The most common surgery was lobectomy (n=67, 76.1%) (conventional lobectomy, n=52; bilobectomy, n=7; and lobectomy and concomitant segmentectomy, n=8), followed by wedge resection in 15 (17.0%) patients and pneumonectomy in six (6.8%) patients. In the second period, six patients underwent VATS (five wedge resection and one lower lobectomy). There was no significant difference between the periods in terms of the type of surgical resection (p=0.506). None of the patients who underwent SA underwent pneumonectomy, while the rate of pneumonectomy was 9.1% in patients with CA (p<0.001).

Complications

In the postoperative period, 43 complications occurred in 29 (33.3%) patients. Ten (11.3%) patients developed more than one complication. The most common complications were PAL (n=13, 12.5%) and empyema (n=7, 7.9%). Other complications included acute respiratory failure (n=5, 5.6%), BPF (n=4, 4.5%), wound site infection (n=4, 4.5%) residual apical space (n=3, 3.4%), hemorrhage requiring thoracotomy (n=3, 3.4%), contralateral pneumothorax (n=1, 1.1%), hoarseness (n=1, 1.1%), atelectasis (n=1, 1.1%), and transudative pleural effusion (n=1, 1.1%).

Age, sex, presence of preoperative symptoms, presence of underlying conditions, and presence of tuberculosis as the underlying condition did not affect the development of complications (Table 2). Although there was no significant difference between wedge resection and lobectomy in terms of complications (33.3% *vs.* 28.4%, respectively; p=0.702), parenchyma-preserving

Table 1. Patient characteristics and comparison between groups according to periods and the types of aspergilloma

	Total			First period (n=40)			Second period (n=40)				SA (n=22)			CA (n=66)			
	n	%	Mean±SD	n	%	Mean±SD	n	%	Mean±SD	*p*	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			45.4±11.2			46.7±10.7			44.0±11.8	0.335			44.1±12.4			45.8±10.9	0.576
Sex																	
Male	69	78.4		38	86.4		31	70.5			16	72.7		53	80.3		
Female	19	21.6		6	13.6		13	29.5			6	27.3		13	19.75		
Preoperative FEV1			67.6±9.2			67.4±9.9			67.7±8.5	0.877			73.2±9.0			65.7±8.6	**0.001**
The presence of underlying disease	78	88.6		42	95.5		36	81.8		0.04	14	63.6		64	97.0		<0.001
History of tuberculosis	64	72.7		37	84.1		27	61.4		0.01	12	54.5		52	78.8		**0.02**
Asymptomatic patients	5	5.7		1	2.3		4	9.1		0.360	2	9.1		3	4.5		0.595
Hemoptysis	61	69.3		34	77.3		27	61.4		0.106	10	45.5		51	77.3		**0.005**
Type of aspergilloma										0.140							-
Simple	22	25.0		8	18.2		14	31.8			-	-		-	-		
Complex	66	75.0		36	81.8		30	68.2			-	-		-	-		
The type of surgical resection										0.506							**<0.001**
Wedge resection	15	17.0		7	15.9		8	18.2			13	59.1		2	3.0		
Lobectomy	67	76.1		33	75.0		34	77.3			9	40.9		58	87.9		
Pneumonectomy	6	6.8		4	9.1		2	4.5			-			6	9.1		
Length of hospital stay (days)			11.6±6.0			11.9±5.7			11.3±5.7	0.821			10.9±1.3			12.4±2.6	0.545
Re-hospitalization	21	23.9		13	29.5		8	18.2		0.211	4	18.2		17	25.8		0.573

SA: Simple aspergilloma; CA: Complex aspergilloma; SD: Standard deviation; FEV1: First second of forced expiration; Boldface indicates statistical significance.

Table 2. Factors affecting complications and mortality

	Complication (n=29)			Mortality (n=5)		
Risk factor	n	%	*p*	n	%	*p*
Sex			0.818			0.581
Male	22	31.8		5	7.2	
Female	7	36.8		0	0	
Type of aspergilloma			0.513			0.325
Simple	6	27.3		0	0	
Complex	23	34.8		5	7.2	
Period			0.257			1.000
First	17	38.6		3	6.8	
Second	12	27.3		2	4.5	
Preoperative symptom			1.000			1.000
Yes	27	32.5		5	6.0	
No	2	40.0		0	0	
Underlying disease			0.724			1.000
Yes	25	32.1		5	6.4	
No	4	40.0		0	0	
Underlying disorder tuberculosis			0.287			0.611
Yes	19	29.7		3	4.7	
No	10	41.7		2	8.3	
Resection type			**0.01**			**0.03**
Wedge or lobectomy	24	29.3		3	3.7	
Pneumonectomy	5	83.3		2	33.3	

Boldface indicates statistical significance.

resections (lobectomy and wedge resection) were significantly associated with a lower rate of complication compared to pneumonectomy (29.3% *vs*. 83.3%, respectively; p=0.01) (odds ratio [OR]=12.083, 95% confidence interval [CI]: 1.340-108.954).

