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Original Article / Özgün Makale

Factors affecting complication rates of pneumonectomy in destroyed lung

Harap akciğerde pnömonektominin komplikasyon oranlarını etkileyen faktörler

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ABSTRACT

Background: This study aims to investigate the relationship between characteristics of patients who were performed pneumonectomy for destroyed lung and their surgical procedures with postoperative complications.

Methods: Thirty-nine patients (19 males, 20 females; mean age 35 years; range, 6 to 71 years) who were performed pneumonectomy with a diagnosis of destroyed lung between February 2007 and October 2014 were retrospectively evaluated. Patients were divided into two as those who did not develop any postoperative complication (group 1) and those who developed a postoperative complication (group 2). Patients' characteristics and details of the surgical procedures were compared between the two groups.

Results: Twenty-nine patients (74%) were performed left pneumonectomy. Mean duration of hospital stay was nine days. During the postoperative three-month follow-up period, morbidity and mortality were reported for 13 patients (33.3%) and one patient (2.6%), respectively. No significant difference was found between groups 1 and 2 in terms of age, gender, concomitant diseases, spirometric findings, blood transfusion status, surgical resection width or methods of bronchial stump closure.

Conclusion: Low albumin levels increased the risk of developing postoperative complications in patients who were performed surgical resection for destroyed lung. Postpneumonectomy morbidity and mortality rates were at acceptable levels. Pneumonectomy should not be avoided as surgical treatment in eligible patients with destroyed lung.

Keywords: Complication; destroyed lung; pneumonectomy.

ÖZ

Amaç: Bu çalışmada harap akciğer nedeniyle pnömonektomi uygulanan hastaların özellikleri ve cerrahi prosedürleri ile ameliyat sonrası komplikasyonlar arasındaki ilişki araştırıldı.

Çalışma planı: Şubat 2007 - Ekim 2014 tarihleri arasında harap akciğer tanısı ile pnömonektomi uygulanan 39 hasta (19 erkek, 20 kadın; ort. yaş 35 yıl; dağılım, 6-71 yıl) retrospektif olarak değerlendirildi. Hastalar ameliyat sonrası komplikasyon gelişmeyenler (grup 1) ve komplikasyon gelişenler (grup 2) olarak ikiye ayrıldı. Hastaların özellikleri ve cerrahi prosedürlerin detayları iki grup arasında karşılaştırıldı.

Bulgular: Yirmi dokuz hastaya (%74) sol pnömonektomi uygulandı. Hastanede kalış süresi ortalama dokuz gün idi. Ameliyat sonrası üç aylık izlem döneminde morbidite ve mortalite sırasıyla 13 (%33.3) ve bir hastada (%2.6) bildirildi. Grup 1 ve 2 arasında yaş, cinsiyet, ek hastalıklar, spirometrik bulgular, kan transfüzyon durumu, cerrahi rezeksiyon genişliği ve bronş güdüğü kapama yöntemleri açısından anlamlı farklılık bulunmadı.

Sonuç: Harap akciğer nedeniyle cerrahi rezeksiyon uygulanan hastalarda düşük albumin düzeyleri ameliyat sonrası komplikasyon gelişme riskini artırdı. Pnömonektomi sonrası morbidite ve mortalite oranları kabul edilebilir düzeylerde idi. Harap akciğerli uygun hastalarda cerrahi tedavi olarak pnömonektomiden kaçınılmamalıdır.

Anahtar sözcükler: Komplikasyon; harap akciğer; pnömonektomi.

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Destroyed lung is a term used to describe a radiologically-defined, irreversible disease, which is physiologically characterized by an obvious decrease in the ventilation to perfusion ratio. While the most commonly reported underlying cause of destroyed lung is tuberculosis, the other benign factors involved in the etiology of destroyed lung include bronchiectasis, bullous emphysema, aspergilloma, chronic interstitial pneumonia and organized pneumonia.[1-5] Complications such as massive hemoptysis, empyema, secondary fungal infections, secondary amyloidosis, pulmonary systemic shunting and respiratory failure negatively affect the quality of life of patients with destroyed lung and pneumonectomy may become necessary. Pneumonectomy is a high-risk surgical procedure, which may result in mortality and morbidity. In the literature, there are only a few studies investigating surgical repair of the destroyed lung. In the reported series, postoperative morbidity and mortality rates ranged between 9.6% to 45.7% and 1.1% to 6.8%, respectively.[6-8] Bronchopleural fistula and subsequently, postpneumonectomy empyema represent the most feared complications of pneumonectomy. The presence of preoperative empyema and aspergilloma cavity, right side localization and the need for re-thoracotomy for revision are the conditions reported to be associated with the complications.[6-9] On the other hand, there is no consensus on the conditions that increase the complication risk.

