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ORIGINAL ARTICLE

Clinical analysis of pneumonectomy for destroyed lung: a retrospective study of 32 patients

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Abstract

Objective Destroyed lung is whole lung destruction secondary to chronic or recurrent lung infections. This clinical condition can result in irreversible changes in the lung parenchyma. In this study, we aimed to evaluate patients undergoing pneumonectomy with a diagnosis of lung destruction in terms of surgical technique, post-operative morbidity and mortality, and long-term outcomes.

Methods A total of 32 patients that underwent pneumonectomy due to a destroyed lung between 2005 and 2017 were retrospectively reviewed. Age, gender, presenting symptoms, etiologies, localization of the destruction, pre-operative medical history, pre- and post-operative respiratory function tests, intraoperative complications and bleeding volume, morbidity and mortality, length of hospital stay, and long-term follow-up outcomes were reviewed for each patient.

Results The study included 32 patients with a mean age of 31.7 ± 10.8 years. All the patients presented with persistent cough, whereas sputum production was presented by 25, hemoptysis by 18, and chest pain by 11 patients. The underlying primary diseases included nonspecific bronchiectasis in 20 (62.5%), tuberculosis in 9 (28.1%), left pulmonary hypoplasia accompanied by Bochdalek hernia in 2 (6.2%), and aspiration of a foreign body lodged in the left main bronchus in 1 (3.1%) patient. Mean operative time was 220.6 ± 40.2 min and mean perioperative bleeding was 450.9 ± 225.7 ml. Post-operative complications occurred in 14.2% of the patients, most commonly including atelectasis associated with stasis of secretions and wound site infection. Mean post-operative hospital stay was 11.8 ± 2.8 days and mean follow-up period was 35.5 ± 28.3 months. A significant clinical improvement was observed in 81.2% of the patients post-operatively.

Conclusions Favorable long-term outcomes were obtained in our patients through careful patient selection and appropriate pre-operative work-up and surgical technique.

Keywords Bronchiectasia · Destroyed lung · Pneumonectomy · Comfort of life

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Introduction

Destroyed lung is defined as whole lung destruction secondary to chronic or recurrent lung infections. This term also refers to a radiological impression characterized by diffuse opacity and large cavitary images in the lung. Destroyed lung is mostly caused by tuberculosis, followed by bronchiectasis and sequelae of necrotizing pneumonia [1]. Since destroyed lung mostly results from tuberculosis, it is more commonly seen in countries with underdeveloped health systems [2]. On the other hand, the underlying chronic suppurative diseases such as bronchiectasis and tuberculosis do not only affect the quality of life of the patients but also may lead to life-threatening complications including massive hemoptysis, empyema, secondary fungal infections, septicemia, and pulmonary–systemic shunting [3].

Pneumonectomy for destroyed lung is the only treatment method that enables symptomatic healing and cure, although it leads to surgical difficulties and post-operative complications [3–5]. Moreover, surgical resection does not only reduce the respiratory symptoms but also leads to a significant improvement in the quality of life of the patients [4]. However, pneumonectomy for destroyed lung is a challenging and critical procedure for thoracic surgeons. Nevertheless, the accumulating knowledge on lung function, anatomy, and advanced surgical techniques have led to a significant reduction in perioperative morbidity and mortality rates in patients with destroyed lung [6, 7].

The aim of this study was to evaluate patients undergoing pneumonectomy with a diagnosis of lung destruction in terms of surgical technique, post-operative morbidity and mortality, and long-term outcomes.