Patients in the first period had a higher complication rate than those in the second period (38.6% *vs*. 27.3%, respectively), although there was no statistically significant difference between the two periods (p=0.257). The complication rate was lower in patients with SA than in those with CA (27.3% *vs*. 34.8%, respectively; p=0.513).

Major complications occurred in 15 patients (17.0%). Patients in the first period had a higher major complication rate than those in the second period (22.7% *vs*. 11.3%, respectively), although this difference was not statistically significant (p=0.156). The major complication rate was lower in patients with SA than in those with CA (4.5% *vs*. 21.2%, respectively), although the difference was not statistically significant (p=0.102). All patients who developed BPF had CA, and the risk factor that was significantly associated with the development of BPF was pneumonectomy (3.0% after lobectomy *vs*. 33.3% after pneumonectomy, respectively; p=0.01).

Mortality

The overall mortality rate was 5.7% (n=5). Two deaths occurred after lobectomy, of which one was complicated by pneumonia and the other by pulmonary embolism, and one death occurred after right upper bilobectomy complicated by empyema with BPF and respiratory failure. Of the six patients who underwent pneumonectomy, two died. One patient after right pneumonectomy was diagnosed with BPF and empyema during the postoperative period, and the patient died on postoperative Day 52 due to multiple organ dysfunction syndrome. One patient, who had a destroyed lung and underwent right pneumonectomy, was complicated by left lung pneumonia and acute respiratory distress syndrome (ARDS), and died.

Age, sex, preoperative symptoms, underlying disease, and history of tuberculosis did not affect mortality. The likelihood of mortality changed in parallel with the type of surgical resection (p=0.01). There was no significant difference between wedge

resection and lobectomy in terms of mortality (0% *vs.* 4.5%, respectively; p=0.367). Parenchyma-preserving resection (lobectomy and wedge resection) was significantly associated with a lower mortality rate (3.7% *vs.* 33.3%, respectively; p=0.03) (OR=13.167, 95% CI: 1.692-102.470).

There was no significant difference between the periods and types of aspergillomas in terms of mortality (p=1.000 and p=0.325, respectively) (Table 2).

Follow-up

During follow-up, three patients (3.4%) in the CA group developed recurrent disease. They suffered from PAL complications, and two of them had a residual apical space concomitantly in the early postoperative period. The recurrence rate was 4.5% (n=2) in the first period and 2.2% (n=1) in the second period. Two patients underwent upper lobectomy, and one underwent upper bilobectomy.

DISCUSSION

Pulmonary aspergilloma often develops in a preexisting cavity in the lung tissue.[12] It may be complicated by many cavitary lung diseases, such as tuberculosis, fibrocystic sarcoidosis, tumors, pulmonary fibrosis, lung abscess and bronchiectasis, bronchial cyst, hydatid cyst, histoplasmosis, pulmonary infarction, and infections.[5-7,13,14] Tuberculosis has been reported as the most common underlying disease causing cavitary lesions in all published series of patients from Europe and Asia.[1,2,5-7,13,14] In a study of 544 cases with cavitary pulmonary lesions secondary to tuberculosis, the rate of PA based on radiological evidence was reported to be 11% in the first year, and this rate increased to 17% after three years.[14] In the present study, the most common underlying disease was tuberculosis, and a history of tuberculosis was less common in the second period (84.1% *vs.* 61.4%). Ten (11.3%) patients did not have any history of underlying disease, and there was an increase in patients who had a PA with no underlying disease (4.5% for the first period and 18.2% for the second period). Similarly, Regnard et al.[2] reported attenuation in the statistical relationship between aspergilloma and tuberculosis in recent years (81.8% in the first 10 years, 60.4% in the last 10 years) and an increase in the prevalence of aspergilloma in the absence of an underlying condition (2.2% in the first 10 years, 13.9% in the last 10 years). In another study, most PAs that occurred during the recent period developed in patients without a history of tuberculosis.[10] This finding can be attributed to the decreased incidence of tuberculosis in recent years or easy access to anti-tuberculosis medications. Moreover, while comparing the first and second periods, we observed that the rate of SA increased in the second period (from 18 to 31%). Similar to the present study, another study indicated that the prevalence of CA significantly decreased over the years (from 80 to 41%).[10]

It has been reported that the most common symptom associated with PA is hemoptysis in the published series,[3-5,15] which occurred in 69.3% of patients in the present study. The rate of hemoptysis decreased by approximately 16% over time, although the difference was not significant. Similarly, in one study, it did not change significantly between two periods (41.6% during 1992-1997, 54.5% during 1998-2009).[10] In PA, the presence of progressive pulmonary fibrosis and cavitary lung disease may explain the absence of a significant decrease in the rate of hemoptysis. The results of the present study confirm that surgery is effective in stopping hemoptysis, and none of our patients presented with recurrence of hemoptysis after surgery.

In the current study, we observed that the incidence of asymptomatic forms of PA increased in the recent period (9.1%), compared to that of the previous period (2.3%), although the difference was not significant. Lejay et al.[10] explained the reason for the increase in asymptomatic patients using a resolute surgical approach. In addition, this may be attributed to the fact that patients have easier access to healthcare and that PAs, which do not yet cause symptoms, are detected more incidentally. However, there is no strong evidence to support this hypothesis.

