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Original research

Surgical treatment of bronchiectasis: A retrospective observational study of 260 patients

Yu-xing Jin, Yi Zhang, Liang Duan, Yang Yang, Ge-ning Jiang*, Jia-an Ding

Department of Thoracic Surgery, Shanghai Pulmonary Hospital Affiliated to Tongji University, Shanghai 200433, China

HIGHLIGHTS

- Surgery is an effective treatment option for bronchiectasis.
- Sputum volume lower than 30 mL is risk factor for successful treatment.
- Negative proof of Gram-negative bacteria is risk factor for successful treatment.
- Bronchial stump coverage is risk factor for successful treatment.
- Special attention has to be given to any complications in elderly patients.

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ABSTRACT

Objective: This study aims to demonstrate our surgical experience for bronchiectasis and analyze the risk factors related with the surgery outcome. **Methods**: We retrospectively reviewed medical records of 260 consecutive patients who underwent surgery for bronchiectasis between January 2000 and December 2010. The factors related with the outcome were analyzed and the candidate factors were screened by χ^2 test and t test. Furthermore, logistic regression analysis was used for multiple factor analysis to obtain the independent factors that affected the surgical outcome. **Results**: Complications occurred in 30 (11.5%) patients during perioperative period. The univariate analysis showed that significant differences can be observed in age ($P = 0.000$), sputum volume ($P = 0.000$), smoking history ($P = 0.033$), pulmonary function ($P = 0.003$), Gram-negative bacillus infection ($P = 0.000$), bronchial stump coverage ($P = 0.016$) using intercostals muscles or pedicle pleura embedding and surgical approach ($P = 0.003$) between the patients with excellent and poor outcome. The multivariable analyses showed that sputum volume ($P = 0.000$), Gram-negative bacillus infection ($P = 0.000$) and bronchial stump coverage ($P = 0.000$) were the three independent factors related with surgical outcome. **Conclusion**: Surgery is an effective treatment option for bronchiectasis. Sputum volumes lower than 30 mL, negative proof of Gram-negative bacteria and bronchial stump coverage using intercostals muscles or pedicle pleura embedding are the key factors for successful treatment. Special attention has to be given to any complications in elderly patients.

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1. Introduction

Bronchiectasis, as a chronic suppurative lung disease, is first described in 1819 by Laenec et al., which is currently defined as dilation of the bronchi, repeated infection and destruction of the bronchial wall and lung [1]. The disease arises from a cycle of inflammation and infection [2]. The normal musculoelastic tissue and cartilage of the bronchial wall are destroyed, resulting in fibrosis [3]. Bronchiectasis causes severe pulmonary infections and loss of lung function, leading to chronic morbidity, and may contribute to premature mortality [4,5].

In developed countries, the prevalence of bronchiectasis has decreased and patients in early disease stages could be successfully treated by conservative procedures [6]. But bronchiectasis is still an important problem for some serious pulmonary infections in developing countries [7]. Conservative treatments, such as antibiotic treatment, postural drainage and bronchodilators, have been used to control the symptom, but a mortality of 19–31% still exists [8]. In addition, surgical resection can alleviate symptoms or

* Corresponding author. Department of Thoracic Surgery, Shanghai Pulmonary Hospital Affiliated to Tongji University, Zhengmin Road, No. 507 Yangpu District, Shanghai 200433, China.
E-mail address: GeningJianggng@163.com (G.-n. Jiang).

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shorten the duration of conservative treatment, which has been applied in the bronchiectasis treatment from the late 1930s [9]. However, complexity of surgical procedure, high rate of post-operative complications, and few available clinical and follow-up reports hinder the development in surgical treatment of bronchiectasis [10].

In this study, we retrospectively reviewed clinical data of 260 cases of bronchiectasis and tried to find the key factors that affected the incidence of the complications of bronchiectasis in order to improve the clinical outcome.

2. Patients and methods

2.1. Patients population

We retrospectively reviewed medical records of 260 patients with surgical resection for bronchiectasis between January 2000 and December 2010 at the Department of Cardiothoracic Surgery in Shanghai Pulmonary Hospital. Major clinical symptoms of patients were recurrent cough or productive cough, including repeated hemoptysis and obvious moist rales in lung. Thin computed tomography (CT) test for chest was used to evaluate the small airway disease and bronchoscope was performed for lesion test. Patients were performed with microbiologic culture analysis for respiratory tracts and pulmonary ventilation function tests including forced expiratory volume in one second (FEV1), forced vital capacity, peak expiratory flow before surgery. All of the patients assigned the informed consent.