Fig. 1 Pre-operative tomography image

Methods

Study design

The retrospective study included 32 patients that underwent pneumonectomy due to a destroyed lung at the Thoracic Surgery clinic in Van Yuzuncu Yil University Medical School, and Van Training and Research Hospital between 2005 and 2017. Age, gender, presenting symptoms, etiologies, localization of the destruction, medical history, pre- and post-operative respiratory function tests, intraoperative complications and bleeding volume, morbidity and mortality, length of hospital stay, and long-term follow-up outcomes were reviewed for each patient. Pre-operative biochemical and hematological tests followed by bronchoscopic brushing, pleural lavage cytology, and microbiological examination were performed in all the patients except for those who underwent emergency surgery. A tuberculin skin test (TST) and an acid-fast bacillus (AFB) stain in sputum were performed to rule out tuberculosis. A positive AFB result was considered a contraindication for surgery but no positive result was obtained in any patient.

Pre-operative chest radiography and chest computed tomography (CT) was performed in each patient (Fig. 1). A destroyed lung was diagnosed based on the radiographic evidence of irreversible parenchymal destruction, cavitation, fibrosis, diffuse pleural thickening, and presence of adhesions. Moreover, the CT examination was performed to evaluate the compatibility of the patients with regard to adhesions and scar formation, and also to determine the potential risks.

Following the radiographic diagnosis of the patients, a decision of pneumonectomy was made based on several conditions including recurrent infection resistant to medical treatment, chronic cough and sputum production, a history of frequent hospitalization, massive hemoptysis, and reduced daily-life activity.

Pre-operative respiratory function tests included arterial blood gas test, forced expiratory volume in 1 s (FEV1), forced vital capacity (FVC), 6-min walk test (6-MWT), and stairs climbing test. In adult patients, a decision of pneumonectomy was made based on a pre-operative FEV1 value of 2 L or more, or after evaluating the contributing function and the respiratory capacity of the affected lung using a ventilation/perfusion (V/Q) lung scan. Respiratory function tests were also performed in four children who were relatively older and could cooperate well. The remaining four children were evaluated using an exercise tolerance test. The 6MWT was conducted in one of the hospital corridors. Arterial oxygen saturation (SaO2) was measured pre- and post-operatively using finger pulse oximeters and the measurements were recorded at 30-s intervals. All the four patients completed the 6MWT and the lowest SaO2 value recorded throughout the test was 96.5%. During the 6MWT, a desaturation of 2% or higher was considered to indicate a risk status.

An electrocardiogram (ECG) was performed in each patient. Additionally, an echocardiogram was performed in each adult patient to measure the cardiac reserve and pulmonary artery pressure. A routine consultation was made with the cardiology and chest disease departments and with other departments as needed.

In the patients that underwent elective surgery, respiratory physiotherapy was performed for the 10 days before the surgery to improve the respiratory values of the patients and to achieve postural drainage. Purulent sputum volume was reduced by programmed postural drainage and active physiotherapy. The patients were given a high-energy, high-protein, and vitamin-supplemented diet. An antibiotic therapy (depending on the antibiogram in patients with a positive culture antibiogram) and expectorant therapy were administered for 2 weeks prior to the surgery. Each patient was informed about the surgical procedure, risks, and complications, and signed a written informed consent prior to the procedure. The study was accepted by local ethics committee (16.08.2011/27) with waiver of individual patient consent.

Surgical technique

Prior to thoracotomy, the tracheobronchial tree was cleansed using bronchoscopy with bronchoalveolar lavage (BAL) and aspiration, and care was taken to minimize the risk of intraoperative bronchial contamination.

All the surgical procedures were performed under general anesthesia with the patient placed in the lateral decubitus position. In older children ($n=4$) and adults ($n=24$), a double-lumen endotracheal tube was used to avoid the spillage of the infected material into the contralateral bronchus. The younger children ($n=4$) were intubated using a single-lumen tube and were repeatedly aspirated intraoperatively. The standard posterolateral thoracotomy approach was performed in all the patients. In most patients ($n=24$), pneumonectomy was performed in the intrapleural plane since the patients had severe pleural and pleuroparenchymal adhesions. In the remaining patients, due to the adhesions, extrapleural pneumonectomy was performed in five and intrapericardial pneumonectomy was performed in three patients.

