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Change in Pulmonary Function Following Empyemectomy and Decortication in Tuberculous and Non-Tuberculous Chronic Empyema Thoracis

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Chronic empyema thoracis results from various etiologies. Improvement in pulmonary function after empyemectomy and decortication has proved difficult to predict when the etiology of chronic empyema thoracis is tuberculosis. The purpose of this study was to confirm the changes in pulmonary function according to the etiology after an operation. Sixty-five patients were classified into two groups according to their etiology: Group A (tuberculous) and Group B (non-tuberculous), and they were retrospectively evaluated with regard to their forced expiratory volume in 1 second (FEV1), forced vital capacity (FVC), percentage of predicted normal value of FEV1 (%FEV1) and FVC (%FVC). Empyemectomy and decortication was performed for all the patients and the two groups were similar in age, gender and preoperative spirometric parameters. In Group A (n=41), the pre- and postoperative mean values were 2.31L and 2.88L in FEV1, 65.8% and 80.5% in %FEV1, 2.62L and 2.55 L in VC, 61.9% and 71.8% in %VC, respectively. In Group B (n=24), the pre- and postoperative mean values were 2.13L and 2.49L in FEV1, 66.4% and 73.8% in %FEV1, 2.55L and 2.95 L in FVC, 64.9% and 71.8% in %FVC, respectively. All the spirometric parameters improved significantly in both groups compared to their preoperative values. However, no significance was shown in the rate of increase of the spirometric parameters between the two groups. In conclusion, improvement of lung function is expected after empyemectomy and decortication, regardless of the etiology of the chronic empyema thoracis.

Key Words: Chronic pleural empyema, empyemectomy, tuberculous, lung function

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INTRODUCTION

Chronic empyema is the last phase of the triphasic process for pleural empyema development. The collection of purulent fluid in the pleural space and the thickened fibrous peel restrict the movement and expansion of the lung, and secondary atelectasis leads to perfusion and ventilation alterations. The object of the surgical treatment of empyema thoracis is to remove the pyogenic membrane and to obliterate the dead space in the thoracic cavity.

Although many authors have reported no or minimal improvement in individual cases, decortication is usually followed by an improvement in ventilation and increased lung volumes, as measured by improvements in the vital capacity, total capacity and maximal breathing capacity.[1-12] But only a few authors have reported their findings according to the disease etiologies and these authors have concluded that pulmonary function did not improve or it even deteriorate after empyemectomy and decortication when the etiology was tuberculousis.[1,3,5,6,12] The purpose of this contribution was to add further information on the basis of the change in the pulmonary function for tuberculous chronic empyema thoracis.

MATERIALS AND METHODS

Between January 1991 and December 2002, a total of 163 cases involving lung decortication were seen at our institution. Sixty-five cases received empyemectomy and decortication, and all the cases had preoperative and postoperative pulmonary function tests performed; these were the subjects selected for our study. Exclusion criteria were those patients who'd received thoracoscopic decortication, or if they had postresectional empyema, or if they had a resection of a part of their lung or chest wall. The primary choice of therapy was based upon the CT scan findings and the general condition of the patient. A preoperative pulmonary function test was performed within one month prior to the operation.

All patients received a diagnostic work up, which included chest radiography, computed tomography and a microbiological sputum study. A closed thoracostomy was performed if the patient had symptoms caused by a large amount of pleural fluid or fever.

The patients were classified into two groups according to their etiology: 41 patients in the Group A (tuberculous empyema) and 24 in the Group B (non-tuberculous empyema). Tuberculous empyema was confirmed by AFB staining or by the presence of typical caseous necrosis in the resected specimens. In Group A, sputum staining for AFB was negative for all patients. In Group B, the microbiological studies were positive for all the patients and various organisms were identified such as *Staphylococcus aureus, Streptococcus pneumoniae, Klebsiella pnumoniae, Enterococcus* or some anaerobic organisms. All patients were empirically given broad-spectrum antibiotics until the specific microorganism was identified.

Complete lung decortication was performed through a posterolateral thoracotomy. The parietal wall of the empyema sac was detached from the chest wall by an extrapleural dissection. The peel, including the calcified thick layer, was completely removed from both the parietal wall and the visceral pleura, and this resulted in tiny air leaks, which had to be closed by meticulous stitching followed by an irrigation. These procedures are accomplished to achieve a complete empyemectomy, the result of which is a more sterilized cavity with better lung reexpansion and chest wall movement. Two chest tubes were inserted before closing the pleural cavity and postoperative wound pain was treated with a thoracic epidural anesthesia. Ventilator weaning and extubation were usually performed as soon as possible after the operation. The chest tube was removed after the air leaks ceased and the amount of drainage decreased to less than 100 ml per day.

A spirometer was used to analyze the forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV1). The %FVC and the %FEV1, the percentages of the predicted normal values, were then calculated. From these values, the rate of change was calculated as follows: rate of change={(postoperative value-preoperative value) divided by the preoperative value} $\times$ 100.

The postoperative evaluations were performed at least two times after a postoperative period of three months at the outpatient clinic. The last set of data obtained was used for the analyses. The median interval from the operation to the follow-up pulmonary function testing was similar for both groups (10.7 months for Group A and 10.1 months for Group B, p=0.455).