2.2. Preoperative treatment

All patients except 25 patients with significant hemoptysis were assessed by the physician, trained with abdominal respiration and processed with anti-infection treatment. The 25 patients were transferred to the surgical emergency. A total of 235 patients were prescribed with anti-biotic treatment. Among them, 143 (60.9%) were applied with mono-antibiotic therapy and 92 (39.1%) were with dual antibiotic therapy. The duration of the anti-biotic treatment was between 7 and 21 days and the average time was 11.5 days. Fifty patients were with mean sputum volume larger than 30 mL before operation and 210 were less than or equal to 30 mL. The sputum culture results showed that 36 patients (13.8%) were infected with Gram-negative mycobacteria and 224 (86.2%) not infected. FEV1 value of the pulmonary function was from 1.45 to 2.89 with a mean of 1.86. The percentages of the FEV1 were from 56% to 110% with a mean of 65%.

2.3. Surgical approach, duration and bleeding volume

Twenty-five patients with uncontrollable hemoptysis were processed with emergency operation and others were processed with selective operation. The type of surgery was summarized in Table 1. Among all patients, 233 cases were performed with bronchial stump coverage using intercostals muscles or pedicle pleura embedding and 27 were not performed with bronchial stump coverage. The operation time was 2–12 h with an average time of 4.5 h. The average blood loss during the operation was 750 mL (50–3200 mL). The mean volume of blood transfusion was 828 mL (0–4200 mL).

2.4. Postoperative treatment and follow-up

In postoperative treatment, the average indwelling time of the thoracic duct was 3.5 days (2–8 days). The duration of the anti-biotic medication was from 5 to 52 days (mean value was 12.8 days). The hospital stay was from 8 to 67 days (mean value was 19.7 days). All patients were followed up in our outpatient clinic.

Table 1
Characteristic of patients.

	Number of patients	Number of patients
Lesion locations		
Single right lobe	70	
Multiple right lobes	42	
Single left lobe	81	
Multiple left lobes	29	
Multiple bilateral lobes	38	
Surgical approach	**Left lung**	**Right lung**
Pneumonectomy	29	12
Upper lobectomy	41	32
Middle lobectomy	0	34
Lower lobectomy	46	16
Upper and middle lobectomy	0	14
Middle (or lingual) and lower lobectomy	8	7
Upper and lower lobectomy	2	9
Segmentectomy	6	4
Comorbidities or complications		
Lung abscess	95	
Pneumonia	78	
Damaged lung	26	
Aspergillosis infection	24	
Broncholithiasis	17	
Bullae of lung	15	
Pulmonary interstitial fibrosis	3	
Kartagener syndrome	2	

2.5. Data analysis

The risk factors included gender, age, tuberculosis history, smoke history (including short-term smoking history or long-term involvement in the second-hand smoke), sputum volume control, pulmonary function FEV1, Gram-negative *Pseudomonas aeruginosa*, and *klebsiella pneumonia* infection and other common respiratory tract bacteria infection, bronchial stump coverage, bleeding volume during operation, and surgical approach. The factors affecting the surgery efficiency were listed and patients were grouped based on the factors, such as the incidence of complications, the symptoms of hemoptysis and productive cough in 3 years follow-up and if no obvious disease foci were observed by CT test, the outcome of the surgical procedure was considered successful. The relationships between potential factors and postoperative complications were assessed by univariate analyses. The risk of poor surgical outcome was evaluated with forward and backward stepwise logistic regression analysis to estimate odds ratios (OR) and 95% confidence intervals (CI). Quantitative variables were compared by t test and chi-square test. All data were analyzed using SPSS 17.0 for Windows (SPSS Inc., Chicago, IL, USA). A value of $P \leq 0.05$ was considered statistically significant.

3. Results

A total of 260 patients who underwent surgical treatment for bronchiectasis in our department were included in this study. The mean age of these patients was 30.2 years. Among them, 163 patients were female and 97 patients were male. The courses of the disease were from 1 month to 30 years and 93 (35.8%) of the patients were more than a decade. Productive cough and recurrent hemoptysis was found in 135 (51.9%) and 125 (48.1%) patients, respectively; while there were 38 (14.6%) patients with recurrent massive hemoptysis (hemoptysis volume was more than 300 mL at one time or 600 mL in 24 h). Chest CT scan showed that 110 (42.3%) cases were with disease foci on the left lung; 112 (43.1%) cases were on the right lung; and 38 (14.6%) cases were on the bilateral lung (Table 1). The pathological section results confirmed that all

patients were non-tuberculous purulent bronchiectasis. Among them, 85 (32.7%) cases were with cystic bronchiectasis; 42 (16.2%) cases were with cylindrical bronchiectasis; and 123 (47.3%) cases were with mixed bronchiectasis.