Following the initiation of the surgery, the bronchus was cut open and the bronchial stump was made using three rows of 2/0 polyglactin (Vicryl®) absorbable suture “continuous horizontal matrix + over and over continuous suture + single U shape suture”. To prevent fistula development and fix the suture line, the stump was covered with adjacent tissues such as mediastinal pleura and pericardial fat pad. In four patients, lung volume was reduced by rib resection and the stump was reinforced with an intercostal muscle flap. After the surgery, a chest tube was inserted into the pleural space in all the patients.

All the patients except for 4 patients were extubated in the operating room. Following the surgery, the patients were transferred to the intensive care unit and were followed up for the first 24 h. After the 24-h follow-up period, patients with stable vital signs were transferred to the general ward. The chest tube was clamped intermittently to maintain mediastinal stability and the tube was removed if the drainage volume was 300 ml or less within the first 24 h. Post-operative follow-up was performed using chest radiography and CT if needed at months 1, 3, 6, and 12, and every 12 months afterwards.

Results

The study included 32 patients (22 men and 10 women) who were operatively treated due to a destroyed lung between 2005 and 2017. The patients included 8 child patients and had a mean age of 31.7 ± 10.8 (range 12–52) years.

The underlying primary diseases included nonspecific bronchiectasia in 20 (62.5%), tuberculosis in 9 (28.1%), left pulmonary hypoplasia accompanied by Bochdalek hernia in 2 (6.2%), and aspiration of a foreign body lodged in the left main bronchus in 1 (3.1%) patient. Table 1 presents the clinical characteristics of the patients.

All the patients presented with persistent cough during admission, whereas sputum production was presented by 25 (78%), hemoptysis by 18 (56.2%), and chest pain by 11 (34.3%) patients. Duration of symptoms ranged from 3 to 23 years. Signs of chronic infection were present in 13 (40.6%) patients. All the patients had a history of frequent medical visits due to chronic inflammatory symptoms and 17 patients had a history of frequent hospitalization.

Table 1 Clinical characteristics of the patients

Variables	($N=32$)
Age	31.7 (12–52)
Gender	
Male	22 (68.7%)
Female	10 (31.2%)
Side	
Left	26 (81.2)
Right	6 (18.7%)
Etiology	
Bronchiectasis	20 (62.5%)
Tuberculosis	9 (28.1%)
Bochdalek hernia	2 (6.2%)
Foreign body aspiration	1 (3.1%)
Symptom	
Cough	32 (100%)
Sputum expectoration	25 (78%)
Hemoptysis	18 (56.2%)
Chest pain	11 (34.3%)
Pulmonary function (pre-operative)	
FEV1 (L)	1.52 ± 0.06
FEV1 (%)	54% (42–70)
FVC (L)	1.61 ± 0.26
FVC (%)	57% (46–67)

Fev1 forced expiratory volume in 1 s, *FVC* forced vital capacity

Table 2 Treatment period of 32 patients by years

Period (years)	< 1	1–3	3–5	5–8	8 >
Patients (number)	3	11	8	6	4

Table 2 presents the year-based distribution of the medical histories of the patients.

Pre-operative respiratory function tests and arterial blood gas test were performed in 4 child patients and 21 adult patients. Patients with bronchiectasis showed restrictive pattern and the patients with tuberculosis showed obstructive pattern. Mean pre-operative FEV1 was 1.52 ± 0.06 (range 0.66–2.43) L/s and 54% (range 42–70%) of the predicted FEV1, while mean pre-operative FVC value was 1.61 ± 0.26 (range 1.2–2.2) L/s and 57% (range 46–67%) of the predicted value. Due to the negative effect of thoracotomy on pulmonary function in the early post-operative period, the pre-operative FEV1 value in our study was reduced by almost 19% (range 15–20%) at post-operative month 1. A V/Q scintigraphy was performed in 13 adult patients. The contribution of the affected lung to perfusion was remarkably low (mean 5.3%; range 2.8–6.8%).

