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Title: Change in pulmonary function following decortication for chronic pleural empyema

Short Title: Impact of Decortication on pulmonary function

Authors: Sujith Varghese Abraham[1], Prashant Chikkahonnaiah[2]

Instutions: [1]Department of Pulmonary Medicine, MMC&RI, Mysuru
[2]Department of Pulmonary Medicine, MMC&RI, Mysuru

Address for correspondence: Prashant Chikkahonnaiah, Department of Pulmonary Medicine, PK TB & CD Hospital, Oppo: Brindavan extension, Kumbar Koppal, Mysuru Pin 570002

E-mail: prshnthcr@gmail.com

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Abstract

OBJECTIVES: Chronic empyema is the final stage of the triphasic pathogenesis of empyema characterised by fibrin deposits in both pleural surfaces leading to thickened pleural peel. This restricts the lung movements giving rise to trapped lung and impairs pulmonary function. The aim of this study was to determine the change in pulmonary function following decortication for chronic empyema.

MATERIALS AND METHODS: A total of 35 patients with chronic pleural empyema who underwent decortication via a posterolateral thoracotomy between July 2016 and July 2017 were reviewed and followed up 6 ± 3 months after surgery. All patients had a pulmonary function test done using spirometry before and after surgery. Pre-operation spirometric values [mean forced expiratory volume in 1s (FEV1) and Mean forced vital capacity (FVC)] were compared with post-operation data obtained

during follow up and the change was quantified by statistical analysis.

RESULTS: FEV1 was 70.51 before surgery vs. 83.43 after surgery ($p < 0.001$). FVC was 69.74% before surgery vs. 85.40% after surgery ($p < 0.001$). There was no influence of bacteriology, side of the lesion, smoking habit or diabetes mellitus before operation on lung function ($p>001$).

CONCLUSION: Decortication and pleurectomy via a posterolateral thoracotomy result in significant clinico-functional improvement in patients with chronic empyema regardless of bacteriology, side of the lesion, smoking habit or diabetic status.

Keywords: Pleural empyema, Decortication, Empyemectomy, pulmonary function, spirometry

INTRODUCTION

Empyema Thoracis is defined as the presence of pus in the pleural space or a purulent pleural effusion [1]. Pleural empyema is most commonly a complication of bacterial pneumonia. Alcohol abuse, diabetes mellitus, gastroesophageal reflux disease, and intravenous drug abuse are the major risk factors leading to severe bacterial pneumonia complicated with parapneumonic empyema. Microaspiration and poor oral hygiene also predispose to anaerobic bacterial infections, which eventually leads to empyema [2]. The other causes of the pleural infection unrelated to bacterial pneumonia are mainly iatrogenic, including thoracic (20%) and upper gastrointestinal surgery, oesophagal perforation, and trauma (5%) [3].

Diagnosing parapneumonic effusion at the right time and prompt treatment with antimicrobial drugs is crucial in preventing complications. Mismanagement of empyema leads to progression of the disease process through an exudative phase and fibrinopurulent phase to organizing chronic phase. Since many causes of empyema are indolent, it presents to a physician only after it has progressed to fibro-purulent

or organized stage. An empyema lasting 4 weeks and beyond is classified as chronic empyema [4]. In this stage, the pleural cavity is surrounded by a cortex and effusion becomes organized. Fibroblasts deposit collagen over this organized clotted pleural fluid leading to formation of an inelastic membrane also known as “the peel”. It exerts a restrictive effect on the lung parenchyma leading to a condition known as trapped lung. This encapsulation prevents drug penetration resulting in failure of medical management and development of acquired drug resistance.

Chronic empyema thoracis remains a serious thoracic disease with challenging management strategies. The success of various management strategies depend partly on the stage of empyema presentation. Therapeutic pleural aspiration, intrapleural thrombolytic, underwater seal drainage, open surgical drainage with rib resection were all practiced earlier, but despite these available treatments, the condition was frequently fatal. Although video assisted thoracoscopic surgery (VATS) is a better novel technique to treat empyema, its efficacy in chronic empyema is questionable as a thick pleural peel or cortex hinders perfect clearance. The treatment options should aim at complete debridement so as to achieve full lung re-expansion without atelectasis, air leaks or residual spaces. And if underlying lung parenchyma is not healthy, convert to an open lung resectional surgery. Hence at chronic organized empyema stage the standard treatment option is only empyemectomy via open thoracotomy and decortication as it has the advantage of draining the purulent effusion adequately and completely, freeing the lung from loculations and re-expanding the lung to fill the pleural space [5-7].

