Pneumonectomy for unilateral destroyed lung with pulmonary hypertension due to systemic blood flow through broncho-pulmonary shunts

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Abstract

Objective: Three decades ago, a few patients with pulmonary hypertension and respiratory failure associated with a unilateral destroyed lung were reported to have been treated by a pneumonectomy. In the present study, we investigated the clinical features, operative indications, and results of four cases with pulmonary hypertension that underwent a pneumonectomy for a unilateral destroyed lung. Methods: Four patients (three males, one female) with a destroyed lung and pulmonary hypertension (mean pulmonary arterial pressure > 25 mmHg) were treated by a pneumonectomy between 1999 and 2002 at our institution. Their mean age was 59 years old (range 42-68 years). The underlying lung disease, Medical Research Council (MRC) dyspnea scale, respiratory function, arterial blood gas analysis, pulmonary arterial pressure, preoperative management, operative procedure, and postoperative course for each were reviewed retrospectively. Results: The underlying lung disease that caused the destroyed lung was bronchiectasis in two patients, chronic empyema with bronchopleural fistula in one, and necrotizing pneumonia in one. The average mean pulmonary artery pressure was 33 mmHg (range 25-42 mmHg), which decreased to 27 mmHg (range 19-36 mmHg) after occlusion of the pulmonary artery in the affected lung. Following the pneumonectomy, the average mean pulmonary artery pressure was decreased to 17 mmHg (range 11-25 mmHg). Chronic inflammatory symptoms and functional impairments (shown by blood gas analysis, pulmonary arterial pressure, or MRC dyspnea scale) improved post-pneumonectomy. There was no operative death, though postoperative cardiorespiratory failure occurred in one patient. All patients were discharged from the hospital. Conclusions: We concluded that a pneumonectomy procedure may be indicated for selected patients with a unilateral destroyed lung and pulmonary hypertension due to systemic blood flow through broncho-pulmonary shunts.

Keywords: Pneumonectomy; Destroyed lung; Pulmonary hypertension

1. Introduction

In a destroyed lung, systemic blood inflow from the bronchial artery to the pulmonary arterial tree is increased, which occasionally results in secondary pulmonary hypertension and, finally, respiratory failure, despite a normal contralateral lung, while a pneumonectomy was able to reduce pulmonary hypertension and consequently relieve respiratory failure [1-3]. Herein, we report four patients with pulmonary hypertension treated with a pneumonectomy for a unilateral destroyed lung.

2. Material and methods

From 1999 to 2002, 23 pneumonectomies for benign lung disease were performed at the National Hospital Organization Kinki-chuo Chest Medical Center, while four (17%) patients with pulmonary hypertension (mean pulmonary arterial pressure > 25 mmHg) and respiratory failure underwent a pneumonectomy for a unilateral destroyed lung. The records of these patients were retrospectively reviewed and analyzed for clinical findings, underlying lung disease, Medical Research Council (MRC) dyspnea scale [4], pulmonary function, pulmonary arterial pressure (PAP), unilateral pulmonary arterial occlusion (UPAO) test results, arterial blood gas measurement, preoperative management, operative procedure, and postoperative course.

3. Clinical findings

The clinical findings are summarized in Table 1. The patients were three men and one woman, with an average age of 59 years old (range 42-68 years). The underlying lung disease was bronchiectasis in two patients, empyema with a bronchopleural fistula (25 years after a right upper lobectomy for pulmonary tuberculosis) in one, and unknown severe necrotizing pneumonia in one. The symptoms were suppurative secretion in two patients, recurrent hemoptysis in one, and chronic fever in one. Microbacterial examinations of sputum detected pseudomonas aeruginosa in
three patients, and no bacteria in one. As for MRC dyspnea scale, three patients were grade 4, and one was grade 5. Each patient required continuous oxygen therapy. Results of the arterial blood gas measurements showed that average oxygen tension \( (p_{O_2}) \) was 77 Torr (range 66–88 Torr) and average carbon-dioxide tension \( (p_{CO_2}) \) was 58 Torr (range 40–70 Torr), with oxygen inhalation ranging from 1 to 2 l/min. Hypercapnia \( (p_{CO_2} > 45 \text{ Torr}) \) was confirmed in three patients.