A lung perfusion scan was performed for thirty of the sixty-five patients (20 in Group A, 10 in Group B) both before and after the operation. Perfusion scan views were obtained from the sitting position in four different projections (anterior, posterior, left posterior oblique and right posterior oblique) with 7×10^6 counts per image, and each view was taken on a one-head gamma camera (Vertex Epi, Philips ADAC, USA). Tc-99m-labeled macroaggregates of albumin were parenterally administrated.

Comparisons between the groups were made using unpaired or paired t tests. A p value of less than 0.05 was regarded as significant.

RESULTS

The number of tuberculous chronic empyema thoracis and nontuberculous chronic empyema thoracis patients were 41 and 24, respectively. The preoperative characteristics of the patients did not differ significantly between the two groups (Table 1).

Significant improvement of the spirometric parameters was observed in both groups after the empyemectomy and decortication (Table 2). However, there were no significant differences in the

Table 1. Clinical Characteristics of the Study Group (value in continuous variables are mean ± SD)

	Group A	Group B	*p*
Age (years)	35.8 ± 14.1	42.3 ± 12.4	0.282
M : F	35:06:00	20:04	0.827
Right : Left	27:14:00	13:11	0.35
Preoperative spirometric parameter			
FEV1 (L)	2.31 ± 0.11	2.14 ± 0.13	0.284
FVC (L)	2.63 ±0.75	2.54 ± 0.81	0.728
%FEV1 (%)	65.8 ± 16.8	66.4 ± 19.1	0.712
%FVC (%)	61.9 ± 15.1	12.8 ± 9.42	0.455

M, male; F, female; FEV1, forced expiratory volume in 1 second; %FEV1, percentage of predicted normal value for FEV1; VC, vital capacity; %VC, percentage of predicted normal value for VC; SD, standard deviation.

Table 2. Changes of Spirometric Parameters and Perfusion before and after the Empyemectomy and Decortication in Groups A and B*

		Group A (n=41)			Group B (n=24)			*p*
		Before	After	*p*	Before	After	*p*	
FEV1	L	2.31 ± 0.71	2.38±0.74	0.001	2.14 ± 0.68	2.49±0.59	0.002	
	%†	30.2			22			0.347
FVC	L	2.63 ± 0.75	3.24±0.75	0.001	2.54 ± +0.81	2.95±0.71	0.003	
	%†	29.1			21.7			0.406
%FEV1	%	65.8 ± 16.8	80.5±16.4	0.001	66.4 ± 19.0	75.8±15.9	0.021	
	%†	26.5			17.1			0.183
%FVC	%	61.9 ± 15.1	75.4±13.8	0.001	64.9 ± 17.7	71.8±14.8	0.009	
	%†	26.4			14.2			0.086
Perfusion‡	%	31.3 ± 7.4	37.9±8.9	0.003	31.8 ± 4.3	39.6±6.8	0.009	
	%†	27.1			26.5			0.965

*Data are shown as the mean ± one standard deviation.
†Rate of change.
‡Perfusion on affected side of twenty patients in Group A and ten patients in Group B.

amount change in the spirometric parameters between the two groups.

For seven patients (three in Group A and four in B), all the spirometric parameters were reduced compared to their preoperative values. It was found that the mean amount of change in the %FEV1 and %FVC were -12.1% and -9.9%, respectively.

The changes in the spirometric parameters, according to the affected side, are shown in Table 3. There was no significant difference observed in functional recovery with respect to the affected side in either group.

Twenty subjects in Group A and ten subjects in Group B underwent lung perfusion scans before and after decortication. The preoperative scintigraphy showed a reduction of perfusion on the affected side in all patients. The perfusion distributions for the involved side are shown in Table 2. Perfusion was improved significantly after decortication in both groups, but there were no significant differences in the amount of change of perfusion between the two groups.

There were no perioperative or late deaths

Table 3. Changes of Spirometric Parameters Before and After Decortication, Separately for Affected Side in Groups A and B*

		Group A*				p
		Right (n=27)		Left (n=14)		
		Before	After	Before	After	
FEV1	L	2.36 ± 0.71	2.93 ± 0.69	2.22 ± 0.72	2.79 ± 0.84	
	%†	30.3		30.1		0.984
VC	L	2.68 ± 0.71	3.32 ± 0.68	2.52 ± 0.84	3.09 ± 0.90	
	%†	30.1		38.6		0.813
%FEV1	%	66.0 ± 16.3	82.1 ± 16.6	65.4 ± 18.3	77.5 ± 16.1	
	%†	28.9		21.8		0.463
%VC	%	62.3 ± 14.7	77.2 ± 13.0	61.2 ± 16.1	71.8 ± 15.1	
	%†	29.5		20.4		0.367
		Group B*				p
		Right (n=13)		Left (n=11)		
		Before	After	Before	After	
FEV1	L	2.21 ± 0.77	2.51 ± 0.68	2.05 ± 0.58	2.47 ± 0.49	
	%†	20.2		24.2		0.938
VC	L	2.68 ± 0.87	2.97 ± 0.77	2.47 ± 0.77	2.92 ± 0.69	
	%†	21.4		21.9		0.941
%FEV1	%	67.5 ± 16.8	74.4 ± 18.8	65.1 ± 22.1	73.0 ± 12.7	
	%†	12.1		19.2		0.984
%VC	%	65.9 ± 16.1	72.0 ± 15.1	63.9 ± 20.1	71.6 ± 15.1	
	%†	11.8		16.9		0.955

*Data are shown as the mean ± one standard deviation.
†Rate of change.

related to the operations. Nonfatal complications occurred in five patients. These complications were wound dehiscence in two patients, pneumonia in one and redo thoracotomy due to bleeding in two.