Complications occurred in 30 (11.5%) patients during perioperative period. Two patients were dead postoperatively and both of them were processed with emergency pneumonectomy, one of whom was diagnosed as pulmonary embolism and one was acute arrhythmia. Eight patients with acute respiratory failure got better when 3 patients were ventilated with non-invasive ventilator and 5 were processed with endotracheal intubation or mechanical ventilation. Atelectasis occurred in 9 (3.5%) patients who got better after fiberbronchoscope suction for once or several times. Bronchopleural fistul and empyema were observed in 11 (4.2%) patients, among whom 6, 3 and 2 patients were performed with right, left pneumonectomy and lobectomy, respectively. Bronchial stump suture through thoracotomy was processed in 3 patients. Four cases underwent thoracic closed drainage and 4 cases underwent dressing change in the chest and stuffing operation by muscle segment.

Follow-up data were obtained from 255 (98.1%) patients. The mean follow-up time of these patients was 6.7 years (range from 3 to 10 years). The symptoms disappeared in 199 (76.5%) patients, and 52 (20.0%) patients showed occasional symptoms with cough or frothy sputum but did not show recurrent hemoptysis or yellow phlegm. A total of 7 (2.7%) patients showed small amount of recurrent hemoptysis and yellow phlegm, among whom 2 were operated with left lower lobectomy; 2 with right lower lobectomy; 3 with left lingular segment of the lung and lower lobe lobectomy. There were 5 deaths in 2–7 years of follow-up period, among whom 3 died from pulmonary heart disease, 2 from kidney failure and 1 from unknown reason.

Univariate analysis results showed that there were significant differences in age ($P < 0.00001$), sputum volume ($P < 0.00001$), smoking history ($P = 0.033$), pulmonary function ($P = 0.003$), Gram-negative bacillus infection ($P < 0.00001$), bronchial stump coverage ($P = 0.016$) and surgical approach ($P = 0.003$) between the patients with excellent and poor outcome (Table 2). The multivariable analyses showed that age (95% CI = 1.004–1.086, $P = 0.032$), sputum volume (95% CI = 1.034–1.117, $P < 0.00001$), Gram-negative bacillus infection (95% CI = 8.004–96.971, $P < 0.00001$) and bronchial stump coverage (95% CI = 0.006–0.129, $P < 0.00001$) were the four independent factors related with surgical outcome (Table 3).

Table 2
Factors associated with postoperative outcome with univariate analysis for bronchiectasis.

Risk factors	Number of patients with satisfied outcome ($n = 223$, %)	Number of patients without satisfied outcome ($n = 37$, %)	χ^2 or t value	P value
Sex			0.438	0.508
Male	138 (61.9%)	25 (67.6%)		
Female	85 (38.1%)	12 (32.4%)		
Age			17.940	<0.00001
Youth (<45 years)	126 (56.5%)	7 (18.9%)		
Old (≥45)	97 (43.5%)	30 (81.1%)		
Tuberculosis history			0.174	0.677
Yes	14 (6.3%)	3 (8.1%)		
No	209 (93.7%)	34 (91.9%)		
Smoking history			4.538	0.033
Yes	134 (60.1%)	29 (78.4%)		
No	89 (39.9%)	8 (21.6%)		
Gram-negative bacillus infection			31.252	<0.00001
Positive	20 (9.0%)	16 (43.2%)		
Negative	203 (91.0%)	21 (56.8%)		
Sputum volume			28.655	<0.00001
≤30	192 (86.1%)	18 (48.6%)		
>30	31 (13.9%)	19 (51.4%)		
Bronchial stump coverage			5.853	0.016
Yes	204 (91.5%)	29 (78.4%)		
No	19 (8.5%)	8 (21.6%)		
Pneumonectomy			9.018	0.003
Yes	29 (13.0%)	12 (32.4%)		
No	194 (87.0%)	25 (67.6%)		
	Range	**Mean**	***T***	***P* value**
Pulmonary function (FEV1%)	1.45–2.89 (56%–110%)	1.86	3.023	0.003
Bleeding volume (mL)	50–3200 mL	750 mL	−0.012	0.991

Table 3
Variables that adversely affected surgical results with logistic regression analysis for bronchiectasis.

Variables	OR	P value	95% CI
Age	1.044	0.032	1.004–1.086
Sputum volume	1.075	<0.00001	1.034–1.117
Smoking history	1.999	0.272	0.581–6.880
Gram-negative bacillus infection	27.929	<0.00001	8.044–96.971
Pulmonary function (FEV1%)	0.988	0.486	0.956–1.022
Bronchial stump coverage	0.027	<0.00001	0.006–0.129
Pneumonectomy	2.210	0.245	0.581–8.408

OR, odds ratios; CI, confidence intervals.