Similar to the present study, lobectomy is the most commonly performed resection.[1,2,4,16] It has been shown that parenchyma-preserving surgical procedures (lobectomy or wedge resection) are more often performed in patients with SA, and all patients undergoing pneumonectomy are in the CA group. Although the prevalence of CA has decreased over the years, the type of surgical resection does not show any difference. This can be attributed to the decrease in CA prevalence, which was statistically non-significant.

The rate of complications ranges from 15 to 63% in previous studies.[5,7,17,18] The rates of complications in the present study were comparable (32.9%). The rate of complications is reported to be 25 to 80% in patients undergoing pneumonectomy.[1,2,19] Although there was no significant difference between wedge resection and lobectomy in terms of complications (33.3% *vs.* 28.4%), it was found that the risk of developing complications in patients who underwent pneumonectomy was

12 times higher. Pneumonectomy for PA is a high-risk technique. Conversely, the complications were not related to the radiological type of aspergilloma, periods, or underlying disease. However, the complication rate decreased over the years. Due to inflammatory reactions caused by aspergilloma, tissue planes are disrupted, pleural obliteration develops, and hilar structures become firm. As a result, it was thought that there was no change in the rate of complications between periods. Moreover, it should be noted that there was no significant change in the type of surgical resection between the two periods. This led to no change in the overall complication rates.

In contrast, we found that the rate of major complications decreased by two folds in the second period compared to that in the first period. This may be attributed to some changes in the surgical details and management of patients in the second period. Since the bronchial stump was always covered with a parietal pleura flap or pericardial fat after surgical resection in the last 10 years, BPF was not developed in patients who underwent pneumonectomy in the second period. With the maneuvers of the pleural space reduction and prevention of parenchyma leaks, we observed a decrease in both the rates of PAL (18.1% in the first period and 11.4% in the second period) and residual apical space (6.8% in the first period and 0% in the second period) in the second period. Since a preoperative respiratory exercise program was created to provide the best respiratory function before the surgery, there was a decrease in the number of patients who developed postoperative respiratory failure between the two periods (9.0% in the first period and 2.2% in the second period).

Although some studies have suggested that complications are more frequent in CA, some studies report no significant difference between the radiological groups.[5-7,17-20] The lack of a significant difference can be explained by the presence of parenchymal infection in both types of aspergilloma and the inflammatory nature of aspergilloma. Although statistically non-significant, the present study showed that complications were more frequent in the CA group. Considering the increased prevalence of SA in recent years, it may be suggested that the rate of complications would be reduced in the ensuing years. In the published successive reports by the same team from France, statistical significance was reached in their recent report in terms of morbidity (bleeding, pleural space problems, prolonged hospital stay), although it was not reached in their previous experience.[9,10] Between the two periods, there was a double increase in the rate of SA, probably secondary to the double decrease in the rate of major complications. Although this difference was not statistically significant, it can be speculated that it would be significant with the increase in the number of patients.

The mortality rate ranges from 1 to 4.4% in previous studies.[7-20] The rate of surgical mortality is slightly higher than that reported in the recent literature (5.6%). However, there was a downward trend in the second period compared to that in the first period (4.5% *vs*. 6.8%). An increase in the number of patients with SA may explain the decrease in the mortality rate observed in recent years. Although statistically non-significant, the mortality rate was higher in patients with CA (7.2% *vs*. 0%). This may indicate that the decrease in the rate of major complications in the second period is effective in decreasing mortality. Furthermore, there has been a decrease in the mortality rate for PA over the years, which can be attributed to meticulous preoperative patient preparation and some changes in the perioperative procedures mentioned above in the second period.

During the follow-up period, three (3.4%) patients developed recurrent disease, and they had CA in the first operation. Interestingly, all these patients suffered from a PAL complication, and two of them had a concomitant residual apical space. The rate of recurrence showed a downward trend in the second period (4.5% in the first period and 2.2% in the second period). In published studies, the recurrence rate varies between 0 and 18%, and it is related to the differences in the radiological characteristics of patients in these studies and the type of surgical resections performed.[21-24]

In conclusion, surgery is still the mainstay of treatment for pulmonary aspergilloma, as there is no effective alternative treatment. Although hemoptysis is still the most common symptom, the number of asymptomatic patients has been increasing. Patients undergoing surgery for pulmonary aspergilloma in the last decade have a lower history of tuberculosis than those operated in the past 10 years, there was no change in postoperative complications and mortality rates. The rate of complications did not significant differ according to the type of aspergilloma. Nevertheless, mortality was higher in patients with complex aspergilloma than patients with simple aspergilloma. With an increase in the incidence of SA, surgery for aspergilloma may offer more satisfactory early and long-term results in the future.

Ethics Committee Approval: The study protocol was approved by the Yedikule Chest Diseases and Thoracic Surgery Training and Research Hospital Institutional Review Board (No: 281-6). The study was conducted in accordance with the principles of the Declaration of Helsinki.

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

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

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