DISCUSSION

Empyema is classified into 3 stages: the initial or exudative stage, which progresses to the fibrinopurulent stage and then it culminates in the organized stage.[13] During the third stage, organization begins as the fibroblasts in the fibrin layer begin the deposition of fibrous tissue. As the organization progresses, a peel of fibrous tissue forms between the visceral and parietal pleura, the lung becomes encased and is less mobile. This process leads to a gradual decline in aeration, with resultant atelectasis and reduced pulmonary function, perhaps leading to the total destruction of the lung and to chest deformity. If the infection continues uninterrupted, it may spontaneously drain into the tracheobronchial tree, the mediastinum, the diaphragm, or chest wall.[14] Respiratory functions severely deteriorate if pleural empyema thoracis leads to atelectasis of a compressed and incarcerated lung. As a result of atelectasis, gas exchanges are markedly reduced. Also, atelectasis induces constriction of the arteries and a high resistance in the pulmonary blood circulation will exist.[15]

We prefer empyemectomy and decortication in chronic empyema thoracis, although it is an extensive operation, it's currently the best treatment modality available. It also retains the functional capacity of the lung to a great extent16. However, to what extent the lung function can be restored by surgical decortication has been a matter of some controversy, as it is reported and discussed in the literature.[16,17]

When the dominant etiologic factor in chronic empyema thoracis was tuberculosis, this factor carries a high risk of morbidity and a fatal outcome may result.[18] In addition, many authors showed that the spirometric parameters did not improve after the operation.[3,6,8,11,12] Toomes et al. and Petro et al. showed that measured spirometric parameters did not improve significantly after an operation.[3,6] They explained the cause simply by stating that patients in tuberculous chronic empyema thoracis were many. But, in their studies, tuberculous chronic empyema thoracis was an etiologic factor only in 25% of cases. However, our results showed that the spirometric parameters improved significantly, despite the fact of tuberculosis being the cause of chronic empyema thoracis.

We performed a postoperative pulmonary function test more than three months after discharge from the hospital to avoid potential adverse effects. Because of prolonged lung collapse, postoperative pain, anesthetic effect, restriction due to chest wall resection, prolonged bed rest and ineffective sputum expectoration, there are complications, such as atelectasis or respiratory failure, which may develop postoperatively. These complications may result in the development of adverse pulmonary function effects.

There is no single spirometric parameter that explains the physiology of chronic empyema thoracis. In all the patients, the preoperative mean %FEV1 and %FVC were reduced below normal limit. The preoperative mean forced expiratory ratio (%FEV1/%FVC) was 105.1. It indicated that a more restrictive ventilatory defect existed. After the operation, the forced expiratory ratio was unchanged as 105.3, although the other spirometric parameters increased significantly. It was evident that a restrictive ventilatory defect still existed despite the operation. We speculated that the mobility of the chest wall or diaphragm could not be recovered back to a normal state.

Swoboda et al. showed that the mean rate of change was +70% in perfusion, only +22.3% in FEV1 and +30% in FVC4. Rzyman et al. concluded that the affected lung circulation increased almost two fold, but that the mean FEV1 and FVC increased by 15 and 20%, respectively.[8] In these two studies, the preoperative mean value and amount of change for the spirometric parameters were similar with our data. But we observed that the mean amount of change in lung perfusion was only +27.1% in Group A and +26.5% in Group B. We thought that duration of disease probably affected organic change in pulmonary vessels although the duration of disease was not introduced to their reports as well as ours. In fact, it was difficult that duration of disease was evaluated because patients did not know exact time at disease onset. Ahmed et al. studied the histology of re-expanded rabbit lungs after 28 weeks of collapse, and concluded that a fibroelastic thickening of the intima of the pulmonary muscular arteries had occurred.[19] And Morton JR et al. showed that patients with disease of short duration demonstrated more improvement after decortication than did those who had thickened pleura for prolonged periods of time.[1] This indicates that organic change had taken place in the parenchyma of the chronically collapsed lungs and duration of disease affected postoperative pulmonary function. From these two studies, we supposed that any relation between organic change in pulmonary vessels and duration of disease existed. Unfortunately, none have studied the relation. Therefore, further investigation is required on the organic changes of pulmonary vessels according to duration of disease.

In conclusion, the improvement in the lung function and perfusion was proposed to have resulted from the empyemectomy and decortication in chronic empyema thoracis and a similar improvement was expected, even if the etiology of the disease was tuberculous.

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