Elective surgery was performed in 29 patients who were hospitalized and received respiratory physiotherapy for 10 days before the surgery. Sputum analysis and acid-fast bacillus (AFB) testing were performed by bronchoscopic brushing and peritoneal lavage cytology. Among the patients with a history of tuberculosis, only those who were confirmed to have sputum smear negative for AFB underwent surgery. Of the nine patients who were diagnosed with tuberculosis-destroyed lung, three patients were accompanied by empyema. The empyema was drained with a chest tube and the intrathoracic space was washed with povidone-iodine solution every day and these patients underwent surgery after they were confirmed with a negative pleural fluid culture. The most common pathogens isolated from the patients with a destroyed lung associated with bronchiectasis were *Streptococcus pneumoniae*, followed by *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*. All the pneumonectomies were performed after the administration of appropriate antibiotic therapies and sufficient expectoration. However, three patients that had a tuberculosis-destroyed lung underwent emergency surgery due to massive hemoptysis.

Pneumonectomy was applied to the left side in 26 (81.2%) and to the right side in 6 (18.7%) patients. Seventeen patients had partial pleural adhesions, 11 patients had complete pleural adhesions, and 4 patients had no pleural adhesions. Pneumonectomy was performed in the extrapleural plane in five patients due to severe adhesions and division of hilar vessels was performed intrapericardially in 3 patients. Mean operative time was 220.6 ± 40.2 (range 190–370) min and mean perioperative bleeding was 450.9 ± 225.7 (range 280–1450) ml. No intraoperative complication occurred in any patient.

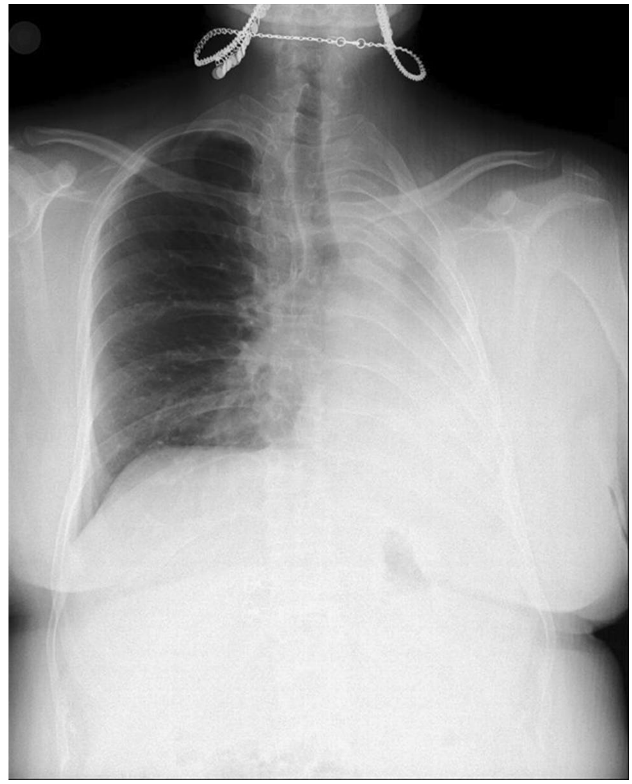

Fig. 2 Post-operative X-ray

Post-operative complications were considered as those occurring within 30 days post-operatively. The complications occurred in 14.2% of the patients, including atelectasis associated with stasis of secretions in 7 and wound site infection in 6 patients. A patient with tuberculosis who underwent right pneumonectomy developed bronchopleural fistula (BPF) on post-operative day 6. The patient died as a result of sepsis and respiratory failure secondary to pneumonia in the follow-up period. Accordingly, overall mortality rate was 3.1% and mean post-operative hospital stay was 11.8 ± 2.8 days in our series.

