

Decortication in chronic pleural empyema — effect on lung function[☆]

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Abstract

Objective: The aim of the present study is to evaluate the lung function before and after the lung decortication in patients with chronic pleural empyema (CPE). **Methods:** Twenty-six patients with diagnosis of CPE were evaluated in a prospective manner by lung perfusion scintigraphy, blood gas analysis and spirometry before and 35 weeks (± 17) after the lung decortication. **Results:** Preoperative scintigraphy showed reduction of lung perfusion on the affected side to 24.5% ($\pm 12.6\%$) in 11 right side empyemas (predicted value 55%) and to 18% ($\pm 8\%$) in 15 left side empyemas (predicted value 45%). The postoperative measurements showed improvement in perfusion to 45.2% ($\pm 7.7\%$) in patients with right side empyema and 34.1% ($\pm 8.5\%$) with the left side affection. The preoperative vital capacity (VC) was reduced to 62.3% ($\pm 13.8\%$) of the predicted value and forced expiratory volume in 1 s (FEV1) to 50% ($\pm 15.5\%$) of the predicted value. Postoperatively, slight improvement was achieved to 79.8% ($\pm 12.9\%$) for VC and 69.2% ($\pm 12.7\%$) for FEV1. Blood gas analysis showed decreased values in majority of the patients before operation and significant improvement in postoperative evaluation. **Conclusions:** Perfusion and spirometry improves significantly in patients with CPE after the lung decortication but function of the affected lung remains impaired. There was no influence of the age, gender, side of the disease, bacteriology or duration of the empyema before operation on lung function. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Chronic pleural empyema; Decortication; Lung function; Lung perfusion scintigraphy; Spirometry

1. Introduction

Chronic pleural empyema (CPE) is the last phase of the triphasic process of pleural empyema development. Accumulation of purulent fluid in the pleural space and thickened fibrous peel restricts the movement and expansion of the lung. Secondary atelectasis leads to perfusion and ventilation alteration. Gas exchange in the lung, which is the essence of respiration, is severely impaired.

Compression and incarceration of the lung diminishes its function mainly due to ventilation–perfusion disturbances. Blood flow through the collapsed lung is reduced as a result of vascular contraction in the atelectatic area due to hypoxia and hypercapnia [1,2]. There are controversies whether those morphological changes persist after lung resection [1–4]. In the majority of physiological experimental studies on animals, Webb et al. and Benfield et al.

observed significant reduction of perfusion, ventilation and oxygen uptake in the atelectatic lung, which resolved significantly after reexpansion [4,5]. Benfield et al. also confirmed restoration of lung function following resection of an atelectatic lung — in their experimental studies on hemodynamics in the pulmonary circulation in dogs — but observed that the same animals did not survive contralateral pneumonectomy a few weeks later [5,6]. The dogs died with oedematous condition in the remaining resected lung, with dilatation of the right ventricle and congestion of the liver. This experiment showed that the lung function must be evaluated on multiple levels.

The respiratory function depends on respiratory mechanics (respiratory muscles function), ventilation, perfusion and alveolar epithelial permeability. Lung function after treatment of CPE was evaluated by many authors, especially with regard to spirometric parameters [7–16]. There are also some data concerning evaluation of perfusion as well but the number of patients in these studies is usually limited [1,6,11,12,17,18,19,20]. We expect this study to support data concerning the lung function following decortication. The aim of our study was to determine the function of the reexpanded lung on different functional levels by

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evaluation of the lung perfusion, spirometry and blood gas analysis before and after lung decortication in patients with CPE.

2. Materials and methods

The lung function of 26 patients treated for CPE with lung decortication between 1993 and 1997 were evaluated in a prospective manner. The study began after receiving an approval by the Regional Ethics Committee on Human Research of Medical University of Gdańsk (TKEBN/257/94). The informed consent was obtained from all the evaluated patients. The diagnosis of CPE was based on the typical clinical course (fever, chills, cough, chest pain etc), plain chest radiograph and computer tomography (CT) evaluation. Only patients with pleural effusion who met all of the following radiological criteria were included into this study: (1) multiloculate pleural effusion and pleura enhancement; (2) mediastinal shift; (3) elevation of the diaphragm and (4) narrowing of the intercostal spaces. Patients with postresectional empyema and with the part of the lung excised or with severe parenchyma changes were excluded. Two patients with tuberculous CPE without destruction of lung parenchyma were included. One had positive culture from the pleural fluid obtained during operation, without evidence of positive sputum. In the other patient, tuberculosis (TBC) was diagnosed just 2 weeks before decortication. He was operated 2 weeks after beginning of chemotherapy. Trauma of the thorax was the etiologic factor in five instances. None of these patients had severely injured lung parenchyma or flail chest requiring mechanical ventilation.

