Ann Thorac Cardiovasc Surg 2015; 21: 440–445
Online May 25, 2015
doi: 10.5761/atcs.oa.14-00361

Original Article

Analysis of Pneumonectomy for Benign Disease: A Single Institution Retrospective Study on 59 Patients

Lei Yang, MD, Chun-Liu Ding, MBBS, Xiu-Jun Chang, MM, Fu-Gen Li, MM, Tian-Hui Zhang, MM, and Zi-Tong Wang, MD

Introduction: Pneumonectomy is the only curative treatment for some benign diseases but the operation is a challenging procedure. Herein, we present our experiences of pneumonectomy for 59 patients.
Methods: The medical records of 59 patients who undergone pneumonectomy for benign lung diseases from 2008 to 2013 at the Division of Thoracic Surgery in Beijing Chest Hospital were retrospectively reviewed.
Results: There were 23 male and 36 female patients. Three procedures including pneumonectomy, pleuropneumonectomy and completion pneumonectomy were used. The operative time and intraoperative blood loss were statistically different in the patients who undergone different operations. The operative time of the patients with and without tuberculosis had no difference but the intraoperative blood loss was more in the patients with tuberculosis (P = 0.035). The operative type, age and operative blood loss were relevant with the morbidity, the P value were 0.024, 0.042 and 0.027 respectively.
Conclusions: Pneumonectomy for patients with benign disease may be more difficult than for patients with lung cancer, mean while pleuropneumonectomy and completion pneumonectomy may be greater challenges. But with careful patient selection and operative technique, it is a satisfactory treatment method for benign lung disease. The morbidity is acceptable and associated with operative type, age and operative blood loss.

Keywords: pneumonectomy, benign disease, morbidity

Introduction

In 1931, Rudolph Nissen performed pneumonectomy for a patient with bronchiectasis in Berlin.[1] It was the first pneumonectomy in the world. From then on, pneumonectomy had become the only curative treatment for some benign diseases such as complication of tuberculosis, cystic bronchiectasis, suppurative lung disease, invasive opportunistic infection in immunocompromised patients, massive pulmonary trauma, hemoptysis, Casetleman's disease, rare congenital abnormalities and so on.[2–4] In spite of the development of the devices and skills of the operation, pneumonectomy for benign lung disease is still a challenging procedure. Because of the dense scar tissue and inflammation surrounding major vascular, the fused pleural surface and the medical comorbidities, the morbidity of the patients with benign lung disease after pneumonectomy was almost three times higher than that for lung cancer patients.[5] So, some authors believed that this procedure is one of exaggerated risks and advised to be cautious when deciding whenever to perform it.[5–7] However, some surgeons advocate that pneumonectomy for

Thoracic Department, Beijing Chest Hospital, Capital Medical University, Beijing, China

Received: December 25, 2014; Accepted: April 19, 2015
Corresponding author: Yang Lei. Thoracic Department, Beijing Chest Hospital, Capital Medical University, Beijing, China
Email: yangleiyuying@163.com

Table 1 The causes of pneumonectomy

Disease	Number of patients, n	%
Pulmonary tuberculosis	41	69.5
Tuberculous empyema	7	11.9
Congenital multicystic pulmonary	4	6.8
Bronchiectasis	4	6.8
Aspergilloma	2	3.4
Middle lung lobe syndrome	1	1.6

benign disease can be performed with acceptable morbidity and mortality.[3,4,8]

We retrospectively evaluated the patients who underwent pneumonectomy, pleuropneumonectomy and completion pneumonectomy for treating benign disease to show the factors influencing the outcomes.

Methods

From January 2008 to December 2013, 59 patients with benign disease underwent pneumonectomy at the Division of Thoracic Surgery in Beijing Chest Hospital. Their medical records, operative procedures, histological examinations and follow-up data were reviewed. Before reviewing the data, we had obtained the approval of my institutional review board. The operative time and intraoperative blood loss in different groups were estimated using nonparametric test. A *P*-value less than 0.05 was considered to be statistically significant. All statistical analyses were performed with the SPSS ver. 13.0.

Results

Clinical features

There were 23 male and 36 female patients. The age at the time of operation ranged from 22 years and 2 months to 65 years and 10 months (mean age was 38 years and 7 months). The diseases of the patients were depicted in **Table 1**. The most common aetiology leading to pneumonectomy was pulmonary tuberculosis which accounted for 69.5% of all the patients (41), the other diseases included tuberculous empyema (7, 11.9%), congenital multicystic pulmonary (4, 6.8%), bronchiectasis (4, 6.8%), aspergilloma (2, 3.4%) and middle lung lobe syndrome (1, 1.6%).