The follow-up chest radiographs and CT scans indicated a mediastinal shift to the opposite side and marked herniation of the remaining lung (Fig. 1). All the patients were followed up radiographically and clinically in the post-operative period (Fig. 2). On the other hand, although the FEV1 value decreased by 19% at post-operative month 1, a significant improvement was observed in the inflammatory symptoms and the quality of life in 81.2% of the patients. Moreover, all the child patients showed a significant improvement in the respiratory symptoms as well as complete recovery over the long-term follow-up. There was no improvement in the symptoms in 5 (15.6%) patients. Although there were no abnormal radiological findings out of expected changes in chest radiographs, three patients had the symptoms such as a cough and sputum expectoration due to secondary changes related with pneumonectomy. Other two patients who were operated with the diagnosis of the destroyed lung related to bronchiectasis had symptoms and radiological findings of minimally localized bronchiectasis in the remaining contralateral lung. However, the severity and frequency of symptoms were less in the post-operative period. Mean follow-up period was 35.5 ± 28.3 (range 9–180) months. Table 3 presents the intra- and post-operative outcomes of the patients.

Discussion

Destroyed lung, which results from pulmonary infectious diseases and is characterized by diffuse lung destruction, is more commonly seen in developing countries. Moreover, it is also characterized by absent perfusion and ventilation caused by benign inflammatory lung diseases [4, 8]. The most common cause of destroyed lung is tuberculosis, followed by other chronic lung infections including bronchiectasis, chronic interstitial pneumonia, organized pneumonia, and aspergilloma [9, 10]. However, in our study, the most common cause of destroyed lung was nonspecific bronchiectasis, followed by tuberculosis.

Table 3 Operative and post-operative results of the patients

Variables	(*N* = 32)
Operation	
Pneumonectomy	24 (75%)
Extrapleural pneumonectomy	5 (15.6%)
Intrapericardial pneumonectomy	3 (9.3%)
Pleural adhesion	
Partial	17 (53.1%)
Complete	11 (34.3%)
None	4 (12.5%)
Operation duration (min)	220.6 ± 40.2
Blood lost (ml)	450.9 ± 225.7
Intraoperative complication	0 (0%)
Post-operative complication	
Atelectasis	7 (21.8%)
Wound infection	6 (18.7%)
Atrial fibrillation	1 (3.1%)
Pneumonia	1 (3.1%)
Bronchopleural fistula	1 (3.1%)
Hospital stay (days)	11.8 ± 2.8
Mortality	1 (3.1%)
Follow-up period (months)	35.5 ± 28.3
Cure rate (%)	81.2%

Bronchiectasis, which is mostly caused by airflow obstruction, can be caused by numerous factors. In our child patients, bronchiectasis was mostly caused by frequent exposure to pulmonary infections and inadequate medical treatment. Moreover, most of the patients had a history of insufficient and irregular antibiotic use. Literature indicates that enlarged lymph nodes following pulmonary infections or narrowing secondary to thickening of the bronchial lumen increase the progression of the bronchiectasis with pneumonia and destruction, and may result in total pulmonary bronchiectasis [11–13]. The same situation has been shown to occur in children with tuberculosis [14]. Meaningfully, whole lung bronchiectasis can also result from foreign body aspirations over the long term, as in one of our patients.

The primary aim in the surgical treatment of destroyed lung is to resolve the life-threatening complications caused by the disease and to improve the overall quality of life of the patients [4]. Of note, patients with a destroyed lung have a higher risk of developing life-threatening complications including massive hemoptysis, empyema, secondary fungal infections, septicemia, amyloidosis, pulmonary-systemic shunting, and pulmonary hypertension [1]. Therefore, surgery is highly essential in patients with a destroyed lung for the prevention of these complications and the improvement of the quality of life of the patients. Among the surgical techniques performed to date, pneumonectomy has been shown to be the most rapid and effective method for the treatment of serious complications [8, 9, 15]. Additionally, pneumonectomy is the only treatment method that enables symptomatic healing in patients with destroyed lung despite all the surgical difficulties and potential complications [3] and pneumonectomy is absolutely indicated in patients with massive hemoptysis, recurrent infections, and multidrug-resistant tuberculosis [5]. However, bronchiectasia rarely leads to massive hemoptysis and mostly leads to moderate hemoptysis. In our study, three patients that developed massive hemoptysis were operated under emergency conditions and all of them had a tuberculosis-destroyed lung.

