Use of lung-preserving surgery in left inflammatory bronchial occlusion and distal atelectasis: preliminary results

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Abstract

OBJECTIVES: Lung-preserving surgery was proved to be effective and safe to treat patients with benign bronchial strictures. However, this surgical treatment has been rarely reported in patients with complete occlusion in the left main bronchus. The aim of this study was to assess the value of this procedure and report our experience in the treatment of these patients with left atelectasis caused by inflammatory bronchial occlusion.

METHODS: We reviewed and analysed the medical records of 8 patients who had undergone left main bronchus sleeve resection for symptomatic left atelectasis caused by inflammatory bronchial occlusion from May 2007 to April 2011.

RESULTS: Eight patients (3 men and 5 women) with a medical history of active pulmonary tuberculosis were involved in this study. The median age was 23 years. Parenchyma-sparing left main bronchus resection was performed in 4 patients, 1 of whom received partial wedge resection in the lingual lobe. Left main bronchus sleeve resection plus superior lobectomy was performed in 2 patients and left main bronchus sleeve resection plus left inferior lobectomy in 2 patients, 1 of whom received additional partial wedge resection of the lingual lobe. The procedure was completed successfully in all 8 patients without postoperative deaths. The mean follow-up time was 49.3 months, ranging from 23 to 69 months. No major complications, including stenosis and atelectasis, were observed during the follow-up period. The symptoms of pulmonary atelectasis disappeared and pulmonary ventilation function improved significantly.

CONCLUSIONS: In symptomatic patients with left atelectasis caused by inflammatory bronchial occlusion, lung-preserving surgery is an effective and safe surgical treatment.

Keywords: Endobronchial inflammation • Bronchial occlusion • Left atelectasis • Surgical treatment • Sleeve resection

INTRODUCTION

Left atelectasis resulting from inflammatory bronchial occlusion may lead to consolidation of parenchyma and further destruction of the lung. Without symptoms of infection, no special treatment is undertaken in these patients, but pneumonectomy would be the last alternative when the left lung is destroyed. In this situation, patients will have both physiological and psychological trauma, including dyspnoea, compensatory emphysema and thorax collapse, which lead to a poor quality of life.

Inflammation of the left main bronchus can lead to bronchial cicatricial stenosis and complete occlusion, resulting in left atelectasis. The most common reason is endobronchial tuberculosis, which is defined as microbiological or histopathological evidence of tuberculous infection of the tracheobronchial tree [1]. In recent years, the incidence of pulmonary tuberculosis has increased, and there are ~8.8 million new cases each year [2, 3]. It has been reported that ~10–20% of patients with active pulmonary tuberculosis also have endobronchial tuberculosis, and ~90% of these patients have varying degrees of bronchostenosis [4].

Reports concerning the treatment of bronchostenosis resulting from endobronchial tuberculosis are now common, whereas those concerning the treatment of left atelectasis caused by complete occlusion of the main bronchi are rare. In patients with bronchostenosis, some treatment options are available, such as therapeutic bronchoscopy or surgery, which have shown satisfactory results [5–7]. However, if complete occlusion has occurred in the bronchial lumen, drug or interventional therapy is ineffective in atelectatic lungs [8]. To avoid destruction of the lung and pneumonectomy, we performed lung-preserving surgery in several patients with left atelectasis because of left main bronchus occlusion caused by bronchial inflammation between May 2007 and April 2011, with satisfactory preliminary results.

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patients with left atelectasis caused by inflammatory bronchial occlusion.

MATERIALS AND METHODS

All the patients included in this retrospective study had undergone left main bronchus sleeve resection for left atelectasis because of inflammatory left main bronchus occlusion in the Department of Thoracic Surgery of Tongji Hospital affiliated to the Tongji Medical College of Huazhong University of Science and Technology between May 2007 and April 2011. Before data collection, consent was obtained from each patient. Permission for the study was obtained from the Institutional Ethics Committee of Tongji Hospital.

