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Original Article

Indications and outcomes of pneumonectomy for benign diseases: A single-center experience

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Abstract

Background: Pneumonectomy can be used to manage destroyed lung; however, it is associated with a high risk of complications. This study analyzed the outcomes of pneumonectomy in patients with destroyed lungs.

Methods: The study included 28 patients who had pneumonectomy for benign lung diseases from January 2011 to December 2017. Descriptive analysis was used to present patients' demographics, surgical details, and postoperative outcomes. Intraoperative blood loss was compared in tuberculous vs. non-tuberculous patients and those who had extrapleural vs. intrapleural pneumonectomy.

Results: The study included 11 (39%) males, and the mean age was 36.6 ± 9.8 years (range: 5– 61). The persistent cough was the presenting symptom in 93% of cases, expectoration in 78.6%, hemoptysis in 46.4%, and chest pain in 28.6% of patients. Indications for pneumonectomy were tuberculosis in 13 (46.4%), septic bronchiectasis in 10 (35.7%), invasive opportunistic infections in 3 (10.7%), neglected endobronchial foreign body in 1 (3.6%), and neglected rupture bronchus in 1 (3.6%) patient. Pneumonectomy was left-sided in 21 (75%) patients. We performed extrapleural pneumonectomy in 7 (25%) patients, intra-pericardial isolation in 5 (17.9%) patients, and two patients (7.2%) had completion pneumonectomy. Mean perioperative bleeding was 390.7± 233.8 ml. The intraoperative blood loss was more in patients with tuberculosis and extrapleural pneumonectomy ($P< 0.05$). Postoperative complications occurred in 7 patients (25%), and we reported one operative mortality.

Conclusion: Pneumonectomy for benign lung disease is a challenging procedure. Destroyed lung due to TB and bronchiectasis are the most common indications. The outcome could be improved with careful patient selection, appropriate preoperative preparation, meticulous operative techniques, and high postoperative care standards.

KEYWORDS
Destroyed lung; Pneumonectomy; Bronchiectasis; Benign pneumonectomy; Pulmonary tuberculosis

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Introduction

Several pulmonary diseases have a progressive course that can ultimately destroy the lung parenchyma, a condition known as a destroyed lung. Patients with destroyed lungs usually present with a long history of respiratory symptoms associated with significantly abnormal imaging studies [1]. Pneumonectomy was

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proposed as a treatment option for patients with destroyed lung [2]. It became the main treatment line for benign and destroyed lung diseases such as tuberculosis, bronchiectasis, and suppurative lung disease [3-5]. Pneumonectomy is associated with several complications and should be performed in carefully selected patients [6-8]. However, many surgeons believe that pneumonectomy for benign lung diseases can be performed with acceptable morbidity and mortality [3, 9, 10].

We aimed to describe the preoperative preparation, surgical techniques, and outcomes of pneumonectomy for patients with benign destroyed lungs.

Patients and Methods:

Design:

This research is a retrospective study that included all patients who underwent elective pneumonectomy for benign lung diseases between January 2011 and December 2017. After approval of the Medical Ethics Committee of the University (Reference number: SU-MR-179-2019), the medical files and records of those patients were reviewed and analyzed.

Data

Data collected for each patient included preoperative, operative, and postoperative variables. The preoperative data included patients' demographics, symptoms, etiology, and site of the lung disease, comorbidities, preoperative respiratory function tests, full preoperative hematological, microbiological, and biochemical laboratory tests.

The decision of pneumonectomy was made based on the following criteria; radiological findings on the high-resolution computed tomography (CT) chest scan (Figure 1), the presence of symptoms of chronic pulmonary infection, history of frequent hospitalization, reduced daily activity, and low quality of life assessed with a Questionnaire Assessing the Quality of Life of Patients with Chronic Respiratory Diseases by Jacobs and colleagues [11].

In addition to the radiological findings and clinical symptoms of destroyed lung, the contralateral lung must be healthy without systemic severe medical illness. The CT findings in patients with destroyed lung were decreased volume of the affected lung with or without residual cystic bronchiectasis, herniation of the contralateral healthy lung, a decrease in the diameter of the pulmonary vessels of the affected lung, and hypertrophy of the ribs of the affected side.