Pulmonary function tests (PFT) were available for review on 49 patients, nine patients did not undergo PFT because of the tendency of severe hemoptysis. The forced expiratory volume in 1 s (FEV1) ranged from 0.66 to 3.09 L (mean 1.75 L); the mean predicted FEV1 was 71.6% (39.4%–93.5%). The maximum ventilator volume (MVV) ranged from 19.01 to 137.26 L (mean 57.58 L); the mean predicted MVV was 50.9% (14.3%–94.7%).

Before the operation, hemoglobin (HGB) and albumin (ALB) of all the patients were measured. The HGB ranged from 74 to 151 g/L (mean 118 g/L). The ALB ranged from 26.6 to 49.8 g/L (mean 38.2 g/L).

Operation

There were 14 right and 45 left pneumonectomies. The indication of the operations was the involvement of the lung was too extensive to be treated by lobectomy or bilobectomy. Some patients underwent pleuropneumonectomy because of the fused pleural surface. Two patients had undergone pulmonary resection before this operation, so we performed completion pneumonectomy for them. All procedures were performed through a classic posterolateral thoracotomy. One-lung ventilation was established by a double-lumen endotracheal tube in all patients. Bronchial closure was routinely achieved with a stapling device, and the bronchial stump was not covered. According to the condition of the patients, three procedures including pneumonectomy, pleuropneumonectomy and completion pneumonectomy were used. There were 36 patients undergone pneumonectomy, accounted for 61.0% of all the patients. Pleuropneumonectomy and completion pneumonectomy performed for 21 (35.6%) and 2 (3.4%) patients respectively. The operative time and intraoperative blood loss were showed in **Table 2**. The mean operative time of pneumonectomy, pleuropeumonectomy and completion pneumonectomy were 142 (65–250)min, 196 (100–310)min and 280 (260–300)min respectively; and the mean intraoperative blood loss of the three procedures were 504 (50–1500)ml, 1673 (500–3400)ml and 3250 (3000–3500)ml. The operative time and intraoperative blood loss were statistically different in the patients who undergone different operations. Since tuberculosis was the cause leading to pneumonectomy (pulmonary tuberculosis and tuberculous empyema), we compared the operative time and intraoperative blood loss in patients with and without tuberculosis (**Table 3**). The results showed that the operative time of the patients with and without tuberculosis had no difference but the

Table 2 The operative time and blood losses of the patients received different operation

	Operative time (min)	Operative blood loss (ml)
Pneumonectomy	142 (65–250)	504 (50–1500)
Pleuropneumonectomy	196 (100–310)	1673 (500–3400)
Completion pneumonectomy	280 (260–300)	3250 (3000–3500)
P value	0.000	0.000

Table 3 The operative time and blood losses of the patients with and without tuberculosis

	Operative time (min)	Operative blood loss (ml)
With tuberculosis	167 (65–310)	1151 (50–3500)
Without tuberculosis	145 (90–240)	640 (50–3000)
P value	0.165	0.035

Table 4 Major postoperative complications

	N (%)	TB/without TB	Pleuropneumonectomy and completion pneumonectomy/ pneumonectomy
Atrial fibrillation	9 (15.3%)	6/3	7/2
Reintubation due to respiratory failure	4 (6.8%)	3/1	2/2
Pneumonia	4 (6.8%)	3/1	2/2
Initial Ventilation >24 h	2 (3.4%)	2/0	1/1
Heart failure	2 (3.4%)	1/1	1/1
Empyema	1 (1.6%)	1/0	1/0
Esophageal fistula	1 (1.6%)	1/0	0/1
Bronchopleural fistula	1 (1.6%)	1/0	1/0
Wound infection	1 (1.6%)	1/0	0/1
Recurrent laryngeal nerve injury	1 (1.6%)	0/1	0/1

intraoperative blood loss was more in the patients with tuberculosis.

Postoperative complications

There was no intraoperative death. A single patient died after the operation. The 65 year old man received emergency right pleuropneumonectomy for massive hemoptysis owing to pulmonary tuberculosis. Before the operation the HGB and ALB were 74 g/L and 28 g/L respectively. After the operation, the patient undergone assistant respiration by ventilator because of hypoxemia and ultimately died on the 13th postoperative day because of multiple organ dysfunction syndrome (MODS) resulting of severe infection.