In our patients, the left lung was affected in 26 (81.2%) and the right lung in 6 (18.7%) patients. Similar to our study, the other patient series reported that the left lung was more commonly affected than the right lung in patients with the destroyed lung [8, 9]. This difference could be attributed to several reasons. The left main bronchus is anatomically longer and approximately 15% narrower than the right one, the peribronchial space is limited by its proximity to the aorta and is more likely to be obstructed by the enlargement of adjacent lymph nodes, and the left main bronchus has a more horizontal course compared to the right main bronchus, which may have an effect on the drainage of secretions.

Pneumonectomy for an inflammatory lung disease is regarded as a high-risk procedure since it leads to technical difficulties and a relatively higher risk of post-operative complications [16]. Major technical difficulties that complicate resection include anatomical ambiguity of the structures, dense pleural adhesions, and perihilar fibrous thickening. In addition, lymph node enlargement around the vascular structures, which occurs secondary to recurrent infections, and its difficult anatomical dissection may lead to massive bleeding.

Pneumonectomy has been associated with high mortality and high frequencies of post-pneumonectomy empyema and BPF [16]. In addition, pneumonectomy has been associated with high risk of complications in the settings of tuberculosis, right localization, positive sputum culture, pre-operative coexistence of empyema, pleuropneumonectomy, intraoperative pleural contamination, and aspergilloma [1]. In our study, one patient who underwent right pneumonectomy developed BPF and died in the follow-up period.

Minimizing sputum production through the elimination of underlying infections prior to surgery does not only maximize the nutritional status of the patient but also minimizes the chance of intraoperative spillage and decreases the risk of post-operative BPF and post-pneumonectomy empyema. Moreover, using an appropriate closure technique for the bronchial stump and fixing it by adjacent tissues decreases the risk of BPF. In our study, the bronchial stump was closed manually using three rows of 2/0 polyglactin absorbable suture and was covered by adjacent tissue. Nevertheless, despite our sensitivity in stump closure, one patient developed BPF, which could be attributed to predisposing factors such as right localization and history of tuberculosis.

The rate of operative mortality in inflammatory lung diseases has been reported to vary between 4 and 8.5% [16, 17]. In our series, this rate was 3.1%. One patient who had a destroyed lung secondary to tuberculosis underwent right pneumonectomy and developed BPF. The patient developed pneumonia and empyema, and died of respiratory failure in the follow-up period.

Patients with destroyed lung can present with obstructive, restrictive, or mixed respiratory dysfunction [18]. In our study, a restrictive pattern was indicated by the respiratory function tests, particularly in patients with bronchiectasis. This finding could be associated with the diffuse lung damage along bronchopulmonary segments. Several studies indicated that the functional-respiratory parameters were affected negatively within the first 3 months after lung resection. On the contrary, some other studies demonstrated that exercise tolerance improved at an earlier stage and complete healing was achieved in the patients [19]. Due to the negative effects of thoracotomy such as early period pain, the mean FEV1 value was lower in the post-operative 1st month. The symptoms improved significantly beginning from month 1, and patient satisfaction (81.2%) was remarkably high at post-operative month 6.

Pneumonectomy, though a risky intervention, provides favorable outcomes in patients with destroyed lung, leading to a significant improvement in the symptomatic and respiratory functions. Moreover, it also leads to better oxygenation by avoiding shunting after blocking the blood flow into the nonfunctional lung. In our series, most of the patients (62.5%) had a destroyed lung associated with bronchiectasis and also had a history of frequent hospitalization due to recurrent lung infections. In these patients, pneumonectomy led to a significant improvement both in the quality of life and the functional-respiratory symptoms of the patients.