All patients with destroyed lung, either with a definite history of tuberculosis (TB) or not, were subjected to complete microbiological workup to exclude the presence of active TB before surgery. Positive detection of TB in sputum or bronchial lavage was considered a contraindication for surgery. The patient started on anti-TB therapy, and we postponed the operation for six months.

We assessed the preoperative respiratory functions either with spirometry, room air arterial blood gas analysis, 6-minutes walk test (6-MWT), stairs climbing test, or ventilation/perfusion (V/Q) lung scan.

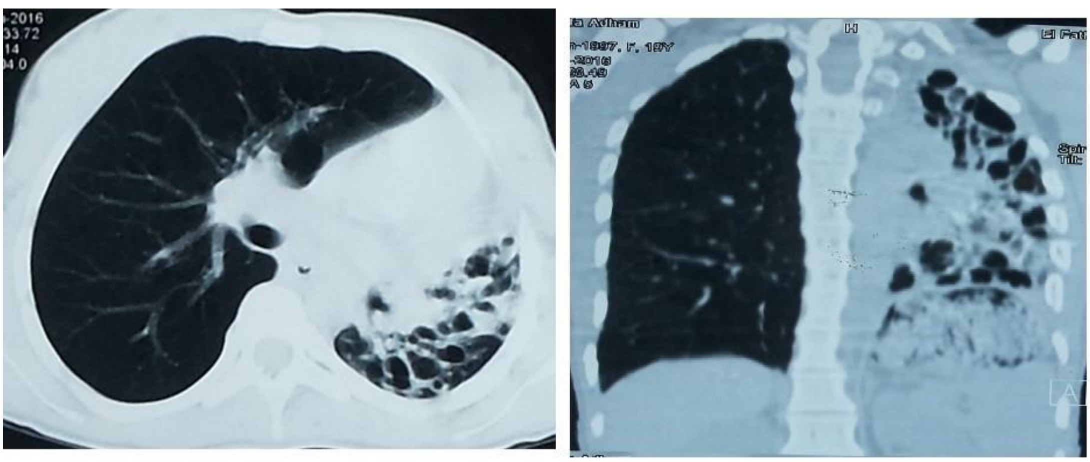

Figure 1: CT chest (axial and coronal views) shows destroyed left lung due to bronchiectasis

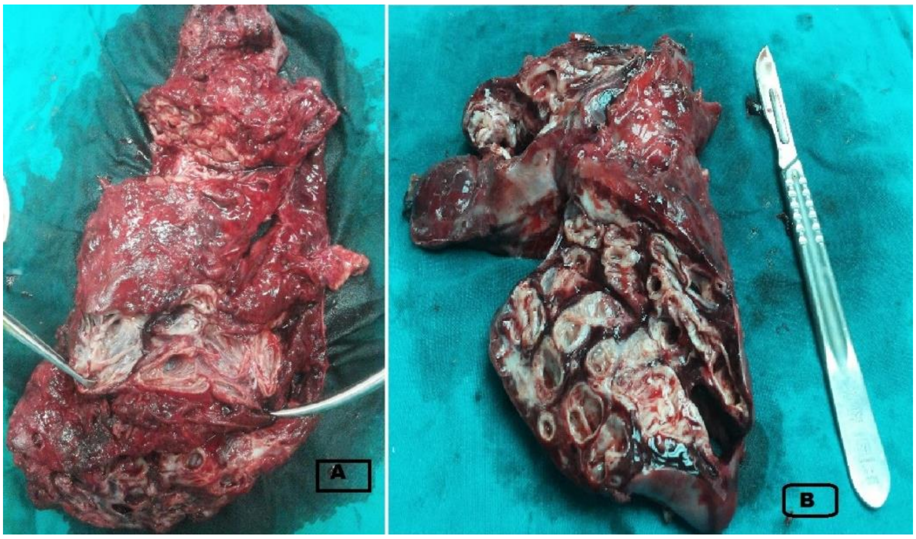

Figure 2: Pneumonectomy specimens; A: TB destroyed lung, B: bronchiectasis destroyed lung

In adult patients with a destroyed lung, if the preoperative FEV1 was less than 1.8L, the decision for pneumonectomy was made based on the V/Q lung scan and diffusion capacity of the lung for carbon monoxide (DLCO), which detected the respiratory capacity of the affected lung.

We evaluated children younger than 12 years with 6MWT. Arterial oxygen saturation (SO2) was assessed by finger pulse oximetry before and after the test. All the children could walk continually for 6 minutes, and none of them showed oxygen saturation lower than 93%.