The mean time between onset of acute illness to hospitalisation, institution of first chest tube drainage and operation was 15 days (± 11), 23 days (± 22) and 67 days (± 44), respectively. Initially all patients were treated by closed chest tube drainage in the hospitals of primary admission. Following transfer to the thoracic department, new or additional drainage was performed in ten cases.

Complete lung decortication was performed through postero-lateral thoracotomy with or without rib resection. Removal of the entity of fibrous peel from the lung and diaphragm was a standard procedure while pericardial peel was removed only when possible without the risk of injuring important anatomic structures. The parietal wall of the empyema sac was detached from the chest wall by extra-pleural dissection.

This series consists of 16 men and 10 women from 17 to 61 years of age (mean 39.8 ± 12.7). All patients were referred to the thoracic surgery department from other wards or other hospitals. Eleven right and 15 left lung decortications were performed. The study is based on the evaluation of pre- and postoperative blood gas analysis, spirometric values, electrocardiography (ECG) and the lung perfusion scintigraphy. Postoperative evaluation was

performed in outpatient clinic from 15 to 71 weeks (mean 35 ± 17) after discharge from hospital. According to the protocol, postoperative control was scheduled between 15 and 30 weeks from the date of decortication. Only 14 preoperatively assessed patients kept the appointment. Therefore the rest of the group was evaluated in a later period. After the study in 26 patients was completed, statistical analysis was done for the group of 14 patients examined before and 12 after 30 postoperative weeks. No difference between the groups was found in all analysed functional parameters. Therefore we did the final analysis for the whole group of 26 patients, although range of interval between operation and postoperative evaluation varied significantly.

Plain chest radiograph and CT scans were evaluated in order to exclude inflammatory, atelectatic or neoplastic changes. Spirometries were performed on the fasting patient in the morning. The Master-Screen Pneumo spirometer with programme based on the normal range values — as proposed by European Community for Coal and Steel [21] — was used to analyse vital capacity (VC) and forced expiratory volume in 1 s (FEV1). Arterial blood gas analyses included oxygen pressure (PO₂), carbon dioxide pressure (PCO₂), oxygen saturation (SO₂) and pH. The reference values were as follows: PO₂, 11.0–14.0 kPa; PCO₂, 4.7–6.0 kPa; SO₂, 0.94–0.99 (fraction), pH; 7.35–7.45. ECGs were assessed by the same cardiologist. Scintigraphic studies were performed in the Nuclear Medicine Department of Medical University of Gdańsk with use of DIACAM gamma camera equipped with ICON system (Siemens, Germany) and LEHR collimator. Lung perfusion scans were performed after intravenous (i.v.) injection of MAA (CIS-BIO International, France) labelled with technetium 99m. The activity of 300 mBq was administered in 2 ml 0.9% saline (each dose consisted of approximately 150 000 particles). After injection (in recumbent posture), scans were performed in standard projections (antero-posterior, postero-anterior, left posterior obliquus, right-posterior obliquus, left and right) – 700 000 counts pro scan; 128 × 128 matrix. AP, PA and a virtual projection [square root of (AP pixel value × PA pixel value)] were then processed. Each projection was divided into six equal size ROIs, three on each lung. Relative uptake and left lung/right lung uptake ratio were calculated. The normal value for the left lung uptake is 45% ($\pm 5\%$) and for the right lung 55% ($\pm 5\%$) as estimated in our nuclear department.

2.1. Statistical analysis

Chi-square test and Fisher's exact test were used for comparison of proportions. Mann-Whitney *U* test was used for comparison of groups with continuous unpaired variables. Wilcoxon matched-pairs test was applied when groups of continuous variables were paired. Correlation was tested by Spearman's non-parametric method. Type I error of 0.05 was used for hypothesis testing.

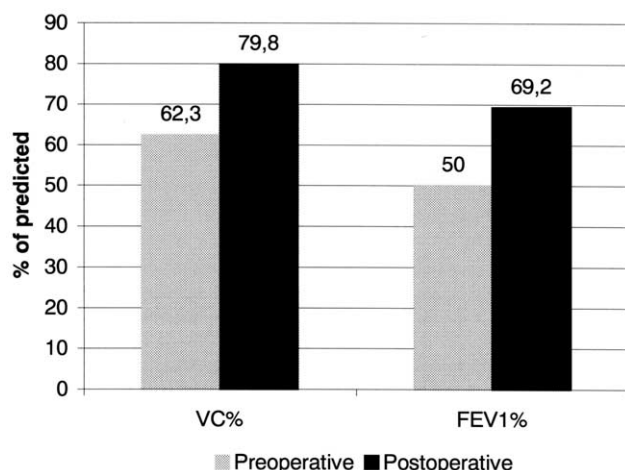


Fig. 1. Mean pre- and postoperative values of spirometric parameters.

