Long-Term Results of Lung Decortication in Patients with Trapped Lung Secondary to Coronary Artery Bypass Grafting

Sezai Celik, MD, Muharrem Celik, Bulent Aydemir, MD, Cemalettin Tunckaya, MD, Tamer Okay, MD, and Ilgaz Dogusoy, MD

Department of Thoracic Surgery, Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital, Istanbul, Turkey

Received: May 26, 2011; Accepted: July 21, 2011
Corresponding author: Sezai Celik, MD. Balkan Cad. Kiptas Yesilvadi Konaklari, A3 Blok, D: 36, 34000 Umranie, Istanbul, Turkey
Email: dr_sezaicelik@hotmail.com
©2011 The Editorial Committee of Annals of Thoracic and Cardiovascular Surgery. All rights reserved.

Purpose: To evaluate long-term results of decortications in patients with symptomatic restrictive pleurisy and trapped lung after coronary bypass grafting.

Methods: Twenty consecutive patients undergoing lung decortications for trapped lung after coronary bypass grafting were prospectively evaluated. Pulmonary function tests were used as objective criteria, and quality of life was assessed by the Medical Research Council dyspnea scale. A p value <0.05 was considered significant.

Results: Twenty patients, 3 women and 17 men, with a median age of 59 years were evaluated. The median time interval between coronary bypass grafting and decortications was 9.3 months. The mean preoperative forced expiratory volume in one second and forced vital capacity were 63.8% ± 7.4% and 50.5% ± 6.6% of the predicted value, respectively, and the improvement rates after decortications were 14.97% ± 6.3% and 17.62% ± 6.38%, respectively. Dyspnea scores improved after decortications (p <0.05). The median follow-up was 25 months. After surgery, 3 patients developed superficial wound infections, and out of 7 patients with prolonged air leaks, 2 underwent re-operation. After surgery, one patient died on day 34 and another, after 3 years.

Conclusion: Lung decortications, re-expanding the affected lung, ensures symptom remission and improves quality of life of patients with trapped lung after coronary bypass grafting in the long-term.

Keywords: lung, decortication, restrictive pleurisy, trapped lung, coronary artery bypass grafting
Materials and Methods

In the present study, 20 consecutive patients who were performed lung decortication for trapped lung developed after CABG surgery, between March 2004 and January 2007, were prospectively evaluated. All of the patients were referred to our clinic from cardiology and cardiovascular surgery departments. The study was approved by the Ethics Committee of Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital. All patients were informed of the study protocol, and written consent from each participant was obtained before any study procedure was started. The diagnosis of trapped lung was based on the clinical course of the disease, roentgenographic examinations [posteroanterior and lateral chest radiographs, and contrast-enhanced spiral computed tomography (CT)]. Patients with post-CABG empyema, hematoma and cardiac failure [Ejection Fraction (EF) <40], and trapped lung cases due to reasons other than coronary bypass surgery (malignancy, complicated parapneumonic effusions, uremic pleurisy, sarcoidosis pleurisy, tuberculous pleurisy), and patients with interstitial lung disease, severe thoracic deformity, moderate-severe chronic obstructive lung diseases were excluded. Cytological, serological, bacteriological and immunological tests were performed to all patients. Additionally, closed pleural biopsy was performed to 3 patients, and the samples were found to be negative for malignancy. Chest roentgenography, tomography, pulmonary function tests, fiberoptic bronchoscopy and echocardiography were routinely performed on all patients before decortications. After decortications, posteroanterior and lateral chest radiographs, tomography and pulmonary function tests were repeated in all patients at 6, 12 and 24 months, and at the final evaluation. During follow-up, the remaining concerns of patients might have been due to symptoms of coronary artery disease; therefore we performed myocardial perfusion scintigraphy for the evaluation. Two patients underwent coronary angiography, and occlusion was determined in one of the patients in a single saphenous vein and medical treatment was decided.

Pulmonary function tests [forced vital capacity (FVC percent predicted) and forced expiratory volume in one second (FEV1 percent predicted)] were used as objective criteria. The effects of decortications on quality of life were subjectively evaluated by the Medical Research Council (MRC) dyspnea scale.