The outcome of thoracotomy and decortication is better, with success rates of up to 95%, but with significant associated complications [8,9]. With modern antibiotics and advancements in perioperative

care, the mortality has become negligible with the procedure. Although it is a proven fact that decortication via open thoracotomy is curative in chronic infectious pleural disease, the long-term pulmonary function outcomes were poorly investigated. Only a handful of studies are available so far regarding the functional outcome in patients undergoing decortication via open thoracotomy [10-13].

This study aims to determine the functional outcome in patients undergoing decortication via open thoracotomy for chronic empyema thoracis comparing various parameters like bacteriology, side of lesion and co morbidities.

MATERIALS AND METHODS

This descriptive and retrospective study was conducted in a tertiary level hospital attached to a medical college. This study was approved by the institutional scientific and ethics committee. The in-patient hospital records of all chronic empyema patients who were subjected to decortication via open thoracotomy between July 2016 and July 2017 were reviewed retrospectively.

Diagnosis of empyema was made by one of the following criteria: (1) drainage of purulent pleural fluid, (2) biochemical parameters of empyema like pH of less than 7.2 and lactate dehydrogenase level > 1000 IU/L, (3) Pleural fluid gram stain or culture positive for bacteria. Chronic empyema was defined according to the American thoracic society staging system, where stage III empyema corresponds to chronic empyema or the organizing stage [14]. This diagnosis was supported by duration of illness more than 15 days before definitive treatment and supportive imaging findings of entrapped lung due to pleural thickening [15].

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Our study group consisted of empyema patients who underwent decortication via open thoracotomy with none of the exclusion parameters mentioned below. Patients who were not willing to give written informed consent, patients with contraindications for spirometry and those with pre operative spirometry data unavailable were excluded from the study. Even though, tuberculosis patients were included in the study, those with parenchymal lesions in xray or with sputum smear positive for acid fast bacilli were excluded. Only exclusive pleural tuberculosis patients diagnosed by pleural fluid analysis or those who had histopathological evidence of tuberculosis in post decortication specimen were selected into the study. Prior administration of anti tuberculosis chemotherapy was not a criterion for exclusion. And patients who had lung resection done along with decortication were also not included in this study. Those patients who had prior history of chest tube insertion were included in the study provided they satisfied the above criteria.

Out of the 40 patients who underwent surgery, only 35 patients met the inclusion criteria. Patients were reassessed in their routine follow up or when they visited the hospital at an invitation to join the study. The post operative evaluation was done 6 ± 3 months after surgery. An informed consent was obtained from all patients who agreed to join the study. Evaluation of patients included spirometry with MIR Spirobank II (Portable multifunction and multifunction spirometer, MIR Medical International Research, Rome, Italy) and an interview on general respiratory condition.

Pre operation spirometric values obtained from case sheets were compared with this post operation data obtained during follow up and the change were quantified by statistical analysis.

Statistical Analysis

Descriptive statistical analysis was expressed in terms of frequency, mean and standard deviation. The frequencies were compared with Pearson chi-square test for categorical variables. The continuous variables were compared with the t-test and ANOVA. p value less than 0.001 was considered significant. Statistical analysis was done by using SPSS Statistical Package for Social Sciences version 16.

RESULTS

Demographics Analysis

Study included 35 patients which included 31 male and four female. The patients' age range was 17-65 years, with a mean age of 38.52±12.36 years. Nineteen patients (54.3%) had empyema on the right side when sixteen (45.7%) had it on the left. Twenty (57.1%) were smokers, seven (20%) had diabetes mellitus, six (17.1%) had anemia and thirteen (37.1%) had leucocytosis. The most common clinical findings prior to the surgery were chest pain (29 patients, 82.85%) and fever (27patients, 77.14%). Thirteen patients (37.14%) had history of dyspnoea during exercise. Mean time between onset of acute illness to decortication was 6.71 ± 4.75 weeks. There is history of ICD insertion in 9 patients (25.7%) before surgery.