The major postoperative complications, depicted in **Table 4**, occurred in 16 (27.1%) patients including atrial fibrillation in nine (15.3%) patients, reintubation due to respiratory failure in four (6.8%) patients, pneumonia in four (6.8%) patients, initial ventilation >24 h in 2 (3.4%) patients, heart failure in two (3.4%) patients, empyema in one (1.6%) patient, esophageal fistula in one (1.6%) patient, bronchopleural fistula in one (1.6%) patient, wound infection in one (1.6%) patient and recurrent laryngeal nerve injury in one (1.6%) patient.

We compared the morbidity in patients with and without tuberculosis, the results showed that the type of disease did not relevant with the morbidity. We also analyzed the relationship of operative type and morbidity. The results showed that the morbidity in the patients undergone pleuropneumonectomy and completion pneumonectomy is higher (43.5%) than the patients undergone pneumonectomy (16.7%). The results depicted in **Table 5**.

We analyzed the influence of age, operative time, intraoperative blood loss, HGB, ALB, FEV1 and MVV

Table 5 Comparison of morbidity in different patients and different operations

	TB	Without TB	Pneumonectomy	Pleuropneumonectomy and completion
Morbidity	14 (29.2%)	2 (18.2%)	6 (16.7%)	10 (43.5%)
χ^2	0.546		5.104	
P value	0.372		0.024	

TB: tuberculosis

on the morbidity using the Logistic regression (SPSS version 13.0). The results showed that age and operative blood loss were relevant with the morbidity, the *P* value were 0.042 and 0.027 respectively.

Discussion

Nowadays, pneumonectomy for benign disease is still a challenge for thoracic surgeon. TB is the leading cause of pneumonectomy for benign disease.[3,4] In the current series, TB accounted for 81.4% of all the patients. This data was compatible with most reports.

Because most of the patients undergone pneumonectomy had TB and other inflammatory diseases, the thoracic surgeons may often need to treat dense scar tissue surrounding major vascular and the fused pleural surface. This is the main difficulty during the operations and may affect choice of procedure, operative time and intraoperative blood loss. In the current series, the mean operative time of pneumonectomy, pleuropneumonectomy and completion pneumonectomy were 142 (65–250)min, 196 (100–310)min and 280 (260–300)min respectively; and the mean intraoperative blood loss of the three procedures were 504 (50–1500)ml, 1673 (500–3400)ml and 3250 (3000–3500)ml. At the same time, the mean operative time and intraoperative blood loss of the patients undergone pneumonectomy because of lung cancer were 100 (60–150)min and 100 (50–400)ml respectively (not published). Recent literature showed that the mean intraoperative blood loss of the patients undergone pneumonectomy because of lung cancer with and without inductive chemotherapy were 351.2 ± 52.8 and 480 ± 179.7 ml, meanwhile the operative time were 315.8 ± 13.4 and 315.7 ± 22.7 min.[9] These results suggested that pneumonectomy for patients with benign disease may be more difficult than for patients with lung cancer, mean while pleuropneumonectomy and completion pneumonectomy may be greater challenges to thoracic surgeons. Since TB was the most common disease in the current series, we compared the operative time and intraoperative blood loss between patients with and without TB. The results showed that the intraoperative blood loss in TB patients was more than the patients without TB, but the operative time between the two groups had no difference. We thought the more intraoperative blood loss may be owing to the chronic inflammation nature of TB.

The mortality and morbidity after pneumonectomy range from 1.2% and 15.2% to 11% and 40.3%, respectively, varying among different authors.[9–14] In the current series, the mortality and morbidity were 1.6% and 27.1% respectively. This data was compatible with most reports of benign disease and lower than some reports of NSCLC. We thought the inductive therapy in NSCLS patients may relate with the difference. Most authors thought right pneumonectomy and emergency operation were associated with high mortality. There was one patient died on the 13th postoperative day. The patient not only had the two risk factors but also with poor nutritional status (Before the operation the HGB and ALB were 74 g/L and 28 g/L respectively.)