3. Results

Blood gas parameters of arterial blood preoperatively were incorrect in 23 (88.5%) patients: 20 had low oxygen saturation, 23 low PO_2 , two high and one low PCO_2 values. The mean values for the whole group were significantly reduced for PO_2 and oxygen saturation; 9.8 kPa (± 1) and 0.93 (± 0.02), respectively. Postoperatively, 11 patients had incorrect blood gas parameters. Both preoperatively reduced parameters (PO_2 and SO_2) increased significantly after decortication and were 11.7 kPa (± 1.8) and 0.96 kPa (± 0.02), respectively.

Preoperatively, right heart overload was noted in the ECG of three patients. One of those patients had chronic obstructive pulmonary disease (COPD) as predisposing factor. In the postoperative examination, only one of them had still electrocardiographic changes while three others had it as a new finding. There was no correlation between ECG alterations and spirometry or perfusion.

Before decortication, only seven patients (27%) had predicted VC over 70%, which is lowest reference value for health population in Poland. The whole group had FEV1 under this limit. In the postoperative evaluation in five (19.2%) patients, both of predicted spirometric values were under 70% and in nine only FEV1 values were diminished. Spirometric parameters before and after decortication are shown in Figs. 1 and 2.

The preoperative scintigraphy showed severe reduction of perfusion on the affected side in almost all patients. Blood circulation was more impaired in right sided than left sided CPE before decortication.

In CPE on the right side, perfusion was 7.2–43% (mean 24.5 ± 12.1) and on the left side 6.3–32% (mean 18 ± 7.8).

After decortication, perfusion became normal in five patients (19.2%); in three operated for left side (20%) and two for right side (18.1%) CPE.

Postoperative perfusion in patients operated on the right side was 26.1–53% (mean 45.2 ± 7.8) and on the left side

was 15.9–47.2% (mean 34.1 ± 8.6). The mean values of analysed functional parameters separately for left and right CPE is shown in Figs. 2 and 3.

The increase of perfusion on the affected side after decortication is statistically significant for the left ($P < 0.001$) and for the right ($P < 0.01$) CPE. There was no influence of the time of drainage or decortication on functional recovery. No significant difference was observed in functional recovery with respect to the side of CPE.

Detailed pre- and postoperative spirometric and scintigraphic data are shown in Fig. 3. Predicted values for right and left lung perfusion are different (45% for the left and 55% for the right lung).

We analysed the influence of age, gender, concomitant diseases, leukocytosis, alkaline phosphatase level, albumin and globulin level, kind of bacterial flora and smoking history on functional recovery. There was no significant correlation between these factors and analysed functional parameters.

In patients who had low preoperative albumin and globu-

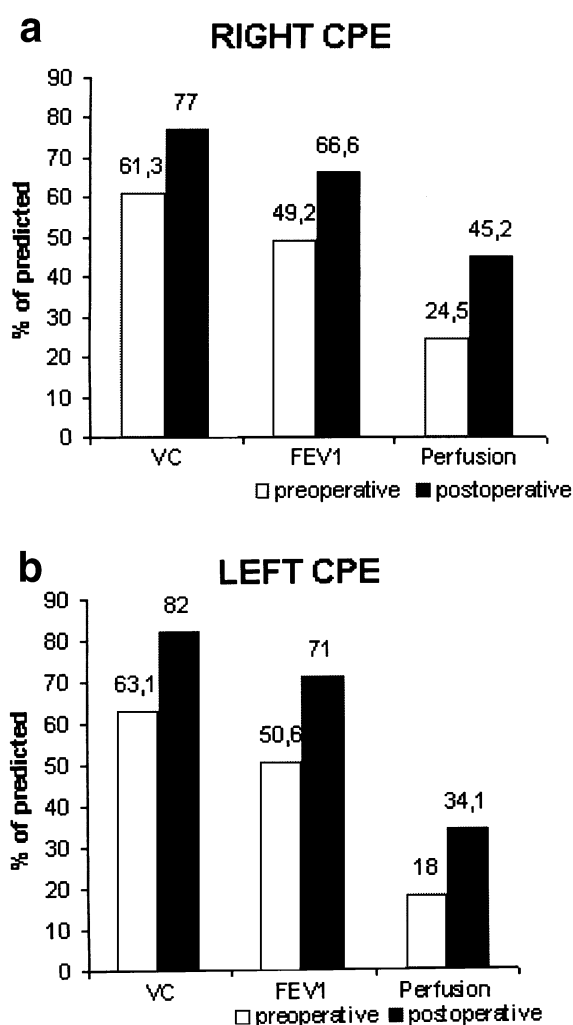


Fig. 2. Mean spirometric and scintigraphic values before and after decortication separately for the right and left CPE.