A standard posterolateral thoracotomy, via the 5th intercostal space, was performed in the lateral decubitus position while the contralateral lung was ventilated. During the surgery, adhesions were meticulously separated with electrocautery on manual ventilation, and the restrictive fibrous layer was peeled away from the lung by blunt dissection. At the end of the operation, before closing the chest, the lung was ventilated with positive-end expiratory pressure and warm saline was installed into the chest cavity to test for air leaks. Significant air leaks were surgically corrected and fibrin glue was used, when necessary. Two chest tubes were placed, and a suction pressure of −20 cm H2O was used.

Statistical analysis

Descriptive data were presented as mean ± standard deviation, median and percentages, where appropriate. Preoperative and postoperative FVC values were compared by the paired t-test, and the preoperative and postoperative FEV1 values and the dyspnea scores were compared with Wilcoxon signed rank test. A p value <0.05 was considered statistically significant.

Results

Twenty patients, 3 women and 17 men, were evaluated. The median age of patients was 59 years (range 41–73 years). The disease was located at the left and right hemithoraces in 15 and 4 patients, respectively, and the disease involved both hemithoraces in one patient. Before decortications, 75% of patients received diclofenac at a dose of 100 mg once a day for 30 days, and the remaining patients received indometacin at a dose of 50 mg twice daily for 30 days. None of the patients received steroids. The median time interval between CABG and decortications was 9.3 months (range 4–32 months), the median EF% was 55 (range 45–70), and the rate of left internal mammary artery (LIMA) use was 99%.

Baseline characteristics of patients and preoperative findings are presented in Table 1. Initially, all the patients had pleural effusions involving more than 25% of one hemithorax.

The mean number of thoracentesis was 3. Tube thoracostomy was performed in 11 (55%) patients. Intrapleural streptokinase was administered to 5 patients with tube thoracostomy, however, trapped lung developed in these patients despite streptokinase administration.

A restrictive pattern was observed in the pulmonary function tests of all patients. The mean preoperative FEV1 % was 63.8% ± 7.4% of the predicted value, and the mean preoperative FVC% was 50.5% ± 6.6% of the

Materials and Methods

In the present study, 20 consecutive patients who were performed lung decortication for trapped lung developed after CABG surgery, between March 2004 and January 2007, were prospectively evaluated. All of the patients were referred to our clinic from cardiology and cardiovascular surgery departments. The study was approved by the Ethics Committee of Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital. All patients were informed of the study protocol, and written consent from each participant was obtained before any study procedure was started. The diagnosis of trapped lung was based on the clinical course of the disease, roentgenographic examinations [posteroanterior and lateral chest radiographs, and contrast-enhanced spiral computed tomography (CT)]. Patients with post-CABG empyema, hematoma and cardiac failure [Ejection Fraction (EF) <40], and trapped lung cases due to reasons other than coronary bypass surgery (malignancy, complicated parapneumonic effusions, uremic pleurisy, sarcoïdosis pleurisy, tuberculous pleurisy), and patients with interstitial lung disease, severe thoracic deformity, moderate-severe chronic obstructive lung diseases were excluded. Cytological, serological, bacteriological and immunological tests were performed to all patients. Additionally, closed pleural biopsy was performed to 3 patients, and the samples were found to be negative for malignancy. Chest roentgenography, tomography, pulmonary function tests, fiberoptic bronchoscopy and echocardiography were routinely performed on all patients before decortications. After decortications, posteroanterior and lateral chest radiographs, tomography and pulmonary function tests were repeated in all patients at 6, 12 and 24 months, and at the final evaluation. During follow-up, the remaining concerns of patients might have been due to symptoms of coronary artery disease; therefore we performed myocardial perfusion scintigraphy for the evaluation. Two patients underwent coronary angiography, and occlusion was determined in one of the patients in a single saphenous vein and medical treatment was decided.