Some authors pointed out some risk factors of postoperative complications such as operative time, type of disease, pulmonary function, age, right pneumonectomy and so on.[14–16] We analyzed the influence of age, operative time, intraoperative blood loss, HGB, ALB, FEV1 and MVV on the morbidity and the results showed that age and operative blood loss were relevant with the morbidity, the *P* value were 0.042 and 0.027 respectively. We compared the morbidity in patients with and without tuberculosis the results showed that the morbidity in the patients with and without TB had no difference. We analyzed the relationship of operative type with morbidity, the results showed that the operative type related with morbidity.

Bronchopleural fistula is a severe complication of lung resections, with mortality reaching over 40% and the major risk factor for this is local active infection.[17–20] Theoretically, pneumonectomy for benign disease has a high risk of bronchopleural fistula; thus, we took great care to prevent this serious complication. First, every patient underwent preoperative bronchoscopy and surgery was

postponed if there were signs of active infection in the bronchus. Second, we tried our best to cut the bronchus where it was healthy. Third, we made the bronchial stump as short as possible. Some authors advocate reinforcing the bronchial stump with adjacent tissues such as a pedicled pericardial fat pad, an intercostal muscle flap, or a pedicled pericardium flap.[20–23] We did not reinforce the bronchial stumps and only one patient suffered bronchopleural fistula in the current series. In our opinion, the reinforcement may be not the crux of bronchopleural fistula. This opinion was approved by some authors.[3]

Recurrent laryngeal nerve injury is a well-known complication of cardiothoracic surgery and most of the complications are associated with mediastinal lymphadenectomy for cancer.[24–27] Because of passing around the aotic arch, the left recurrent laryngeal nerve is vulnerable to injury during some operations such as extended mediastinal lymphadenectomy of the aortopulmonary window.[28] In the current series, one patient with congenital multicystic pulmonary suffered left side recurrent laryngeal nerve injury. As far as we knew, there was no similar report. We thought the mediastinal shift may be resulted in the displacement of left recurrent laryngeal nerve and made it more vulnerable.

Conclusion

Our data suggested that pneumonectomy for patients with benign disease may be more difficult than for patients with lung cancer, mean while pleuropneumonectomy and completion pneumonectomy may be greater challenges to thoracic surgeons. But with careful patient selection and operative technique, it is still a satisfactory treatment method for benign lung disease. The morbidity is acceptable and associated with operative type, age and operative blood loss. During the operation, the surgeons should pay much attention to reduce the risk of bronchopleural fistula.

Abbreviations

PFT: Pulmonary function tests; MVV: maximum ventilator volume; HGB: hemoglobin; ALB: albumin; TB: tuberculosis.

Authors' Contributions

Lei Yang is the author of the paper. Chun-Liu Ding helped in the data and literature research. Xiu-Jun Chang and Fu-Gen Li checked the paper and performed literature research. Tian-Hui Zhang checked the paper and performed linguistic control. Zi-Tong Wang was head of the department and supervised the study. All authors read and approved the final manuscript.

Acknowledgements

We would like to acknowledge and thank our colleagues of medical record department for their support and help.

Disclosure Statements

Lei Yang and other co-authors have no competing interest.

References

1) Fell SC. Special article: a brief history of pneumonectomy. 1999. Chest Surg Clin N Am 2002; **12**: 541-63.
2) Massard G, Dabbagh A, Wihlm JM, et al. Pneumonectomy for chronic infection is a high-risk procedure. Ann Thorac Surg 1996; **62**: 1033-7.
3) Owen RM, Force SD, Pickens A, et al. Pneumonectomy for benign disease: analysis of the early and late outcomes. Eur J Cardiothorac Surg 2013; **43**: 312-7.
4) Conlan AA, Lukanich JM, Shutz J, et al. Elective pneumonectomy for benign lung disease: modern-day mortality and morbidity. J Thorac Cardiovasc Surg 1995; **110**: 1118-24.
5) Shapiro M, Swanson SJ, Wright CD, et al. Predictors of major morbidity and mortality after pneumonectomy utilizing the Society for Thoracic Surgeons General Thoracic Surgery Database. Ann Thorac Surg 2010; **90**: 927-34; discussion 934-5.
6) Chataigner O, Fadel E, Yildizeli B, et al. Factors affecting early and long-term outcomes after completion pneumonectomy. Eur J Cardiothorac Surg 2008; **33**: 837-43.
7) Regnard JF, Icard P, Magdeleinat P, et al. Completion pneumonectomy: experience in eighty patients. J Thorac Cardiovasc Surg 1999; **117**: 1095-101.
8) Sirmali M, Karasu S, Gezer S, et al. Completion pneumonectomy for bronchiectasis: morbidity, mortality and management. Thorac Cardiovasc Surg 2008; **56**: 221-5.
9) Tanaka S, Aoki M, Ishikawa H, et al. Pneumonectomy for node-positive non-small cell lung cancer: can it be a treatment option for N2 disease? Gen Thorac Cardiovasc Surg 2014; **62**: 370-5.
10) Nagai S, Imanishi N, Matsuoka T, et al. Video-assisted thoracoscopic pneumonectomy: retrospective outcome