We performed a cardiac assessment for each patient with transthoracic echocardiography (TTE) and electrocardiogram (ECG). Mild to moderate pulmonary hypertension was detected in 4 cases during routine preoperative echocardiography.

Bronchoscopy was performed to clean the tracheobronchial tree from secretions and rule out intrabronchial disease and neglected foreign bodies. Bronchoscopy was valuable in confirming the diagnosis of a neglected FB, neglected rupture bronchus. Three cases were TB positive in bronchoscopic lavage despite negative sputum.

Sputum smears were obtained from all patients either from expectoration or with a bronchoscope. If microbial growth was detected in the culture, the patient was treated with antibiotics according to culture and sensitivity. In all patients, intensive chest physiotherapy and postural drainage were performed for 14 days before the scheduled surgery to improve the respiratory function.

During the preoperative preparation period and in the postoperative period, patients were subjected to a special dietary program consisting of high energy and a rich protein diet with vitamin supplements.

Anesthetic protocol and operative technique

General anesthesia was used in all patients using fentanyl (2 ug/kg) plus propofol (2mg/kg) for induction and rocuronium (0.6 mg/kg) for intubation and muscle relaxation. Anesthesia was maintained using propofol (2mg/kg/hr.) and fentanyl infusions (2ug/kg/hr.). Before endotracheal intubation, the tracheobronchial tree was washed out of secretions by bronchoscopy to minimize intraoperative contamination.

One lung ventilation was achieved using a double-lumen tube for adult patients and uninvent tube with bronchial blockers in children. We inserted the tube under fiberoptic bronchoscopy guidance in all cases to confirm tube placement.

We performed a classic posterolateral thoracotomy through the fifth intercostal space. A rib resection was performed in patients with narrow intercostal space to gain adequate exposure of the pleural cavity; a small segment (1 cm) from the posterior part of the lower rib was resected in 17 cases.

Classic intrapleural pneumonectomy was the routine procedure in most cases. Dissection was performed in the extrapleural plane if there were severe adhesions between the lung and pleura and empyema history. During extrapleural dissection, attention for hemostasis was essential to reduce blood loss. We performed intra-pericardial control of the hilar vessels if there were dense fibrosis and adhesions at the hilum.

The main bronchus was isolated and cut as short as possible. The bronchial stump was closed with either a bronchial stapler or hand-sewed by absorbable sutures; polyglactin (Vicryl; Ethicon, Edinburgh, UK).

The bronchial stump was reinforced using a mediastinal pleura, or intercostal muscle pedicle as described by Abdallah and his colleagues [12]. No reinforcement was applied for stapled stumps. Before the chest closure, the bronchial stump was examined for air leak underwater, and the pleural space was copiously irrigated with povidone iodine-containing saline solution.

A single chest tube (28–32F) was routinely placed to drain the pleural space underwater seal for 24–48 hours. All specimens were examined grossly (Figure 2) and sent for pathological examination. Operative details were collected and analyzed, including operative time, intraoperative blood loss, and intraoperative events.

Postoperative care, complications, and follow up

Patients were routinely extubated in the operating room. Postoperatively, patients were monitored in the intensive care unit (ICU) for 24 to 48 hours. In the first 72 hours, postoperative analgesia was mainly through a paravertebral or epidural catheter, which was inserted in the operation room.

We observed the patients for signs of the mediastinal shift. The chest tube was clamped intermittently to maintain mediastinal stability, and the tube was removed if the drainage volume was 250 ml (serous) or less within 24 hours. Postoperative follow-up was performed using chest -X-ray and Chest CT if required. We reported the postoperative morbidities and mortalities and length of hospital stay.

Statistical analysis:

The analysis was conducted using the SPSS (Version 20) statistical software for Windows (IBM Corporation, Armonk, NY, USA). Data were presented as mean values or range for continuous variables and as numbers and percentages for categorical variables. Continuous data were compared using the Mann-Whitney test, and the difference was considered significant if P-value was less than 0.05.

Results

The study included 28 patients; 11 (39%) of them were males. The mean age at the time of operation was 36.6 ± 9.8 (range 5-61) years, and the mean duration of symptoms was 11.6 years (range 1– 15). Nineteen (67.9%) patients had a history of frequent hospital admission (Table 1). Spirometry was done for 26 patients. Obstructive patterns were observed in TB patients, while restrictive patterns were observed in patients with bronchiectasis.