Average preoperative vital capacity (VC) was 1240 ml (range 1230–2300 ml) and 47% (range 41–60%) of the predicted value, while average forced expiratory volume in 1 s (FEV\(_1\)) was 1130 ml (range 760–1940 ml) and 41% (range 28–69%) of the predicted FEV\(_1\). Perfusion ventilation scintigrams showed a minimal contribution in the affected site in all of the patients. Average perfusion ratio of affected lung was 4.4% (range 2.2–5.5%). Further, computed tomographic scan and chest roentgenogram showed marked contraction, scarring, and extreme volume loss with a shift of the mediastinum into the affected hemithorax in each patients (Fig. 1). Echocardiogram findings revealed normal wall motion in each and an average ejection fraction of 69% (range 60–80%). Pulmonary angiography demonstrated that pulmonary arterial flow in the affected lungs was reduced or absent (Fig. 2), and thoracic aortography showed bronchial arterial proliferation and systemic inflow to the pulmonary arterial tree from the bronchial circulation (Fig. 3). Preoperative right heart catheterization results showed an average cardiac index of 3.8 l/min per m\(^2\) (range 3.3–4.3 l/min per m\(^2\)). The average mean pulmonary artery pressure (MPAP) was 33 mmHg (range 25–42 mmHg), while 20 min after main pulmonary arterial occlusion on the affected site it was decreased in each patient to an average of 27 mmHg (range 19–36 mmHg).

### 4. Preoperative management

The two patients with bronchiectasis received intensive chest physiotherapy with postural drainage of suppurative sputa. However, since their preoperative bronchoscopic examinations showed massive sputa retention, each underwent a punctured cricothyrotomy [Mini Trach II (Portex)] for direct suction of sputa at 1 month prior to the pneumonectomy and their respiratory symptoms improved with the decrease in sputa. One patient with empyema underwent an open window thoracostomy 1.5 years before...
the pneumonectomy and the empyema was controlled, though purulent sputa and recurrent hemoptysis from the underlying destroyed lung persisted. One patient with necrotizing pneumonia received no preoperative intensive management, because the main symptom was chronic low-grade fever.

5. Indications for pneumonectomy in present patients

Chronic inflammatory symptoms were present in each patient, leading to long-term ill health and recurrent hospitalization. The unilateral lung was destroyed functionally or radiographically, while the contralateral lung was normal or had minimal sequela changes. The diseased lung provided a minimal contribution to total ventilation and the postoperative predicted decrease of respiratory function was minimal. Normal cardiac function was seen in the catheterization and echo-cardiac examination findings. A decrease of MPAP during a UPAO test in each suggested that PH was associated with the unilateral destroyed lung. Thus, a pneumonectomy was anticipated to improve the chronic inflammatory symptoms and reduce pulmonary arterial pressure.

6. Operative procedures and results

The pneumonectomy was done using a standard posterolateral approach for all patients, on the left side in one and the right side in three. A double-lumen tube was inserted and bronchoscopy was performed to clear the airways before the patient was turned to the thoracotomy position. Dense and often highly fibro-vascular pleural adhesions were commonly encountered. To mobilize the affected lung in the easiest and safest plane, we sometimes changed from intrapleural to extrapleural dissection. The bronchial stump was closed with an interrupted hand suture and enforced with the adjacent mediastinal fat tissue or pleura. Operative time ranged from 387 to 664 min (average, 508 min) and operative blood loss ranged from 1090 to 2560 ml (average, 1703 ml). Three patients were extubated in the operating room and one in the intensive care unit on postoperative day 1. The postoperative course was uneventful in three patients, while one patient experienced cardiorespiratory failure 3 days after the operation that required mechanical ventilation and an administration of dopamine for 2 weeks.