In each patient, we recorded age, gender, duration of preoperative antituberculosis therapy, surgical procedure, postoperative hospital stay, pathological examination and duration of follow-up (Table 1). Each patient received a careful management plan preoperatively, especially for pulmonary function. Sputum smear examination for Mycobacterium tuberculosis and the purified protein derivative (PPD) test were performed preoperatively in all patients. Complete pulmonary function tests and arterial blood gas analysis were routinely performed to assess pre- and postoperative lung function. Preoperative flexible bronchoscopy and chest computed tomography (CT) were performed to evaluate the range of resection. The selection criteria were as follows: (i) left atelectasis; (ii) complete occlusion in the lumen of the left main bronchus; (iii) patients were asymptomatic; and (iv) medical history of active pulmonary tuberculosis. The exclusion criteria were as follows: (i) malignant lesions were confirmed pre- or postoperatively; (ii) age was >40 years; (iii) chest CT showed the left lung had been destroyed or with bronchiectasis; (iv) positive results of sputum smears of M. tuberculosis or other examinations indicating active tuberculosis; and (v) pulmonary function could not afford a lobectomy (forced expiratory volume in 1 s <1.0 l or maximum minute ventilation% <40%).

During the surgical procedure, a standard double-lumen tube was used. The chest was entered through the fifth intercostal space via a posterolateral thoracotomy. Whether a parenchyma-sparing left bronchial sleeve resection could be performed depended on the presence of consolidation in the parenchyma and the range of the lesions. Without lobar or segmental consolidation, parenchyma-sparing left main bronchus sleeve resection and airway reconstruction were performed to preserve healthy lung tissue, which could reduce the incidence of postoperative respiratory complications. The reconstruction was undertaken proximally at the level of the carina and distally at the bifurcation. However, a main bronchus sleeve resection plus lobectomy was performed when there was obvious consolidation in the parenchyma and/or occlusion in the lobar bronchi. The reconstruction was undertaken proximally at the level of the carina and distally at the orifice of the lobar bronchus. Additional partial wedge resection must be performed if some of the lung parenchyma does not re-expand after Anastomosis. Non-absorbent 4-0 polypropylene sutures were routinely used for the anastomosis. To reduce the anastomotic tension, the inferior pulmonary ligament was divided, followed by routine dissection of the hilum. Without lobectomy, the anastomosis was not wrapped. In the procedures including lobectomy, because of the higher anastomotic tension, the anastomosis was covered with a pedicled pericardial flap, or omental flap if necessary, after testing for air leaks. The hilar and subcarinal lymph nodes were routinely removed. Two chest drainage tubes were routinely placed.

Follow-up in all patients was available up to 31 March 2013, including chest radiography every 6 months, complete ventilation function 1 year postoperatively, and yearly chest CT and bronchoscopy. All patients received isoniazid–rifampicin–ethambutol combined triple anti-tuberculosis therapy postoperatively for 6 or 9 months.

RESULTS

Eight patients (3 men and 5 women) with a median age of 23 years were included in this retrospective study. The primary symptom was chest tightness and shortness of breath after exertion in 4 patients, irritating cough without sputum or fever in 3 patients and chest pain in 1 patient. Active pulmonary tuberculosis was diagnosed in all patients as the appearance of M. tuberculosis in sputum smears. The anti-tuberculosis therapy lasted from 6 to 12 months before surgery. The sputum smear tests were negative in all patients and the PPD tests were + to ++ (5–10 mm) preoperatively, indicating low levels of tuberculosis activity. Preoperative chest radiography and CT showed left atelectasis, leftward movement of the mediastinum and compensatory expansion of the right lung. No pulmonary tuberculosis was observed (Fig. 1A). Flexible bronchoscopy showed fibrostenosis and occlusion of the left main bronchus, with smooth proximal mucosa (Fig. 1B). Neither a brush cytology test nor biopsy of the mucosa showed evidence of M. tuberculosis. Arterial blood gas analysis was normal and pulmonary ventilatory function showed no surgical contraindications.

Left main bronchus sleeve resection and carinal reconstruction were performed in all 8 patients. Parenchyma-sparing left main bronchus sleeve resection was performed in 4 patients, of whom 1 received additional partial wedge resection in the lingual lobe. Two patients underwent left main bronchus sleeve resection plus superior lobectomy because of complete occlusion in the left superior lobar bronchus and consolidation of the left superior lobe. Left main bronchus sleeve resection plus left inferior lobectomy was performed in the other 2 patients because of occlusion in the left inferior lobar bronchus and consolidation of the left inferior lobe, and 1 patient underwent partial wedge resection in the lingual lobe because of partial consolidation. At surgery, patients showed left atelectasis and small light-yellow clear pleural effusions; none showed pleural adhesions (Fig. 2A). The lateral wall of the left main bronchus was thickened with linear/fatty streaks and this was most obvious in the middle portion. There were numerous secretions in the bronchial lumen (Fig. 2B). The impaired lung expanded well after the surgical procedure (Fig. 2F).