In 11 patients, the FEV1 was very low, which was not satisfactory for the decision of pneumonectomy. Therefore, V/Q scintigraphy was performed to detect the affected lung's contribution to perfusion; the result was significantly low (range 2.85– 5.75 %; mean 4.75 %).

Culture and sensitivity of sputum revealed Streptococcus pneumoniae, Klebsiella pneumoniae, Staphylococcus aureus, and Pseudomonas aeruginosa.

Two out of the 13 patients who had tuberculosis had associated empyema. The empyema space was drained with two chest tubes (apical 22 Fr, basal 30 Fr). The intrathoracic space was washed with povidone-iodine and antibiotic solution (based on culture and sensitivity) twice

Table 1: Preoperative patients' characteristics. Continuous data are presented as mean± SD (range) and categorical data as number (percentages)

Variables	(n= 28)
Males	11 (39%)
Age	36.6± 9.8 (5- 61)
Symptoms	
Cough	26 (93%)
Expectoration	22 (78.6%)
Hemoptysis	13 (46.4%)
Chest pain	8 (28.6%)
Dyspnea	5 (17.9%)
Preoperative spirometry (n= 26)	
FEV1 (L)	1.66 ± 0.07
FEV1 (%)	59% (44–71)
FVC (L/s)	1.71 ± 0.29
FVC (%)	58% (47–65)
Medical comorbidities	
Diabetes mellitus	3 (0.11%)
Hypertension	4 (0.14 %)
COPD	4 (0.14%)
CKD on dialysis	1 (0.035%)
Etiology	
Tuberculosis	13 (46.4 %)
Bronchiectasis	10 (35.7%)
Aspergillosis	3 (10.7%)
Neglected FB	1 (3.6%)
Neglected rupture bronchus	1 (3.6%)

COPD: chronic obstructive lung diseases; CKD: chronic kidney disease; FB: foreign body; FEV1: forced expiratory volume in 1 s, FVC: forced vital capacity

daily. These patients underwent surgery when a sterile pleural space was achieved. (Table 2)

We performed extrapleural pneumonectomy in 7 (25%) cases; 5 patients had extensive adhesions between the lung and pleura with resulting pleural fusion, and two patients had an associated history of chronic empyema. The control and division of the hilar vessels were performed intra-pericardially in 5 (17.9%) patients due to dense fibrosis and severe adhesions.

We used a stapling device for bronchial stump closure in 17 (61%) patients and hand-sewn in 11(39%) cases. We reinforced hand sewed bronchial stumps with mediastinal pleura in five, the pericardial fat pad in three, and intercostal muscle flap in three cases. The mean operative time was 176 min (range 105–315). The mean intraoperative blood loss was 785 (range 50 – 1550) ml.

In one patient, we encountered difficulty releasing the lung from the diaphragm, so we performed a second thoracotomy in the 7th intercostal space from the same skin incision to release the diaphragmatic adhesions.

In two patients, while extrapleural dissection was performed, the diaphragm was detached from its costal attachment while practicing a blunt separation of the parietal pleura from the chest wall. This event necessitates a second thoracotomy in the eighth intercostal space to fix the diaphragm.

Postoperative complications were considered as those occurring within 30 days postoperatively. (Table 2).

Table 2: Operative and postoperative data

Variables	(n= 28)
Pneumonectomy side	
Left	21 (75%)
Right	7 (25%)
Procedure	
Intrapleural pneumonectomy	21 (75%)
Extrapleural pneumonectomy	7 (25%)
Intra-pericardial isolation of hilar vessels	5 (17.9%)
Completion pneumonectomy	2 (7.2%)
Bronchial stump closure	
Stapler closure	17 (61%)
Hand sewed	11 (39%)
Postoperative complications (n= 7, 25%)	
Broncho-pleural fistula+ empyema	1 (3.6%)
Atrial fibrillation	4 (14.3 %)
Atelectasis	3 (10.7%)
Heart failure	2 (7.1%)
Respiratory failure requiring reintubation	1 (3.6 %)
Pneumonia requiring reintubation	1 (3.6 %)
Bleeding requiring re-exploration	1 (3.6 %)
Wound infection	2 (7.2 %)
Hospital mortality	1 (3.6%)