Radiological grading of empyema was done similar to pleural effusion (figure 1). Five patients (14.28%) had mild empyema (amount of purulent effusion does not exceed 4^{th} rib in chest xray), twenty three patients (65.71%) had moderate empyema (purulent effusion located between 2^{th} -4^{th} rib); and seven (20%) had massive empyema (purulent effusion exceeding 2^{nd} rib).

The mean FEV1 and FVC values improved significantly during follow up as shown in the figure 2 and 3. FEV1 was 70.51% before surgery vs. 83.43% after surgery ($p < 0.001$). FVC was 69.74% before surgery

vs. 85.40% after surgery ($p < 0.001$).One patient had a mild decrease in FVC due to post thoracotomy empyema.

Patients were classified into two groups based on etiology: Twenty one patients (60%) in Group A (tuberculous) and fourteen patients (40%) in Group B (non-tuberculous). The mean FEV1 and FVC values before and after surgery were compared among tuberculous and Non-tuberculous patients, which also showed significant improvement. All the above findings were summarised in table 1.

The mean preoperative FEV1 and FVC values improved 14.24% and 17.10% respectively after decortication in the late period in tuberculous patients. Whereas, FEV1 and FVC values improved only 10.93% and 13.50% respectively among non tuberculous patients. Although, Improvement in pulmonary function measured by calculating the difference between preoperative and postoperative values is slightly higher for tuberculous patients, the differences were not statistically significant (table 2). This improvement among tuberculous patients might be attributed to the contributory effect of anti tuberculosis chemotherapy being administered to all patients who were diagnosed to have tuberculosis by histopathological examination of the decortication specimen.

Similarly mean change in pulmonary function was compared among right versus left. Although pulmonary functions showed improvement slightly higher in right-sided cases, these differences were not statistically significant (Table 3).

Analysis was done to check the influence of leukocytosis, concomitant diseases, smoking history and anemia on functional recovery. There was no significant correlation between these factors and analysed functional parameters (Table 4 & Table 5).

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DISCUSSION

Chronic pleural empyema leads to passive atelectasis of the underlying compressed lung. Respiratory mechanics and ventilation are severely deteriorated in the form of restrictive ventilatory defect and ventilation-perfusion mismatch. Due to lesser oxygen penetration to alveoli, perfusion and gas exchange in the lung are also decreased. If the infection is uninterrupted, it may lead to total destruction of lung and chest wall deformity.

Diagnosis and treatment of pleural empyema in the early stage should be done to avoid complications leading to non expansion of lung and permanent restrictive lung defect [16]. Delayed perception of symptoms and diagnosis with late referral leads to empyema progressing to late chronic phase. Initial conservative management is not effective in such patients.

Decortication retains the functional capacity of the lung to a great extend. However, the extent to which the lung function can be restored has been a subject of controversy. There are studies which have contradictory findings attributing to the differences in numbers and quality of analysed material. Patients with tuberculous etiology are prone to worse surgical outcome in terms of morbidity and mortality [17]. When tuberculosis is the etiology, spirometric parameters won't show any improvement after decortication [18,19]. Toomes et al. and Petro et al. concluded based on their studies that measured spirometric parameters did not improve after the treatment [18,19]. There studies also pointed out the fact that only for patients with preoperative vital capacity decrease of more than 40% of their predicted value, benefit functionally postoperatively. However, this study which has 60% of the

subjects with tuberculous etiology contradicts those findings by showing significant improvement in the measured spirometric parameters. The mean preoperative FEV1 and FVC values improved approximately 14% and 17% respectively after decortication in the late period in tuberculous empyema patients in our study. Our study also contributed a fact that bacteriologic etiology doesn't influence the improvement in pulmonary function.

There are numerous studies documenting the impact of decortication on pulmonary function [10-13]. Most of the patients have been shown to have significant increases in forced vital capacity (FVC) and in forced expiratory volume in the first second (FEV1) in all of these series. Choi and colleagues compared preoperative and postoperative spirometric parameters after classifying patients into two groups based on bacteriologic etiology. All spirometric parameters improved significantly in both groups. However, no significance was shown in the rate of increase of parameters between the two groups [10]. Gokce et al. studied pulmonary function of 50 patients who underwent open decortication for empyema and found a mean increase of approximately 18% in the spirometric parameters [12]. A study done in India by Rai S P and colleagues also showed similar improvement [13].