The surgery was successful in all patients, without pulmonary oedema. There were no postoperative deaths. The mean postoperative length of hospital stay was 14.1 days (ranging from 12 to 17 days). The chest drainage tubes were removed 5–7 days postoperatively. Postoperative chest CT and bronchoscopy showed no anastomotic dehiscence or anastomotic stenosis (Fig. 1C, D). No complications, such as pneumonia or atelectasis, occurred. Pathological examination showed chronic inflammatory changes and proliferation of fibrous connective tissue on the left main bronchus wall in all patients without tubercular histologic features (Langhans giant cells, caseous necrosis, etc.). Left inferior pulmonary tuberculosis as well as subcarinal and hilar lymph node tuberculosis were found in 1 patient. Left superior pulmonary

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tuberculosis and reactive hyperplasia in subcarinal and hilar lymph nodes were found in 2 patients. All of them underwent triple antituberculosis therapy for 6–9 months postoperatively, and the drugs were withdrawn only if three consecutive sputum smears were negative for *M. tuberculosis*. The mean follow-up time was 49.3 months, ranging from 23 to 69 months. Chest radiography was performed every 6 months, and chest CT and bronchoscopy every year for the first 2 years postoperatively. No stenosis at the anastomosis or left atelectasis was observed (Fig. 1E, F). A telephone follow-up confirmed a normal exercise capacity in all patients. All patients were able to engage in normal work and social life without dyspnoea, chest tightness, cough or other complaints. Complete pulmonary function tests were performed 1 year after surgery and showed that the pulmonary ventilation had significantly improved compared with the preoperative state (Table 2).

**COMMENT**

Inflammatory bronchial stenosis can lead to complete occlusion and, therefore, result in atelectasis of the whole lung or lobe and obstructive pneumonia if not well treated. Besides anti-infection treatment, there have been no effective treatments reported for atelectatic lungs before the lung is destroyed. Both drug and interventional therapies show a poor effect [9, 10]. Although pneumonectomy is an effective procedure to treat the destroyed lungs [11], there can still be some problems postoperatively. The difficult surgical procedure for lungs destroyed by tuberculosis can cause more postoperative complications [12, 13], including respiratory failure, empyema and bronchopleural fistula, which result in higher mortality. There are also long-term complications, such as dyspnoea, compensatory emphysema, contralateral bronchiec-
tasis and thorax collapse, which can have negative effects on physical and social functioning and lead to a poor quality of life for the patients. So, pneumonectomy should be the last alternative for benign disease, especially in young patients who are in fairly good physical condition.

As a sequela, inflammatory bronchial occlusion mostly results from endobronchial tuberculosis. Owing to better immunity and more severe reactions to inflammatory stimuli, inflammatory bronchial stenosis and occlusion emerge earlier in younger patients. It has also been reported that the left-side and female patients were more likely to be affected for anatomical and pathological reasons [14–16], which is in accordance with the findings in the present study.

Preoperative treatment has an important role in the healing process. Each patient needs to have received a standard 6-month antituberculosis therapy, and sputum smears, endobronchial brushing and biopsy should confirm that there is no active endobronchial tuberculosis. Careful medical screening, especially 3D CT reconstruction of the airway and bronchoscopy, is essential to establish the resection range of the left main bronchus. Combined with preoperative bronchoscopy and chest CT, the whole left main bronchus should be imaged to certify the range of resection. Whether the chronically atelectatic lungs could re-expand and resume meaningful function after the airway reconstruction was our most important concern. Although it has been reported that several chronically atelectatic lungs showed restored ventilation and gas exchange function [17, 18], we still selected the patients strictly. The patients should be symptomatic, relatively young and physically well.
Inflammatory bronchial stenosis and/or occlusion are the result of damaged bronchial cartilage and fibrosis [19]. Two different mechanisms can explain the pathogenesis briefly. One hypothesis is that the bronchial mucosa is invaded by direct implantation of M. tuberculosis; the other is that the infected lymph nodes could compress the bronchial tree and may ultimately ulcerate into it [20]. So, we performed hilar and subcarinal lymph node resection routinely in the case of recurrence of lymphoid tuberculosis. Postoperative pathological examination confirmed hilar and subcarinal lymphoid tuberculosis in 1 patient, which may have led to recurrence.

Figure 1: Preoperative and postoperative chest CT images and bronchoscopic images: (A) preoperative chest CT images show left atelectasis with compensatory expansion in the right parenchyma and movement of the mediastinum to the left. (B) Preoperative bronchoscopy image shows complete occlusion of the left main bronchus. (C) Chest CT images 2 weeks after surgery show well re-expanded parenchyma. (D) Flexible bronchoscopic image 2 weeks after surgery shows no stenosis in the bronchial lumen. (E) Chest CT images 1 year postoperatively show a well re-expanded left lung. (F) Flexible bronchoscopic image shows no stenosis at the bronchial anastomosis 2 years after surgery.