Table 3: The effect of the technique of pneumonectomy and the association of tuberculosis on blood loss and operative time

	Intra-pleural pneumonectomy	Extra-pleural pneumonectomy	P value	Patient With TB	Patients Without TB	P-value
Blood loss (ml)	520 (150–1400)	1541 (550–2900)	0.001	1210 (250–2800)	730 (200–1700)	0.045
Operative time (min)	135 (79–271)	211 (120–330)	0.002	177 (67–322)	156 (88–260)	0.255

Post pneumonectomy empyema with bronchopleural fistula occurred in one patient. The patient had a history of preoperative empyema and diabetes mellitus. Microbiological workup of empyema revealed the presence of Staphylococcus aureus and was managed conservatively.

We recorded on postoperative mortality in 63 years old woman who had extrapleural left pneumonectomy for recurrent hemoptysis from a large left upper lobe mycetoma as a sequel of old pulmonary tuberculosis. The patient was weaned from the ventilator in the ICU on the same day. On the 4th postoperative day, the patient developed postoperative pneumonia and respiratory failure and died on the 16th day postoperatively.

The effect of the technique of pneumonectomy and the associated tuberculosis on blood loss and operative time is presented in Table 3.

The mean perioperative bleeding was 390.7 ± 233.8 ml. The mean postoperative hospital length of stay was 11.3 (range 5 –39) days. In the early and late postoperative period, all the patients were evaluated and followed up by clinical and radiological examination. The mean follow-up period was 32.3 ± 21.2 (range 9- 84) months.

Discussion

The destroyed lung is more prevalent in developing countries [13]. TB was the most common etiology of lung destruction in our study, followed by other chronic lung infections [1, 9]. Other rare causes include bronchial stenosis, pulmonary infarction, massive pulmonary trauma, Castleman's disease, and rare congenital abnormalities [3-5]. In other studies, the most common cause of destroyed lung was septic bronchiectasis, followed by tuberculosis [5, 13, 14]. This difference may be related to the geographical location of the study.

In our patients, bronchiectasis was mostly caused by recurrent exposure to pulmonary infections and inadequate medical treatment. Recent studies reported the same pathogenesis of bronchiectasis [5]. Several studies found that repeated pulmonary infections could lead to either enlargement of peribronchial lymph nodes or thickening of the bronchial lumen with subsequent obstruction [15]. Total lung bronchiectasis can result from neglected foreign body aspiration obstructing the main bronchus over long periods, as in one of our patients.

Patients with a destroyed lung are at risk of developing fatal complications like massive hemoptysis, aspergillosis, septicemia, empyema, systemic-pulmonary shunting, and pulmonary hypertension [16]. It was found that pneumonectomy is the most rapid and effective method for preventing and treating such serious complications [9, 17].

According to previous studies, pneumonectomy is the main therapeutic tool that provides symptomatic relief and improves life quality despite all the operative difficulties and potential morbidities [4, 13, 18, 19]. However, some authors had emphasized the risk of pneumonectomy to manage destroyed lung disease [1, 20]. Therefore, careful patient selection is very imperative. The ideal candidate for pneumonectomy should have symptomatic unilateral total lung destruction, completely