Pulmonary function tests [forced vital capacity (FVC percent predicted) and forced expiratory volume in one second (FEV1 percent predicted)] were used as objective criteria. The effects of decortications on quality of life were subjectively evaluated by the Medical Research Council (MRC) dyspnea scale.

A standard posterolateral thoracotomy, via the 5th intercostal space, was performed in the lateral decubitus position while the contralateral lung was ventilated. During the surgery, adhesions were meticulously separated with electrocautery on manual ventilation, and the restrictive fibrous layer was peeled away from the lung by blunt dissection. At the end of the operation, before closing the chest, the lung was ventilated with positive-end expiratory pressure and warm saline was installed into the chest cavity to test for air leaks. Significant air leaks were surgically corrected and fibrin glue was used, when necessary. Two chest tubes were placed, and a suction pressure of −20 cm H2O was used.

Statistical analysis

Descriptive data were presented as mean ± standard deviation, median and percentages, where appropriate. Preoperative and postoperative FVC values were compared by the paired t-test, and the preoperative and postoperative FEV1 values and the dyspnea scores were compared with Wilcoxon signed rank test. A p value <0.05 was considered statistically significant.

Results

Twenty patients, 3 women and 17 men, were evaluated. The median age of patients was 59 years (range 41–73 years). The disease was located at the left and right hemithoraces in 15 and 4 patients, respectively, and the disease involved both hemithoraces in one patient. Before decortications, 75% of patients received diclofenac at a dose of 100 mg once a day for 30 days, and the remaining patients received indometacin at a dose of 50 mg twice daily for 30 days. None of the patients received steroids. The median time interval between CABG and decortications was 9.3 months (range 4–32 months), the median EF% was 55 (range 45–70), and the rate of left internal mammary artery (LIMA) use was 99%.

Baseline characteristics of patients and preoperative findings are presented in Table 1. Initially, all the patients had pleural effusions involving more than 25% of one hemithorax.

The mean number of thoracentesis was 3. Tube thoracostomy was performed in 11 (55%) patients. Intrapleural streptokinase was administered to 5 patients with tube thoracostomy, however, trapped lung developed in these patients despite streptokinase administration.

A restrictive pattern was observed in the pulmonary function tests of all patients. The mean preoperative FEV1% was 63.8% ± 7.4% of the predicted value, and the mean preoperative FVC% was 50.5% ± 6.6% of the
predicted value. The rates of improvement in mean FEV₁% and mean FVC% after decortications were 14.97% ± 6.3% and 17.62% ± 6.38%, respectively. Preoperative and postoperative spirometric findings are presented in Table 2. Dyspnea scores were 3 in 8 patients, and 4 in 11 patients (median 4). The scores improved by 4 points in 1 patient, 3 points in 17 patients and 2 points in 1 patient after decortications (median 0). The improvement in dyspnea scores after decortications was significant (p < 0.05).

Nine of our patients went back to work in 3 months after decortications; the remaining 11 patients were retired individuals. None of the patients had recurrence of symptoms or required thoracentesis after decortication at long-term follow-up. The median duration of follow-up was 25 months (range, 12–56 months).

After surgery, 3 (15.7%) patients developed superficial wound infection and 7 patients (35%) had prolonged air leaks. Two patients with prolonged air leaks underwent a reoperation, and one patient died on postoperative day 34 from bronchopleural fistulae, empyema and sepsis; another patient, whose progress was followed over the long-term, died 3 years after surgery, from a myocardial infarction.

Atelectasis or expansion failure was not noted in thorax CTs obtained in the long term follow-up (Figs. 1 and 2).