analysis of 47 consecutive patients. Ann Thorac Surg 2014; **97**: 1908-13.
11) Kalathiya RJ, Saha SP. Pneumonectomy for non-small cell lung cancer: outcomes analysis. South Med J 2012; **105**: 350-4.
12) Bai L, Hong Z, Gong C, et al. Surgical treatment efficacy in 172 cases of tuberculosis-destroyed lungs. Eur J Cardiothorac Surg 2012; **41**: 335-40.
13) Kirschbaum A, Kyriss T, Dippon J, et al. Morbidity and mortality after pneumonectomy in smokers with NSCLC. Thorac Surg Sci 2008; **5**: Doc01.
14) Byun CS, Chung KY, Narm KS, et al. Early and Long-term outcomes of pneumonectomy for treating sequelae of pulmonary tuberculosis. Korean J Thorac Cardiovasc Surg 2012; **45**: 110-5.
15) Stolz AJ, Harustiak T, Simonek J, et al. Pneumonectomy for non-small cell lung cancer: predictors of early mortality and morbidity. Acta Chir Belg 2014; **114**: 25-30.
16) Hu XF, Duan L, Jiang GN, et al. Risk factors for early postoperative complications after pneumonectomy for benign lung disease. Ann Thorac Surg 2013; **95**: 1899-904.
17) Cooper WA, Miller JI. Management of bronchopleural fistula after lobectomy. Semin Thorac Cardiovasc Surg 2001; **13**: 8-12.
18) Nagahiro I, Aoe M, Sano Y, et al. Bronchopleural fistula after lobectomy for lung cancer. Asian Cardiovasc Thorac Ann 2007; **15**: 45-8.
19. Tanaka S, Yajima T, Mogi A, et al. Successful management of a large bronchopleural fistula after lobectomy: report of a case. Surg Today. 2011; **12**: 1661-4.
20) Deschamps C, Bernard A, Nichols FC, et al. Empyema and bronchopleural fistula after pneumonectomy: factors affecting incidence. Ann Thorac Surg 2001; **72**: 243-7.
21) Klepetko W, Taghavi S, Pereszlenyi A, et al. Impact of different coverage techniques on incidence of post-pneumonectomy stump fistula. Eur J Cardiothorac Surg 1999; **15**: 758-63.
22) Shiraishi Y, Nakajima Y, Koyama A, et al. Morbidity and mortality after 94 extrapleural pneumonectomies for empyema. Ann Thorac Surg 2000; **70**: 1202-6.
23) Shiraishi Y, Nakajima Y, Katsuragi N, et al. Pneumonectomy for nontuberculous mycobacterial infections. Ann Thorac Surg 2004; **78**: 399-403.
24) Zumtobel M, End A, Bigenzahn W, et al. Reduced quality of life in patients with unilateral vocal cord paralysis after thoracic surgery. Chirurg 2006; **77**: 518-22.
25) Laccourreye O, Malinvaud D, Delas B, et al. Early unilateral laryngeal paralysis after pulmonary resection with mediastinal dissection for cancer. Ann Thorac Surg 2010; **90**: 1075-8.
26) Garas G, Kayani B, Tolley N, et al. Is there a role for intraoperative recurrent laryngeal nerve monitoring during high mediastinal lymph node dissection in three-stage oesophagectomy for oesophageal cancer? Int J Surg 2013; **11**: 370-3.
27) Schneider B, Bigenzahn W, End A, et al. External vocal fold medialization in patients with recurrent nerve paralysis following cardiothoracic surgery. Eur J Cardiothorac Surg 2003; **23**: 477-83.
28) Périé S, Laccourreye O, Bou-Malhab F, et al. Aspiration in unilateral recurrent laryngeal nerve paralysis after surgery. Am J Otolaryngol 1998; **19**: 18-23.