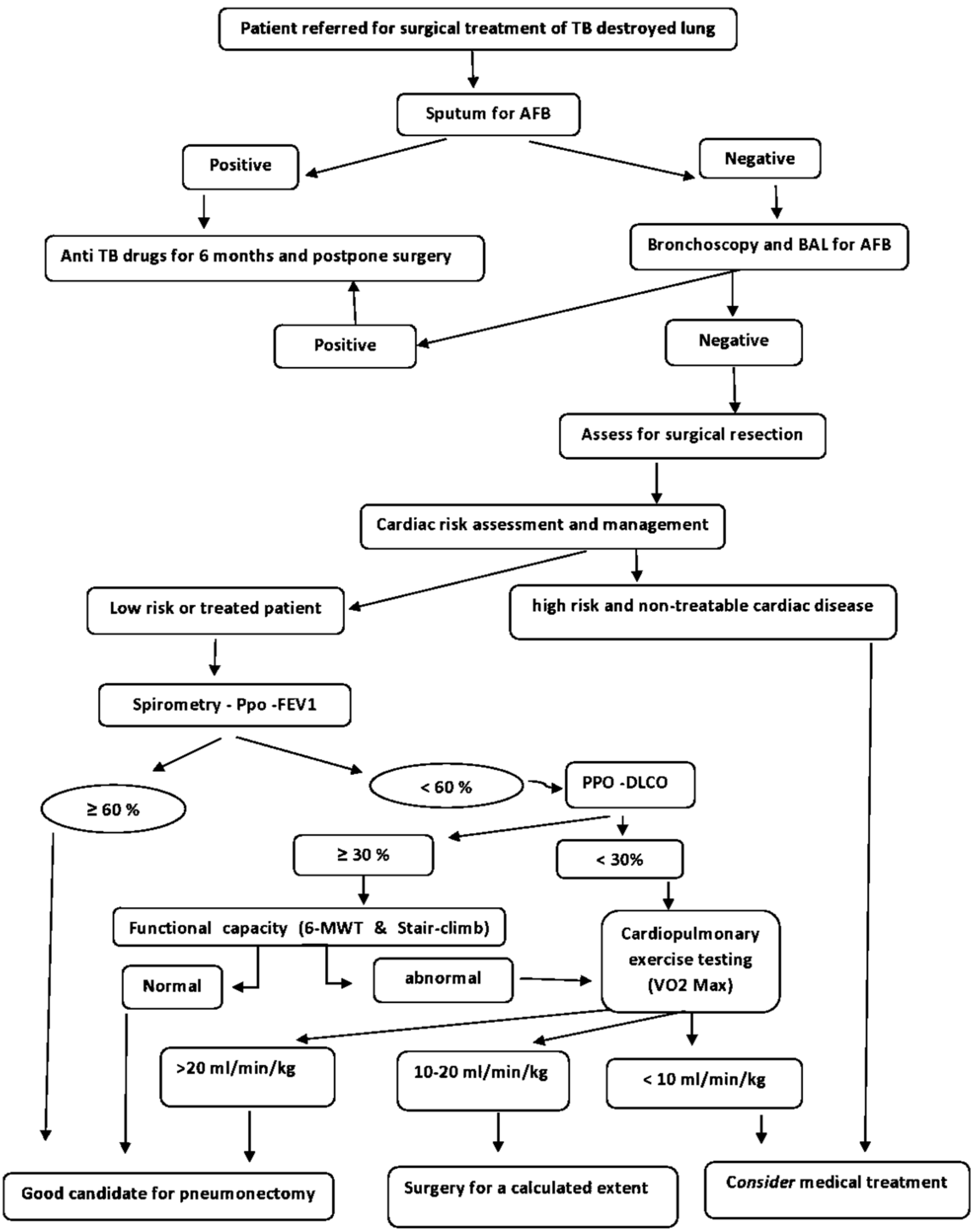

Figure 3: flow chart for management of patients with TB destroyed lung

normal contralateral lung, and absence of associated serious medical comorbidities. In our institution, we developed an algorithm for managing patients with destroyed lung (Figure 3); this algorithm was based on the predicted postoperative pulmonary function rather than the simple preoperative arbitrary numbers for FEV1 values. Diffusion lung capacity for carbon monoxide (DLCO) helps us select the appropriate patients as this test considers the non-functioning lung segments and lobes to predict the postoperative outcome.

In our patient series, the left lung was affected in 75% of the patients, similar to other series [5, 13]. This observation could be due to the more horizontal and narrower left bronchus; additionally, the left peri-bronchial space is limited by its relation to the aorta. It is more likely to be compressed by related enlarged lymph nodes [5]. The most important postoperative complications reported after pneumonectomy included bronchopleural fistula (BPF), empyema, reoperation for bleeding, contralateral pulmonary consolidation, and respiratory failure [14]. Published studies found that the presence of preoperative empyema, aspergillosis, massive blood loss, right pneumonectomy, reoperation for bleeding, and intraoperative dissemination were the most critical issues that lead to significant complications [21, 22].

It has been found that diabetes mellitus, liver dysfunction, nutritional deficiencies, and preoperative empyema were major risk factors for developing postoperative complications, especially BPF [13]. Odell and Henderson reported that the postoperative BPF occurred in more than 40% of patients with preoperative empyema [23]. Decrease sputum production by eradicating the underlying infections before surgery improves the nutritional status and decreases the risk of intraoperative spillage and reduces BPF and empyema. Additionally, using an appropriate closure technique for the bronchial stump and fixing it with adjacent tissues decreases the risk of BPF [5]. We agree with other reports [14], which stated that the bronchial stump management played a critical role in preventing the development of BPF.