Therefore, in this study, we aimed to investigate the relationship between characteristics of patients who were performed pneumonectomy for destroyed lung and their surgical procedures with postoperative complications.

PATIENTS AND METHODS

Patient group

The present study was conducted as a retrospective cohort study in Süreyyapaşa Chest Diseases and Thoracic Surgery Training and Research Hospital. Records of all operations performed between February 2007 and October 2014 were reviewed and 39 patients (19 males, 20 females; mean age 35 years; range, 6 to 71 years) were included who had been diagnosed with destroyed lung based on clinical symptoms and radiological findings and undergone pneumonectomy. The study was conducted in accordance with the principles of the Declaration of Helsinki.

A total of 441 pneumonectomies were performed within the same period. In our institution, we perform approximately 63 pneumonectomies per year and destroyed lung surgery rate is 3.6%. Eight patients (21%) had hypertension. Twenty-six patients (67%) had never smoked. All patients had a history of infections that required more than two hospitalizations per year. Based on the recorded spirometric findings of all patients, mean forced expiratory volume (FEV_1) was 1.5±0.8 L, 50±19% of predicted. In two patients with limited respiratory reserve, the decision of operation was established based on maximal oxygen uptake (VO_{2max}) values which were calculated as 16 and 21. Ventilation-perfusion ratios ranged between 1 to 16%. Preoperative complete blood counts showed that the mean hemoglobin level was 11.9±1.6 g/dL. Mean serum albumin and lactate dehydrogenase (LDH) levels were 3.6±0.6 g/dL and 181±55 U/L, respectively. Preoperative blood transfusion was given to 24 patients (62%). Table 1 shows the demographical characteristics and laboratory findings of all patients.

Decision for the operation

In our hospital, the decision for operating on destroyed lung in symptomatic patients with conditions such as hemoptysis or frequently recurring infections is given by a committee consisting of thoracic surgeons, thoracic diseases specialists and anesthesiologist. Destroyed lung is diagnosed based on clinical and radiological findings and potential preoperative active infections are excluded by sputum culture assessments and microbiological examinations of acid-resistant bacilli in the sputum. Respiratory reserve is evaluated by spirometric and scintigraphic examinations, and VO_{2max} values are taken into account to determine the eligibility of patients with limited respiratory reserve for the operation. Preoperative blood transfusion is given to the patients who require blood transfusion in order to achieve a target preoperative hemoglobin level of >9 g/dL.

Surgical procedure

In the series presented here, all patients underwent standard posterolateral thoracotomy. In order to reach the bronchus as easily as possible, extrapleural pneumonectomy was performed in patients whose pleural cavity was quite disappeared due to previous infections, and intrapericardial pneumonectomy was preferred in patients in whom the vascular structures could only be reached by opening the pericardium. Twenty-nine (74%) and 10 patients (26%) underwent left and right pneumonectomy, respectively. Of the operations, 11 (28%) were extrapleural and seven (18%) were intrapericardial. For bronchial stump closure, stapler (23%) or manual closure (77%) was used based on the surgeon's intraoperative decision. Bronchial

Table 1. Patient characteristics and preoperative laboratory results

	n	Mean±SD	Range	Min-Max
Age (year)		39±13	6-71	
Gender				
Female	20			
Male	19			
Smoking				
Never smoked	26			
Current smoker	13			
Concomitant disease				
COPD	6			
DM	4			
HT	8			
FEV_1% (L)		1.5±0.8		
Albumin		3.6±0.6		2.4-4.9
Hemoglobin		11.9±1.6		8.4-16.1
Lactate dehydrogenase		181±55		108-310
Affected side of the lung				
Right	10			
Left	29			

SD: Standard deviation; Min: Minimum; Max: Maximum; COPD: Chronic obstructive pulmonary disease; DM: Diabetes mellitus; HT: Hypertension; FEV_1: Forced expiratory volume 1.

stump was closed with horizontal matrix and over-over suture. Following resection, a single drain was placed in the thoracic cavity. After the operation, extubated and intubated patients were all followed-up in the postoperative intensive care unit (ICU) under the supervision of the anesthesiologist.