Our study also revealed that there was a slight higher improvement in PFTs after right-sided decortication, which may be due to comparatively larger volume of the right lung. However the rate of increase in parameters between right sided and left sided decortications were not statistically significant. Similarly, the influence of leukocytosis, concomitant diseases, smoking history and anemia on functional recovery were analysed and proved not significant.

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The postoperative evaluation was conducted 6 ± 3 months after the surgery to avoid potential adverse effects. Some authors did not observe functional recovery of the lung during this period and sometimes even deterioration of spirometry [10]. Despite this, there are other limitations for the study which includes relatively low patient number and retrospective design. Selection bias is inevitable since many patients were taken for decortication could have been treated with VATS. The use of only FEV1 and FVC as measures of pulmonary function is a limitation as no single spirometric parameter explains the physiology of chronic empyema thoracis. Since spirometry itself is effort related, an ineffective effort may give false values. Surgical approach is one of the important factors which may affect the outcome [20]. But our study had an advantage that all the patients were operated by a single thoracic surgeon and a single technique i.e, decortication via open thoracotomy.

To conclude, Decortication and empymectomy via open thoracotomy results in significant clinico-functional improvement in patients with chronic empyema. The bacteriologic status, side of lesion, smoking habit or co morbidities will not influence the improvement in lung function.

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TABLES

Table 1. Change in spirometric parameters before and after decortication.

Parameter	Before decortication	After decortication	P value
FEV1	70.51	83.42	<0.001
FVC	69.74	85.40	<0.001
FEV1 (TB)	69.19	83.52	<0.001

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FVC (TB)	70.05	86.76	<0.001
FEV1 (Non-TB)	72.5	83.42	<0.001
FVC (Non-TB)	69.28	82.78	<0.001

FEV1: forced expiratory volume in the first second; FVC – forced vital capacity (both expressed as mean); TB: tuberculosis

Table 2. Comparison of mean change in pulmonary function in tuberculous and non-tuberculous patients.

Pulmonary function	Tuberculous patients	Non-tuberculous patients	T-test value	p
Mean change in FEV1	14.24	10.93	1.141	0.262
Mean change in FVC	17.10	13.50	0.969	0.339

FEV1: forced expiratory volume in the first second; FVC – forced vital capacity; expressed as mean; T-student's t-test; p- paired t-test

Table 3. Comparison of improvements after right and left sided decortications

Pulmonary function	Right sided decortications	Left sided decortications	T-test value	p
Mean change in FEV1	13.16	12.63	0.183	0.856
Mean change	15.84	15.44	0.109	0.914

in FVC				

FEV1: forced expiratory volume in the first second; FVC – forced vital capacity; expressed as mean; T- student's t-test; p- paired t-test

Table 4. Comparison of Mean difference in FEV1 among various groups

Variable		Mean FEV1 difference	T-test value	P-value
Smoking habit	Smokers	12.55	0.291	0.773
	Non-smokers	13.40		
Diabetes Mellitus	Diabetic	10.86	0.715	0.479
	Non-diabetic	13.43		
Leucocytosis	Leucocytosis	12.54	0.200	0.843
	No leucocytosis	13.14		
Anemia	Anemic	16.83	1.260	0.217
	Not anemic	12.10		

FEV1: forced expiratory volume in the first second; T- student's t-test; p- paired t-test

Table 5. Comparison of Mean difference in FVC among various groups

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Variable		Mean FVC difference	T-test value	P-value
Smoking habit	Smokers	14.95	0.444	0.660
	Non-smokers	16.60		
Diabetes Mellitus	Diabetic	12.86	0.776	0.449
	Non-diabetic	16.36		
Leucocytosis	Leucocytosis	17.69	0.856	0.0.397
	No leucocytosis	14.45		
Anemia	Anemic	22.17	1.674	0.104
	Not anemic	14.31		

FVC – forced vital capacity; expressed as mean; T- student's t-test; p- paired t-test

Figure legends

Figure 1. Graph showing change in FEV1 before and after surgery. (FEV1: forced expiratory volume in the first second)