In our study, the bronchial stump was closed manually in 39% of cases using absorbable suture because it is not associated with late suture granuloma formation [24]. Stapler closure was performed in 61% of cases. One patient developed BPF, which could be attributed to predisposing factors such as right-side surgery, history of tuberculosis, and preoperative empyema. In our study, the rate of postoperative empyema and BPF was 3.6%. This low rate compared to others may be attributed to the strict preoperative preparation of the patients and the routine use of stump reinforcement with adjacent viable tissues. Additionally, we had only 2 cases of preoperative empyema, and we excluded emergency cases from the study. Pneumonectomy for destroyed lung leads to better oxygenation by preventing systemic-pulmonary shunting [25]. We achieved satisfactory outcomes in all patients except one who developed postoperative empyema and BPF in the early postoperative period.

The patient characteristics in Egypt and other developing countries are different from other developed countries. In a study by Klapper and colleagues for the outcome of pneumonectomy for the benign disease, they had more males and right-sided disease. A third of their cases were completion pneumonectomy. They did not report cases with neglected FBs and no TB cases [26]. These findings are different from the results reported in our study and other similar studies from developing countries [27]. Klapper and colleagues reported a 29% mortality rate for the entire cohort; in our study, the mortality rate was 3.6 %. This could be attributed to the enrollment of elective cases only. In Klapper's research, 83% of deaths were operated on an emergent or urgent basis with associated serious comorbidities. They found that mortality was reduced to less than 10% after the exclusion of the emergency cases [26], which is following our results and other reports. [28]

Some of the best results reported for benign pneumonectomy have come from areas where pulmonary tuberculosis is endemic, and thus experience with the operative management of these patients is vast. Conlan and colleagues reported the results of benign elective pneumonectomy in 124 patients over 14 years in South Africa, demonstrating hospital mortality of only 2.4% [9]. Likewise, Blythe reported a 1.2% mortality among 155 elective benign pneumonectomies [18].

In the for mentioned studies, the authors practiced a comprehensive approach for recognizing these patients early on and improving their overall performance status, thus avoiding the outcome and consequences of urgent operations. This strategy and results were in accordance with our results. Consequently, it is obvious that, for patients requiring benign pneumonectomy, the most significant mortality predictor is the urgency of surgery.

Some authors have suggested that patients undergoing completion pneumonectomy for benign conditions were more likely to have a more operative risk [29, 30]. On the contrary, other reports did not find higher mortality in the completion pneumonectomy subset [26]. No complications were reported in completion pneumonectomy in our study, but completion pneumonectomy was reported in 2 cases only. Operative time > 4 hours, Old age (>70 y), intraoperative blood loss > 1 liter, and preoperative steroid use were reported to increase the risk of complications associated with benign pneumonectomy [22]. In our study, the increased operative time and blood loss were more in patients who had extrapleural pneumonectomy.

Three patients out of 7 who developed postoperative complications had extrapleural pneumonectomy, and one mortality occurred in this group. Li and colleagues reported two intraoperative deaths during pneumonectomy for inflammatory lung disease, one from uncontrollable bleeding, and the other form contralateral dissemination [14]. In our study, no intraoperative mortality was reported.

The reported postoperative morbidity and mortality rates in our study were 25% and 3.6 % (n = 1), respectively. These results were consistent with the published data (range, 11.9 –23% and 0–5.9, respectively) [13, 14, 19, 20]. Other studies reported postoperative mortality in destroyed lung diseases between 4 and 8.5% [21].

Limitations:

This study's limitations include its retrospective nature and the small sample size, making a barrier against the accurate estimation of the different variables' effect on the outcome.

Conclusion

Pneumonectomy for benign lung disease is a challenging procedure. Destroyed lung due to TB and bronchiectasis are the most common indications. The outcome could be improved with careful patient selection, appropriate preoperative preparation, meticulous operative techniques, and high postoperative care standards.

Meeting Presentation: The preliminary work was presented as an oral presentation at the 25th Annual Meeting of the Egyptian Society of Cardiothoracic Surgery– Cairo, Egypt, during the 17th - 19th of April 2019.

Conflict of interest: Authors declare no conflict of interest.

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