Circumferential retractional scarring and submucosal fibrosis ultimately result in fibrostenosis [21]. In the end, fibrostenosis typically presents as a stiff stricture of the bronchus lined with normal-looking mucosa [22]. We consider that pulmonary tuberculosis may recover and the inflamed tissue may be absorbed under the action of both antituberculosis therapy and the immune system and then develops into a particular type of endobronchial inflammation, which leads to cicatricial occlusion of the left main bronchus and left atelectasis. This is the reason why there was no histological evidence of tuberculosis on the bronchial wall in the postoperative pathological examination.
The resection length should extend beyond the lesions in case recurrence occurs and, if necessary, the margin should be confirmed in a frozen section. The principle is to remove completely the lesions in the bronchus and parenchyma, preserving healthy lung tissues. To reduce tissue reaction and granuloma tissue formation at the anastomosis, which can lead to postoperative anastomotic stenosis, we formed a continuous anastomosis using 4-0 non-absorbent polypropylene sutures. To reduce tension at the anastomosis, the inferior pulmonary ligament should be divided, followed by routine dissection of the hilum. Meanwhile, blood supply to healthy tissues must be protected to avoid bronchial fistula. Owing to its deep position, the anastomosis is covered by pericardium, mediastinal fat and connective tissues, and, so, in some patients, wrapping is not required. However, if necessary, the anastomosis can be covered with a pedicled pericardial or omental flap to reduce the incidence of bronchial fistula. In the present study, we used a pedicled omental flap to cover the anastomosis in 2 patients with high anastomotic tension.

Early postoperative expectoration or sputum suction by the bronchoscope may be important in prevention of postoperative atelectasis and pneumonia. We suggest that antituberculosis therapy can be withdrawn only if regular therapy has lasted for at least 6–9 months and the sputum smear is negative. However, there are still some problems to be overcome. Although high-resolution CT imaging of the chest can evaluate the distal portion, which is inaccessible to bronchoscopy, we still could not precisely determine the range of bronchus resection preoperatively because we could not evaluate the consolidation of the parenchyma preoperatively. It has also been reported that unanticipated bronchial malacia, which is caused by cartilage

### Table 2: Improvement of pulmonary ventilation function

<table>
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<tr>
<th>No.</th>
<th>Preoperative FEV1 (l/s)</th>
<th>1-year postoperative FEV1 (l/s)</th>
<th>Improvement compared with preoperative (%)</th>
<th>Preoperative TLC (l)</th>
<th>1-year postoperative TLC (l)</th>
<th>Improvement compared with preoperative (%)</th>
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<td>Mean ± SD</td>
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<td>2.351 ± 0.686*</td>
<td></td>
<td>3.310 ± 0.810</td>
<td>4.119 ± 0.686*</td>
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FEV1: forced expiratory volume in 1 s; TLC: total lung capacity.

*P <0.05.
destruction by tuberculous inflammation, results in extended resection [23]. A dynamic expiratory CT scan may be able to detect bronchomalacia during the preoperative preparation [24]. During the period of the present study, pneumonectomy was performed on 2 patients for unanticipated involvement of the bifurcation and both of lobar bronchus. Recent research also reported that the artificial material such as stent-supported cryopreserved aortic allograft allowed expansion of the use of parenchymal-sparing surgical procedures [25]. Another problem is perioperative antituberculosis treatment. According to our experience, we suggest that patients with left atelectasis who have a history of pulmonary disease should receive antituberculosis therapy postoperatively in the case of recurrence. Without pulmonary or lymphoid tuberculosis in the postoperative pathological examination, the suggested duration of therapy is 6 months. Alternatively, 9 months of postoperative antituberculosis therapy is suggested. However, whether the postoperative antituberculosis therapy is essential and its duration are still matters of debate and need to be further discussed [9].

In our experience, left main bronchus sleeve resection is an efficient and relatively safe procedure in selected patients with left atelectasis. Based on this experience, we suggest that left main bronchus sleeve resection is an ideal alternative in young patients with symptomatic left atelectasis due to inflammatory bronchial occlusion, which may prevent the impaired lungs from being destroyed.

This review showed a good preliminary result in the patients studied, all of whom had a normal life postoperatively during the follow-up period. The long-term results require further observation.

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