Discussion

Pleural effusion rate in the early period following coronary bypass surgery ranges between 40% and 75%. The effusion is mostly in small quantities, and resolves without necessitating specific treatment, and it mostly results from atelectasis in the postoperative immediate period. The frequency of moderate and large effusions is about 10%. 11957 CABG (10748 on-pump, 1209 off-pump) surgeries were performed in our hospital between 2004 and 2007 years. Annual incidence of pleural effusion changed between 50%–60% in early postoperative follow-up during the study period. Large pleural effusion rate within this period 8%–15%. It is not possible to follow-up some of the patients because, after the operation, they returned to their homes in far-away regions of the country; therefore, we do not reevaluate them for trapped lung or other conditions, over the long-term. Therefore, it is difficult to determine to the true incidence of trapped lung. On the other hand, we thought that routinely electrocautery using for left internal thoracic artery (LITA) harvesting in our hospital led to the occurrence of much

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Baseline patient characteristics and preoperative findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (Male/Female)(n)</td>
<td>17/3</td>
</tr>
<tr>
<td>Age [median(range)]</td>
<td>59 (41–73)</td>
</tr>
<tr>
<td>Disease site (n)</td>
<td>15 left/ 4 right/ 1 bilateral</td>
</tr>
<tr>
<td>The time interval between CABG and decortications [median(range)]</td>
<td>9.3 months (4-32 months)</td>
</tr>
<tr>
<td>EF% [median (range)]</td>
<td>55 (45–70)</td>
</tr>
<tr>
<td>The rate of LIMA use (%)</td>
<td>99</td>
</tr>
<tr>
<td>Preoperative FVC% (mean ± SD)</td>
<td>50.5 ± 6.6</td>
</tr>
<tr>
<td>Preoperative FEV₁% (mean ± SD)</td>
<td>63.8 ± 7.4</td>
</tr>
<tr>
<td>Preoperative MRC dyspnea score (median)</td>
<td>4</td>
</tr>
</tbody>
</table>

CABG: coronary artery bypass grafting; EF: Ejection fraction; FVC: forced vital capacity; FEV₁: forced expiratory volume in one second; LIMA: left internal mammary artery; MRC: Medical Research Council.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Mean forced expiratory volume in one second and forced vital capacity values before and after decortications and improvement rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before decortication (mean ± SD)</td>
<td>After decortication (mean ± SD)</td>
</tr>
<tr>
<td>FEV₁% predicted</td>
<td>63.80 ± 7.40</td>
</tr>
<tr>
<td>FVC% predicted</td>
<td>50.50 ± 6.60</td>
</tr>
</tbody>
</table>

* p <0.05, Wilcoxon test
** p <0.05, Paired t test
FVC: forced vital capacity; FEV₁: forced expiratory volume in one second.
Fig. 1  Contrast thorax computed tomography scan of a patient demonstrating a complicated pleural effusion, persistent left lower lobe collapse with thickened visceral pleura, without any mediastinal shift in the left hemithorax at 8 months after aorta-coronary bypass surgery.

Fig. 2  Axial images of thorax computed tomography showing the complete expansion of the lung of the same patient 2 years after decortication.
effusion and hence, many surgeons began to harvest LITA by using harmonic scalpel. The effusions may be treated by multiple thoracentesis, anti-inflammatory drugs or tube thoracostomy in these stages. Despite the medical treatments, a small percentage of these effusions remain persistent, and adhesions and loculations can develop. In this period, intra-pleural streptokinase, urokinase can be administered or thoracoscopic debridement may be performed. If the process continues as trapped lung, lung volume, diffusion capacity and expiratory flow rates decrease, and chest mechanics deteriorate. Operative intervention is necessary for these patients.

Trapped lung occurs when a fibro-elastic peel is formed over the visceral pleura on part or all of a lung lobe. This fibrotic peel can prevent the expansion of the underlying lung (Fig. 1). A negative pressure is created between the chest wall and the non-expanding lung, consequently leading to the migration of fluid into the pleural space. Thoracentesis is generally unsuccessful in this stage due to the negative pressure gradient and the re-accumulation of the effusion. Pleurodesis is rarely achieved because of the non-expanding lung. In our series, pleurodesis has not been performed in any of the patients because of the presence of trapped lung. Huggins et al. in their study in 2007 reported that a high index of suspicion was a key to diagnosis, and rather than repetitive unnecessary tests, pleural manometry and air-contrast CT should enable rapid diagnosis.