Study protocol

Medical files of all the patients who were enrolled in the study were reviewed. Demographical characteristics, concomitant diseases, smoking status, preoperative hemoglobin (g/dL), serum albumin and lactate dehydrogenase levels, and spirometric findings of all patients were recorded. Duration of the operation, duration of stay in the ICU and duration of hospital stay were recorded. Postoperative follow-up and complete follow-up notes of all patients were reviewed to identify complications.

Pneumonectomies were examined in two groups as extrapleural and intrapleural pneumonectomies. Bronchial stump closures were separated into two groups as those performed using stapler or suture materials (such as polyglactin 910=Vicryl, polypropylene=prolene, polydioxanone). The patients were divided into two groups based on the development of complications as those who did not develop any complication (group 1) and those who developed a complication or those who died (group 2). The data recorded were compared according to the development of complications.

Statistical analysis

Statistical Package for the Social Sciences version 16.0 (SPSS Inc., Chicago, IL, USA) was used for the statistical analysis. Data were presented as mean±standard deviation. Parametric data were compared using Student's t-test and non-parametric data were compared using Mann-Whitney U test. Categorical data were evaluated using chi-square test. *P* values <0.05 were considered as statistically significant.

RESULTS

Bronchial stump was closed using stapler in nine patients (23%) and manually in 30 patients (77%).

Table 2. Major pathological findings of pneumonectomy material

Pathological diagnosis	n	%
Bronchiectasis	20	51
Granulomatous inflammation	13	34
Aspergillosis	2	5
Fibrosis	3	8
Bulla	1	2

For manual closure, 3/0 polyglactin 910 was preferred in 16 (41%), 3/0 polypropylene in nine (23%) and 3/0 polydioxanone in five patients (13%). After the resection, a single drain was placed in the thoracic cavity. Mean duration of operation was 4.6 hours (range 1.5-8 hours).

While 36 patients (92%) were discharged, one patient died and two patients were referred to ICU. The patient who died had undergone left intrapericardial pneumonectomy. Mean duration of hospital stay was 9±6.8 days (range, 2-42 days). The most frequently reported pathological findings in the pneumonectomy materials were bronchiectasis (n=20, 51%), tuberculosis (n=13, 34%), fibrosis (n=3, 8%), aspergilloma (n=2, 5%) and bullous lung (n=1, 2%) (Table 2). While nine patients were left intubated after the operation, remaining 30 patients were transferred to the postoperative ICU after being extubated in the operation room. All drains were drawn on the postoperative first day. In addition to nine patients who were left intubated after the operation, three patients considered to have been extubated early were reintubated; thus a total number of 12 patients (31%) needed mechanical ventilation. Mean duration of mechanical ventilation was 23 hours (range, 2-75 hours). Postoperative blood transfusion was given to 24 patients (62%). During the follow-up, 14 patients (38%) developed complications. Complications were arrhythmia in two patients, empyema in one patient, bronchopleural fistula (BPF) in two patients, bleeding in four patients, pneumonia in four patients, and respiratory failure in one patient. All other complications developed within the first 15 days except a case of bronchopleural fistula recorded at day 90 in one patient (Table 3). Six patients (15%) who developed a complication underwent re-thoracotomy (four patients due to bleeding, one patient due to persistent empyema despite drainage and one patient due to BPF). Of the patients who underwent re-thoracotomy due to bleeding, one developed pneumonia (day 16) and the other had respiratory failure (day 4). Mortality was recorded in the postoperative third month in one patient (2.5%). The patient who had received long-term treatment for empyema during the preoperative period and underwent left intrapericardial pneumonectomy with bronchial stump sutured by 3/0 polyglactin 910 was taken into revision surgery on postoperative second day due to the bleeding and died at the 16th hour. Another patient who underwent right pneumonectomy with bronchial stump closed using 3/0 polydioxanone developed a fistula which was closed using cyanoacrylate by rigid bronchoscopy. In our single patient who developed empyema, stoma was opened in the postoperative third week. Comparison of group 1 to group 2 during the follow-up period showed that the two groups were not correlated in terms of gender, smoking history or concomitant diseases. Preoperative FEV1% was lower and the ventilation percentage was higher in group 2 compared to group 1; the differences being statistically insignificant. Preoperative hemoglobin and LDH levels did not affect the risk of developing complications. Mean albumin levels were 3.8 and 3.3 in groups 1 and 2, respectively; hence, low albumin level was found to increase the complication rate (p=0.016). Preoperative blood transfusions and resection width did not increase the risk of