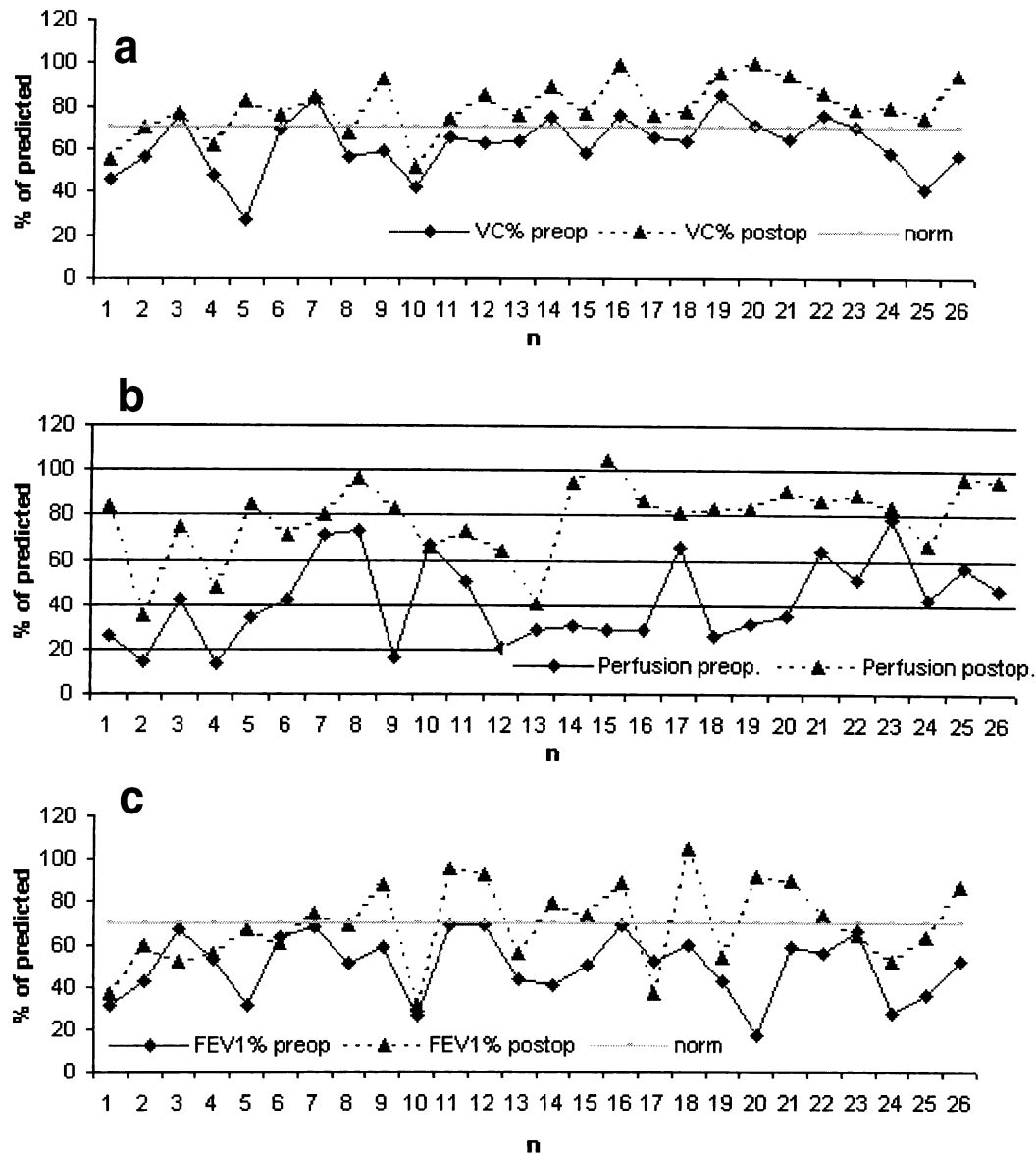


Fig. 3. Spirometric and scintigraphic data for all patients before and after lung decortication. In the diagrams 1 and 2, the lowest normal value for Polish population are marked with a grey line. Preop – preoperative, postop – postoperative, VC% – percent of predicted VC, FEV1% – percent of predicted FEV1. % – percent, n – patient's number.

lin levels, recovery of lung perfusion was lesser than in patients with normal values of these preoperative parameters ($P = 0.06$).