4. Discussion

Although the advances in thoracic surgery, the optimal treatment for bronchiectasis is still in controversy [11]. In the present study, all 260 bronchiectasis patients with medical treatment duration for long time were still accompanied with primary or secondary abscess, organized pneumonia and broncholithiasis, thus requiring surgical treatment. We performed selective surgery for 235 patients and emergency surgery for 25 patients with uncontrollable massive hemoptysis.

In the present study, incidence of postoperative complications was 11.5% as previous study that the incidence and mortality in bronchiectasis treatment with surgery were 9.4%–24.6% and 0%–8.3%, respectively [12]. The higher incidence of postoperative complications and mortality may be due to two reasons. First, the weaker physical condition of bronchiectasis patients increased the risk of postoperative infection. Second, emergency operation and insufficient preoperative preparation happened in some patients due to uncontrollable massive hemoptysis. For the first reason, we assessed the patients' conditions, instructed the patients with respiratory training and anti-biotic treatment, and used nutrition support. For the second reason, emergency operation should be avoided if there was no sufficient time for surgery preparation.

Univariate analysis results showed that age, sputum volume, Gram-negative bacillus infection and bronchial stump coverage were related with the outcome and prognosis. Miyako Hiramatsu et al. showed that an immunocompromised status, *P. aeruginosa* infection, and the extent of residual bronchiectasis were significantly related with the shorter relapse-free interval by univariate analysis [8]. Age was one of the factors that affected the complications after operation, which was consistent with the previous result [13]. In young patients, the disease duration was shorter and irreversible lesions were lighter than that in old ones who were accompanied by physical deterioration, hypertension, pulmonary heart disease and renal insufficiency. Thus, the risk of surgery was

increased in elderly patients. Therefore, we should keep alert on the age of patients. For the old patients, various organs should be examined to assess the risk before operation.

Massive sputum and pulmonary infection are the most common symptoms in bronchiectasis patients and sputum volume represents the severity of the pulmonary infection [4,14]. The patients who have more sputum volume and larger scope of pulmonary infection are inclined to have postoperative complications. Bilateral or multiple lobes disease is present in several patients with bronchiectasis. If the preoperative infection control fails, infection foci would induce bronchial secretion drainage obstruction and sputum accumulation, eventually leading to atelectasis and pulmonary infection. With the ability to clean the intra-tracheal secretion and decrease the sputum volume in airway or sputum accumulation in the pulmonary bronchia, postural drainage is critical for infection control [15]. Most of the Gram-negative bacteria are conditional pathogen and are common in hypoimmunity patients with emphysema, bronchiectasis and lung cancer [16–18]. Gram-negative bacterial infection could lead to severer pulmonary infections and other complications in perioperative period. Therefore, sputum culture analysis is urgently needed before operation, which could provide reference for assessing the incidence of post-operative complications. Patients should be treated with antibiotics and were performed with surgery after negative proof of Gram-negative bacillus.

In the current study, bronchopleural fistula and secondary empyema were found in 11 patients, which might result in severe complications, such as air leakage, empyema of operative side and pulmonary infections. According to the previous reports [19–22], bronchial stump with autologous tissue is related with incidence of the bronchopleural fistula, which is consistent with our results. Therefore, the bronchial stump coverage should be performed to reduce the incidence of complication after pneumonectomy in the bronchiectasis patients. Furthermore, bronchial stump coverage should be carried out under adequate blood supply and with ligation rather than electronic scalpel to stop bleeding in case of destroying the bronchial wall. Finally, bronchial stump coverage was performed using intercostals muscles or pedicle pleura embedding.

The primary limitation of the study is its retrospective nature. The retrospective nature of the study cannot account for the unknown variables affecting the outcome that are not correlated strongly with measured variables. Despite the retrospective and observational nature of the study, we provided data on a large cohort of patients undergoing surgery to treat bronchiectasis which has not been reported before, and demonstrated the safety and efficacy of surgical intervention for treating this pathology. Lastly, we admit the fact that our study has emanated from a single institution. Undoubtedly, any validation of the findings will require further prospective preferably randomized multicenter studies.

In conclusion, we found that surgery treatment was an effective way to cure the bronchiectasis in selective patients, and the surgery decision should be made after the evaluation of the respiratory physician. As age was one of the factors that impacted surgery, special attention must be paid to the management of elderly patients in a specialized center. Sputum volume lower than 30 mL, negative proof of Gram-negative bacillus infection, and bronchial stump coverage are key factors for effective surgery treatment.

Ethical approval

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Author contribution

Please specify the contribution of each author to the paper, e.g. study design, data collections, data analysis and writing.

Conceive and design the experiments: Yu-xing Jin, Yi Zhang.

Acquire and analyze the data: Liang Duan, Jia-an Ding.

Draft and revise the manuscript: Yang Yang, Ge-ning Jiang.

Conflict of interest

The authors have declared that no competing interests exist.

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