Table 3. Postoperative complications and time of onset

Complication	n	Day
Arrhythmia	2	Day 2, Day 4
Empyema	1	Day 13
Bronchopleural fistula	2	Day 2, Month 3
Bleeding	4	Day 1
Pneumonia	4	First 7 days
Respiratory failure and pneumonia	1	Day 1

Table 4. Association between complication development and characteristics of patients and operation

	Group 1 (No comp) (n=25)			Group 2 (Comp) (n=14)			
	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			35±12			42±15	0.109
Gender							
Female	14			6			0.514
Male	11			8			
Smoker/non-smoker	8/17			5/9			0.813
COPD	4	16		2	14		0.887
Diabetes mellitus	1	4		3	21		0.123
Hypertension	3	12		5	36		0.109
FEV_1%			53±19			46±20	0.386
Albumin			3.8±0.5			3.3±0.6	0.016
Hemoglobin			12.1±1.6			11.5±1.5	0.244
Lactate dehydrogenase			189±50			166±64	0.372
Right/left	7/18			3/11			0.711
Preoperative blood tx	17	68		7	50		0.318
Width of the resection							
Normal	13	52		8	57		0.223
Extrapleural	9	36		2	14		
Intrapericardial	3	12		4	29		
Duration of operation			4.4±2.0			5.4±2	0.171
Stump closure							
Polydioxanone	3	12		2	14		0.494
Prolene	4	16		5	36		
Vicryl	12	48		4	29		
Stapler	6	24		3	21		
Pathology							
Tuberculosis	8	32		5	36		0.940
Bronchiectasis	13	52		7	50		
Aspergillus	1	4		12	7		
Bulla	1	4		0	0		
Fibrosis	2	8		1	7		

SD: Standard deviation; COPD: Chronic obstructive pulmonary disease; FEV_1: Forced expiratory volume 1.

complication. Although not statistically significant, the duration of the operation was longer in group 2.

The most commonly used suture in the manual bronchial stump closure, polyglactin 910 (n=16), was compared with stapler (n=9) in terms of fistula development. No statistically significant difference was found between these two methods in terms of the development of complications. The mode of leaving the operation room (intubated/extubated) and the need for postoperative blood transfusions were not significantly different between the groups. Furthermore, rates of pathological diagnoses were also similar between the groups (Table 4).

DISCUSSION

In the previous publications of the destroyed lung, the most frequently reported causes of pneumonectomy were active tuberculosis, sequelae tuberculosis and multidrug resistant tuberculosis. Advances in the treatment of tuberculosis and improved life conditions gradually decreased the incidence of tuberculosis-related destroyed lung.[1-3,5] Kim et al.,[2] Bai et al.,[10]

Byun et al.,[11] Shiarashi et al.,[8] Blyth[6] and Halezaroglu et al.[9] previously reported the pneumonectomy procedures they performed due to active and sequelae tuberculosis, tuberculosis, aspergilloma, bronchiectasis and active tuberculosis, and bronchiectasis, tuberculosis and aspergilloma, respectively. Today, the most commonly observed etiological factor of the destroyed lung is the diagnosis of bronchiectasis. In the presence of bronchiectasis, the most common reasons of destroyed lung development are the superinfections caused by mycobacterial organisms such as Mycobacterium avium, and multidrug resistance.[12] In our series, the most common etiological cause was bronchiectasis.