Postoperative findings are summarized in Table 2. The MRC dyspnea scale was improved in three patients, while one had no remarkable change of MRC scale. VC was decreased by an average of 18% (range 14-23%) and FEV1.0 by an average of 21% (range 13-25%), as compared to the preoperative values. Arterial pO2 improved in three patients in the same condition as the preoperative oxygen inhalation and two of them were no longer dependent upon oxygen therapy ultimately. In two of three patients with preoperative hypercapnia, pCO2 decreased to a normal range. MPAP decreased in all to an average of MAP 17 mmHg (range 11-25 mmHg). All patients were free from long-term inflammatory symptoms, and discharged from the hospital with a significantly improved quality of life. One patient died from an unrelated brain disorder 9 months after the operation, while the others were alive at the time of this study.

Table 2
Pulmonary function in patients

<table>
<thead>
<tr>
<th>Patient 1</th>
<th>MRC</th>
<th>VC (%) (ml)</th>
<th>FEV1.0 (%pred) (ml)</th>
<th>MPAP (*) (mmHg)</th>
<th>pO2 (Torr)</th>
<th>pCO2 (Torr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>4</td>
<td>1230 (44)</td>
<td>870 (37)</td>
<td>39 (32)</td>
<td>66</td>
<td>52</td>
</tr>
<tr>
<td>Post</td>
<td>2</td>
<td>1060 (36)</td>
<td>660 (28)</td>
<td>11</td>
<td>87</td>
<td>42</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Patient 2</th>
<th>MRC</th>
<th>VC (%) (ml)</th>
<th>FEV1.0 (%pred) (ml)</th>
<th>MPAP (*) (mmHg)</th>
<th>pO2 (Torr)</th>
<th>pCO2 (Torr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>4</td>
<td>2030 (59)</td>
<td>1940 (69)</td>
<td>26 (22)</td>
<td>89</td>
<td>40</td>
</tr>
<tr>
<td>Post</td>
<td>2</td>
<td>1660 (50)</td>
<td>1690 (54)</td>
<td>17</td>
<td>94</td>
<td>41</td>
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<table>
<thead>
<tr>
<th>Patient 3</th>
<th>MRC</th>
<th>VC (%) (ml)</th>
<th>FEV1.0 (%pred) (ml)</th>
<th>MPAP (*) (mmHg)</th>
<th>pO2 (Torr)</th>
<th>pCO2 (Torr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>5</td>
<td>1590 (45)</td>
<td>950 (29)</td>
<td>42 (36)</td>
<td>83</td>
<td>70</td>
</tr>
<tr>
<td>Post</td>
<td>5</td>
<td>/</td>
<td>/</td>
<td>25</td>
<td>83</td>
<td>75</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Patient 4</th>
<th>MRC</th>
<th>VC (%) (ml)</th>
<th>FEV1.0 (%pred) (ml)</th>
<th>MPAP (*) (mmHg)</th>
<th>pO2 (Torr)</th>
<th>pCO2 (Torr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>4</td>
<td>1350 (41)</td>
<td>760 (28)</td>
<td>25 (19)</td>
<td>70</td>
<td>67</td>
</tr>
<tr>
<td>Post</td>
<td>3</td>
<td>1040 (32)</td>
<td>570 (21)</td>
<td>16</td>
<td>103</td>
<td>54</td>
</tr>
</tbody>
</table>

MRC, Medical Research Council dyspnea scale; VC, vital capacity; FEV1.0, forced expiratory volume; %pred, FEV1.0/predicted FEV1.0; MPAP, mean pulmonary arterial pressure; (*), MAP after pulmonary arterial occlusion; pre, preoperative value; post, postoperative value.
report for an average of 3.8 years (range 2.1-5.3 years) after the pneumonectomy.