Conclusion

Insufficient antibiotic use and inadequate follow-up in patients with tuberculosis and lung infections form a basis for destroyed lung. A destroyed lung refers to a nonfunctional lung. Our results indicated that pneumonectomy led to a significant improvement both in the quality of life and the functional-respiratory symptoms in the patients whose respiratory reserve could tolerate the surgery. Moreover, pneumonectomy can be useful for the prevention of potential complications.

Author contributions FS, IO and UÇ participated in conception and design. AŞ participated in data analysis and interpretion. FS and IO participated in manuscript writing.

Compliance with ethical standards

Conflict of interest The author has no conflicts of interest to declare.

References

1. Aydın Y, Kaynar H, İntepe YS, Türkyılmaz A, Eroğlu A. Pneumonectomy in destroyed lung cases. Sakarya Med J. 2012;2(2):81–5.
2. Stephen T, Thankachen R, Madhu AP, Neelakantan N, Shukla V, Korula RJ. Surgical results in bronchiectasis: analysis of 149 patients. Asian Cardiovasc Thorac Ann. 2007;15(4):290–6.
3. 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(1):226–31.
4. Yun-Fei WU. Hong Zhi-Peng. Surgical treatment of unilateral destroyed lung. Int J Surg. 2009;36(8):562–5.
5. Yuncu G, Ceylan KC, Sevinc S, Ucvet A, Kaya ŞÖ, Kiter G, et al. Functional results of surgical treatment of bronchiectasis in a developing country. Arch Bronconeumol. 2006;42(4):183–8.
6. Blyth DF. Pneumonectomy for inflammatory lung disease. Eur J Cardiothorac Surg. 2000;18(4):429–34.
7. 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(2):335–40.
8. Halezaroğlu S, Keleş M, Uysal A, Celik M, Senol C, Hacıbrahimoglu G, et al. Factors affecting postoperative

morbidity and mortality in destroyed lung. Ann Thorac Surg. 1997;64:1635–8.
9. Kosasih KA, Amin Z, Amanda AP. Mortality rate of patient with tuberculosis-destroyed lung. Ina J Chest Crit Emerg Med. 2016;3(2):80–5.
10. Eren Ş, Eren MN, Balcı AE. Pneumonectomy in children for destroyed lung and the long term consequences. The J Thorac Cardvasc Surg. 2003;126(2):574–81.
11. Conlan AA, Scott EK. Pneumonectomy for benign disease. In: Deslauries J, Faber LP, editors. Chest surgery clinics of North America. Philadelphia: Saunders; 1999. p. 311–25.
12. Miller JI. Bacterial infections of the lungs and bronchial compressive disorders Shields. In: Thomas W, editor. General thoracic surgery. 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2000. p. 1048–51.
13. Ashour M, Pandya L, Mezraqji A, Qutashat W, Desouki M, Sharif NA, et al. Unilateral post-tuberculous lung destruction: the left bronchus syndrome. Thorax. 1990;45:210–212.
14. Hewitson JP, Oppell UOV. Role of thoracic surgery for childhood tuberculosis. World J Surg. 1997;21:468–74.
15. Conlan AA, Lukanich JM, Shutz J, Hurwitz SS. Elective pneumonectomy for bening lung disease: modern-day mortality and morbidity. J Thorac Cardiovasc Surg. 1995;110:1118–24.
16. 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;62:1033–8.
17. Shiraishi Y, Nakajiama Y, Koyama A, Takasuna K, Yoshida S. Morbidity and mortality after 94 extrapleural pneumonectomies for empyema. Ann Thorac Surg. 2000;70:1202–6.
18. Singh B, Chaudhary O. Trends of pulmonary impairment in persons with treated pulmonary tuberculosis. Int J Med Res. 2015;1(1):8–11.
19. Novoa N, Varela G, Jimenez MF, Aranda JL. Influence of major pulmonary resection on postoperative daily ambulatory activity of the patients. Interact Cardiovasc Thorac Surg. 2009;9:934–8.