The symptoms of destroyed lung include hemoptysis and frequently recurring infections, regardless of the underlying disease.[6,9,11-13] In line with the literature, hemoptysis and frequently recurring infections were the most common symptoms recorded in our patients.

Preoperative examination, particularly the presence of sufficient respiratory reserve before pneumonectomy, provides an insight about the postoperative course of a patient. In the literature, mean FEV1 was reported to vary between 1.6 and 1.7 L. In our study, this value was 1.5 L, similar to the value reported by Kim.[2,8,10,11]

Destroyed lung is reported to occur more commonly in the left than right side. Major causes of this fact include the difficulty to drain the secretions in the narrow and long left main bronchus, limited peribronchial space due to the proximity to the aorta and high predisposition to obstruction.[11] Consistent with this definition and data available in the literature, destroyed lung was the left lung in 29 (74%) of our patients. There are some technical differences between pneumonectomy for destroyed lung and pneumonectomy for lung cancer which effects postoperative complications because of the underlying reason of destroyed lung which is chronic inflammatory diseases. Mostly extrapleural and/or intrapericardial approach which is the most important factor as increased morbidity and mortality is necessary for pleural adhesions and dissection of hilus in destroyed lung pneumonectomy. We present this study since it is quite rare to see such cases in daily practice after enhanced treatment of infection diseases. Of our 39 cases of pneumonectomy, resection was extrapleural in 11 and intrapericardial in seven. All patients who underwent intrapericardial pneumonectomy had the operation in the left side. Among the patients who underwent extrapleural pneumonectomy, eight had left and the remaining three had right extrapleural pneumonectomy. Differently from the literature, the rate of extrapleural pneumonectomy, which is not commonly preferred (9.3%-43%) due to the risk for bleeding,[2,9] was 28% in our series. The rate of intrapericardial pneumonectomy, which was very low in the literature, was 18% in our series. While Shirashi et al.,[8] reinforced the bronchial stump with latissimus dorsi muscle in all patients; Kim et al.,[2] Halezaroglu et al.,[9] and Byun et al.,[11] reported that when required, it could also be supported by the mediastinal pleura, pericardium or intercostal muscle at the surgeon's preference. For manual closure of the bronchial stump, Blyth et al.,[6] frequently used prolene and Vicryl, whereas Kim et al.,[2] and Halezaroglu et al.,[9] commonly preferred the Vicryl. Although we mostly preferred Vicryl, we also used prolene and stapler in some patients. These materials did not cause any difference in terms of the development of bronchopleural fistula. Some authors reported that they perform irrigation with antiseptics to their patients who underwent pneumonectomy particularly for aspergilloma or suppurative lung disease.[2,8,9] However, this is not a routine practice in our clinics.

While morbidity rate was 35.8% in our study, those previously reported in the literature range between 9.6% and 39.7%.[2,6,8,9,11] We believe that the currently available advanced suture materials, the surgeons' experiences of long years, the selection of right antibiotic for the right case and a cautious preoperative preparation strongly decrease the morbidity rates.

Despite the mortality rates ranging between 1.1% and 6.8% in the literature,[2,6,9-11] the mortality rate in our series was 2.5%. As mentioned before, the most feared postoperative complications of pneumonectomy include empyema and bronchopleural fistula, but we followed-up our patients most commonly for bleeding and pneumonia. While the rate of empyema ranged between 4.2% and 16.7% in the previous series,[2,6,8,9,11] it was 2.5% in our series. In our series, the rate of bronchopleural fistula was 2.5%, which was lower compared to those reported by Kim et al.,[2] (7.4%), Halezaroglu et al.,[9] (5.1%) and Byun et al.,[11] (6.9%). Some publications reported that the factors that cause the development of postoperative complications include the presence of preoperative empyema, aspergilloma cavity, excessive intraoperative bleeding, right side localization and re-thoracotomy for revision.[5] However, based on our data, no significant correlation exists between these factors and the complications. In the cases of destroyed lung, pulmonary-systemic shunt is very common and respiratory functions are improved upon resection of the destroyed lung. Pneumonectomy is a high-risk procedure for the treatment of a benign infectious pulmonary disease. The ultimate goals of performing such a high-risk surgery are to resolve

the complications of the disease and to increase the expected quality of life of the patient.[14,15] When making a decision for pneumonectomy, the complications of the destroyed lung and the potential postoperative complications should be carefully weighed against each other.