4. Discussion

Pleural empyema leads to atelectasis of the compressed and incarcerated lung. Respiratory mechanics and ventilation are severely deteriorated. As a result of reduced oxygen penetration to alveoli, perfusion and gas exchange in the lung are decreased. The basic functional element of respiration is impaired. The majority of experimental studies have shown that atelectasis leads to collapse of the alveoli,

which directly and indirectly (hypoxia) induces the constriction of lung arteries and high resistance in lung circulation. In this condition, only 7–15% of cardiac output flows through an atelectatic lung [2,5,23], ventilation is decreased to 24% and oxygen uptake to 14% of expected normal values [6].

There is a lack of clinical studies evaluating the lung function in patients treated for long-term atelectasis with the lung decortication. Most publications have focussed on spirometric studies and oxygen uptake while there are only few evaluating perfusion or ventilation.

Preoperative blood gas analysis has shown significant disturbances in our group. Only three patients (11.5%) had all blood gas parameters within reference values. Our preo-

perative results regarding blood gas parameters are poor than results of other authors [16,22]. Postoperatively in 14 cases, blood gas parameters became normal. In our study, PO₂ and SO₂ levels considerably increased with these levels being lower than the lower limit of normal range before decortication in 23 and 20 patients, respectively but postoperatively these levels became lower only in nine and four patients, respectively. Low PCO₂ postoperatively in four patients had no clinical significance. In our study the postoperative recovery in blood gas analysis was strongly pronounced.

Among functional studies in patients with CPE, spirometry are the most common. The conclusions are contradictory to differences in numbers and quality of analysed material. When TBC or other destructive lung disease is a dominant etiologic factor, spirometric parameters do not improve after the treatment [9,10,13]. Toomes et al. and Petro et al. conclude, based on results of studies where TBC was an etiologic factor only in 25% of cases, that mean VC for the whole group does not improve after the treatment. They also noted that only for patients with preoperative VC decrease of more than 40% of the predicted value, can profit functionally postoperatively [11,15]. In our study — probably due to low TBC occurrence (7.7%), and absence of patients with severe, active parenchymal process — mean FVC and FEV1 increased by 15 and 20%, respectively, after decortication. The postoperative study was in majority of patients done 3–6 months after the operation, the period of time in which some authors did not observe functional recovery of the lung and sometimes even deterioration of spirometry [9,10,14,15]. We have not seen, in contrast to other authors, any influence of time period between the onset of acute empyema and decortication on the lung function [8,13,22]. Only Toomes et al. support our observation [14].

The lung perfusion was the aim of experimental studies where main bronchus was ligated or transected surgically or atelectasis was achieved by pneumothorax [2,3,4,6,23,24]. It induced decrease in the lung perfusion, which in acute phase was 0–34% of total lung perfusion and in chronic phase 7–15% [4,3,6,23]. Our study supports this data showing considerable reduction of flow through the incarcerated lung. Perfusion decreased to more than 50 % of predicted values in CPE on the affected side and significantly increased postoperatively (Fig. 2). The affected lung circulation increased almost twofold and reached the highest level compared to other analysed functional parameters (Figs. 2 and 3). Despite this improvement in the majority of patients, perfusion was still decreased over 20% of the predicted values. Swoboda et al. showed similar reduction of perfusion — in the functional study of nine patients operated for CPE — which significantly increased after decortication [12].

The lung perfusion is more impaired than blood gases or spirometric parameters before decortication, but its recovery is significantly more pronounced and independent of the degree of initial impairment.

Comparison of functional recovery with respect to side of the disease has not shown significant differences concerning any of analysed functional parameters. Correlation between low hypoglobulinemia and hypoalbuminemia and recovery of lung circulation is probably related to general patient status. In patients with low albumin level, functional recovery is impaired, most probably due to severe or long-term infection, which causes destruction of the lung.

5. Conclusions

The following conclusions are made:

1. In patients with CPE, preoperative values of VC, FEV1 and perfusion through atelectatic lung are severely reduced.
2. After lung decortication, VC and FEV1 partly recovers.
3. Perfusion through affected side significantly increases but does not reach predicted values.
4. Blood gases are under reference values in majority of patients but after decortication significant increase of oxygen pressure and saturation occurs.
5. Time of drainage or decortication has no influence on functional recovery.

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