Decortication is the surgical removal of the restrictive fibrous layer from the lung. The technical aim of decortication is to resolve the pathological process affecting the pleura and to provide the re-expansion of the lung. Decortication should be started after formulating an appropriate surgical plan, then in order to liberate the lung the fibrous layer should be peeled away, and the process should be ended by controlling the air leaks and hemorrhage. Prolongation of air leaks may lead to infection, bronchopleural fistulae and death, and long duration of hospitalization increases the costs.

In cases with open-heart surgery where left internal mammary artery (LIMA) is used, as in our series, a meticulous work is necessary especially while decortication is performed on the mediastinal side. At times, a part of the LIMA can be located in this region and may be adhered to the pleura. On the other hand, according to our experience meticulous care should also be taken to control the air leaks. We have observed that electrocauterization is adequate for multiple small erosions of the visceral pleura; however, we believe that larger air leaks necessitate suturing and use of fibrin glue. In fact, surgical revision was performed on 2 patients in our series, and one of these patients died due to empyema and sepsis.

The timing of decortication after CABG is unclear; however, Lee and colleagues reported eight patients with persistent pleural effusions who required surgical intervention after 2 years of follow-up after CABG surgery. As trapped lung represents an end-stage fibrotic process, many authors suggest that the development of trapped lung usually requires several months to years after the pleural injury. However, in order to decide about the surgical correction of the pleuropulmonary process, that had developed after a coronary bypass, there should be a waiting period with certain medical or minimal invasive surgical treatments. In our patients, the median waiting period for surgery was 9.3 months. However, as the effusions developed at a later period in 35% of our cases, and as the durations of medical and conservative treatments were long, the time interval between CABG and decortication was relatively long. Lee et al. recommended surgical intervention in cases with prolonged pleural effusion more than 6 months and trapped lung. Radiological evaluation, particularly CT, identifies the pleural space and the underlying lung parenchyma. It aids in determining the extent and thickness of pleural involvement, thereby serves as an aid in deciding on the appropriate surgical approach. Moreover, it enables the differential diagnosis of parenchymal diseases like interstitial fibrosis, bronchiectasis and malignancies. It also has a significant role in the post-surgical assessment of the thoracic cavity.

Spirometry gives objective data about the lung capacity and the degree of dysfunction. Liu and colleagues observed restrictive ventilatory defects in cases with restrictive pleurisy; there was a decrease in FVC, total lung capacity (TLC), FEV₁, vital capacity (VC) and an increase in residual volume. Petro and colleagues performed decortications in 15 patients and took a conservative approach in 11 patients with unilateral fibrotic pleurisy. They claimed that the conservative approach resulted in better long-term outcomes. However, 3 patients, either due to the physician’s decision, or as they did not consent for the surgery, were followed-up for approximately 22 months, and as their symptoms did not improve, under-went decortication at the end of this period. In our study, mean FEV₁% and mean FVC% significantly improved after decortications (p < 0.05; for each).

Trapped lung is a potentially preventable complication. Interventions performed in the early period can...
prevent these complications. Especially in traumatic hemothorax, early and complete drainage have been reported to decrease the morbidity and mortality and prevent the development of empyema.\(^{16}\)

While assessing patients with trapped lung and restrictive pleurisy, the presence of malign processes like mesothelioma should also be evaluated. If malignancy is suspected, pleural biopsy should be performed. With this suspicion, closed pleural biopsy was performed to 3 patients in our series, malignancy was not detected in the samples and decortication was performed. Video-assisted thoracoscopic surgery (VATS) was performed in one patient in our series, and as the cytological examinations were negative for malignancy, decortication was completed with the thoracotomy. On the other hand, VATS can be used effectively in the period when pleural adhesions and loculations occur. Many patients can be treated by this method before they have complications. Principally, videothoracoscopic approach cannot be used after pleura is strongly attached to the chest wall and the chronic process develops.

**Conclusions**

Consequently, lung decortication re-expands the affected lung, ensures the remission of symptoms, and improves the quality of life in long-term period in patients with trapped lung developed after CABG surgery.

**Disclosure Statement**

The authors have no conflict of interest to declare.

**References**