In conclusion, the morbidity and mortality rates during the postpneumonectomy follow-up of patients with destroyed lung were found to be 35% and 2.5%, respectively, in the present study. While the development of complications was not associated with demographical characteristics of the patients, affected side of the lung, operation type or the method used for bronchial stump closure, low albumin levels were found to be correlated with the complications. In asymptomatic cases, preoperative preparations such as controlling the infections, resolving the malnutrition and eliminating the comorbidities should be performed with caution and only symptomatic patients should be selected for resection.

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REFERENCES

1. Kosar A, Orki A, Kiral H, Demirhan R, Arman B. Pneumonectomy in children for destroyed lung: evaluation of 18 cases. Ann Thorac Surg 2010;89:226-31.
2. Kim YT, Kim HK, Sung SW, Kim JH. Long-term outcomes and risk factor analysis after pneumonectomy for active and sequela forms of pulmonary tuberculosis. Eur J Cardiothorac Surg 2003;23:833-9.
3. Conlan AA, Lukanich JM, Shutz J, Hurwitz SS. Elective pneumonectomy for benign lung disease: modern-day mortality and morbidity. J Thorac Cardiovasc Surg 1995;110:1118-24.
4. Tanaka H, Matsumura A, Okumura M, Iuchi K. Pneumonectomy for unilateral destroyed lung with pulmonary hypertension due to systemic blood flow through broncho-pulmonary shunts. Eur J Cardiothorac Surg 2005;28:389-93.
5. Olgac G, Yilmaz MA, Ortakoylu MG, Kutlu CA. Decision-making for lung resection in patients with empyema and collapsed lung due to tuberculosis. J Thorac Cardiovasc Surg 2005;130:131-5.
6. Blyth DF. Pneumonectomy for inflammatory lung disease. Eur J Cardiothorac Surg 2000;18:429-34.
7. Odell JA, Henderson BJ. Pneumonectomy through an empyema. J Thorac Cardiovasc Surg 1985;89:423-7.
8. Shiraishi Y, Nakajima Y, Koyama A, Takasuna K, Katsuragi N, Yoshida S. Morbidity and mortality after 94 extrapleural pneumonectomies for empyema. Ann Thorac Surg 2000;70:1202-6.
9. Halezeroglu S, Keles M, Uysal A, Celik M, Senol C, Haciibrahimoglu G, et al. Factors affecting postoperative morbidity and mortality in destroyed lung. Ann Thorac Surg 1997;64:1635-8.
10. Bai L, Hong Z, Gong C, Yan D, Liang Z. Surgical treatment efficacy in 172 cases of tuberculosis-destroyed lungs. Eur J Cardiothorac Surg 2012;41:335-40.
11. Byun CS, Chung KY, Narm KS, Lee JG, Hong D, Lee CY. Early and Long-term Outcomes of Pneumonectomy for Treating Sequelae of Pulmonary Tuberculosis. Korean J Thorac Cardiovasc Surg 2012;45:110-5.
12. Toker A, Erus S, Tanju S, Kaya S. Video-assisted thoracoscopic resection for destroyed lung. Ann Thorac Surg 2012;94:632-4.
13. Massard G, Dabbagh A, Wihlm JM, Kessler R, Barsotti P, Roeslin N, et al. Pneumonectomy for chronic infection is a high-risk procedure. Ann Thorac Surg 1996;62:1033-7.
14. Rivera C, Arame A, Pricopi C, Riquet M, Mangiameli G, Abdennadher M, et al. Pneumonectomy for benign disease: indications and postoperative outcomes, a nationwide study. Eur J Cardiothorac Surg 2015;48:435-40.
15. Rhee CK, Yoo KH, Lee JH, Park MJ, Kim WJ, Park YB, et al. Clinical characteristics of patients with tuberculosis-destroyed lung. Int J Tuberc Lung Dis 2013;17:67-75.