7. Discussion

A pneumonectomy remains the only treatment for cure and/or symptomatic improvement in patients with a unilateral destroyed lung. The end stage of a destroyed lung with pulmonary hypertension and respiratory failure is generally considered in the absence of classical indication of a pneumonectomy. Such patients have a history of frequent and lengthy periods of hospitalization, resulting in considerable morbidity. While, a few cases of functional improvement following pneumonectomy of the unilateral destroyed lung have been reported [1-3]. In the first such case, reported by Cohen et al. [1], a pneumonectomy for a unilateral destroyed lung was associated with significant functional improvement in arterial oxygen tension and lowering of pulmonary pressure. Thus, it is suggested that the possibility of pneumonectomy should be considered for suitable patients with a unilateral destroyed lung, even in the absence of classical indications for resection.

Rare cases have shown abnormal communication between the aorta or its branches and pulmonary arterial tree (left to right shunt) and only large left to right shunt can lead to severe irreversible pulmonary arterial hypertension ultimately [5]. Several studies have found increased bronchial circulation along with enlarged and numerous connections to the pulmonary arterial tree in unilateral destroyed lungs [6,7]. Further, Kagawa et al. demonstrated that pulmonary hypertension with a unilateral destroyed lung caused an increase of systemic arterial inflow from the bronchial circulation and a decrease of the pulmonary vascular bed of the affected lung, which was based on histological findings as well as those of bronchial and pulmonary angiograms [3]. In the present patients, the same findings were shown as in the previous reports. Thus, it is suggested that numerous left to right shunts in a unilateral destroyed lung may lead to pulmonary arterial hypertension.

For a successful pneumonectomy procedure, patient selection is most important. A UPAO test is useful for the preoperative assessment of a pneumonectomy for lung cancer, as it simulates loss of the pulmonary vascular bed, and estimates the extent of pulmonary vascular resistance and pulmonary arterial pressure [8]. For patients with a destroyed lung in previous reports, a UPAO test was not always considered necessary, because the pulmonary vascular bed was already decreased on the affected site and total functional destruction was revealed on the ventilation-perfusion scintigram, though pulmonary hemodynamics are not clearly demonstrated on a scintigram. In our experience, a preoperative UPAO test is useful to provide information regarding the pulmonary hemodynamic and operative indication for a unilateral destroyed lung in a patient with pulmonary hypertension. In all of the present cases, pulmonary arterial pressure decreased during the UPAO test and PH was improved after the pneumonectomy.

A pneumonectomy for inflammatory lung disease is high-risk procedure. Mortality and morbidity have been reported to range from 2.4 to 5.9% and 11.9 to 38%, respectively [9-12]. Therefore, preoperative intensive chest physiotherapy is extremely important to reduce postoperative complications, such as post-pneumonectomy empyema, bronchopleural fistula, and contratralateral spillage [10]. Further, method for direct drainage of infectious materials, such as a punctured cricothyrotomy to clean the airway, or open or closed surgical drainage of the empyema cavity, is also necessary. Antibiotics were administered based on microbiological examination and sensitivity results for a patient with clinical signs of active pulmonary infection [10]. When these preoperatively intensive management techniques are not effective, the pneumonectomy will likely be hazardous and difficult to perform. In our series, there were no operative deaths, while morbidity was limited to cardiorespiratory failure in one patient, even in such a severe condition. Therefore, we consider that a pneumonectomy for a destroyed lung with functional impairment is feasible for selected patients.

Though preoperative ventilation-perfusion scintigrams demonstrated minimal functional contribution on the affected site, pulmonary function showed an approximately 20% decrease as compared to the preoperative value, after the pneumonectomy, while MRC dyspnea scale or arterial blood gas analysis results improved. These findings suggest that a pneumonectomy might interrupt systemic blood inflow and reduce pulmonary arterial pressure, leading to an improvement in ventilation efficacy, the potential effect of pCO₂ reduction on pulmonary vascular resistance and relieve respiratory failure.

A unilateral destroyed lung with pulmonary hypertension is a severe and chronic condition. A pneumonectomy is a high-risk procedure for such a condition; however, it is the only current choice for curing, as well as symptomatic and functional improvements. We consider that an elective pneumonectomy is feasible and can provide good results, and may be indicated for patients with a destroyed lung associated with pulmonary hypertension, due to increased systemic inflow to the pulmonary arterial tree from the bronchial circulation.

References