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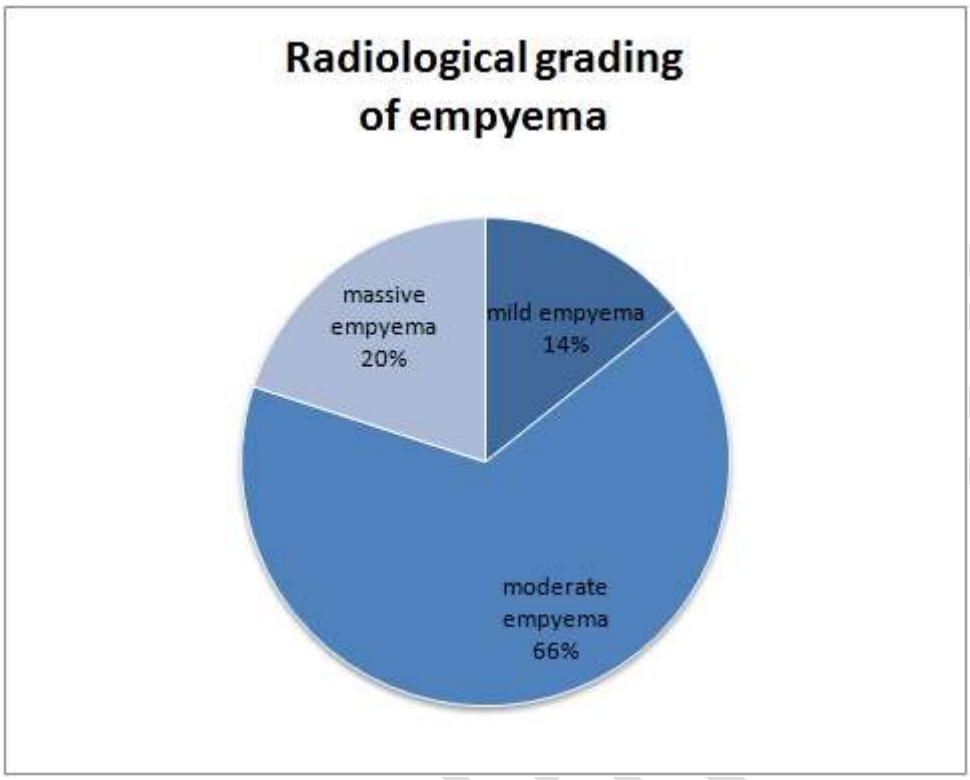
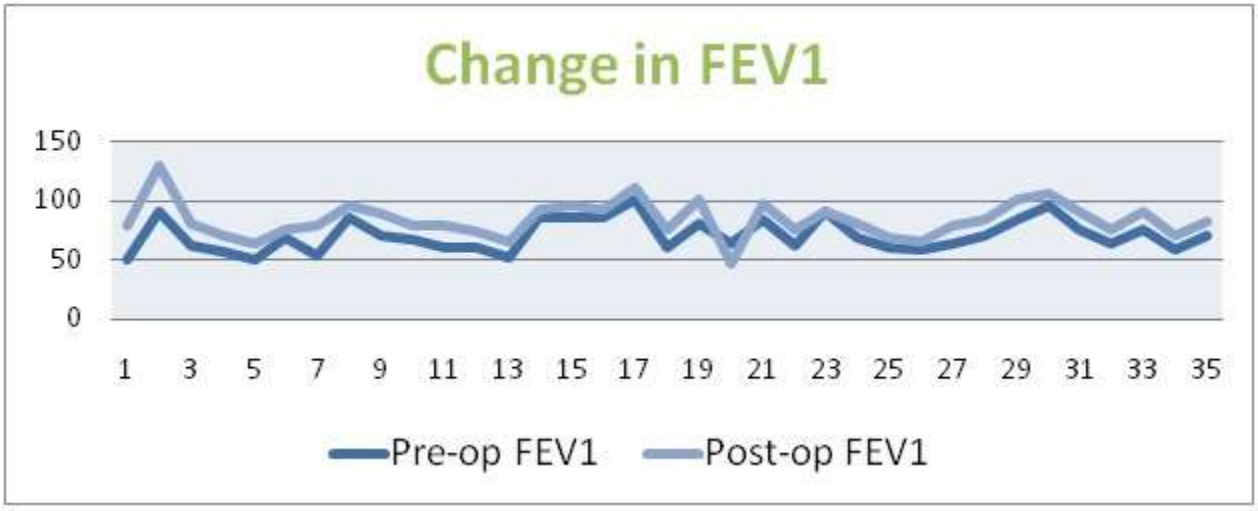


Figure 2. Graph showing change in FVC before and after surgery. (FVC – forced vital capacity)



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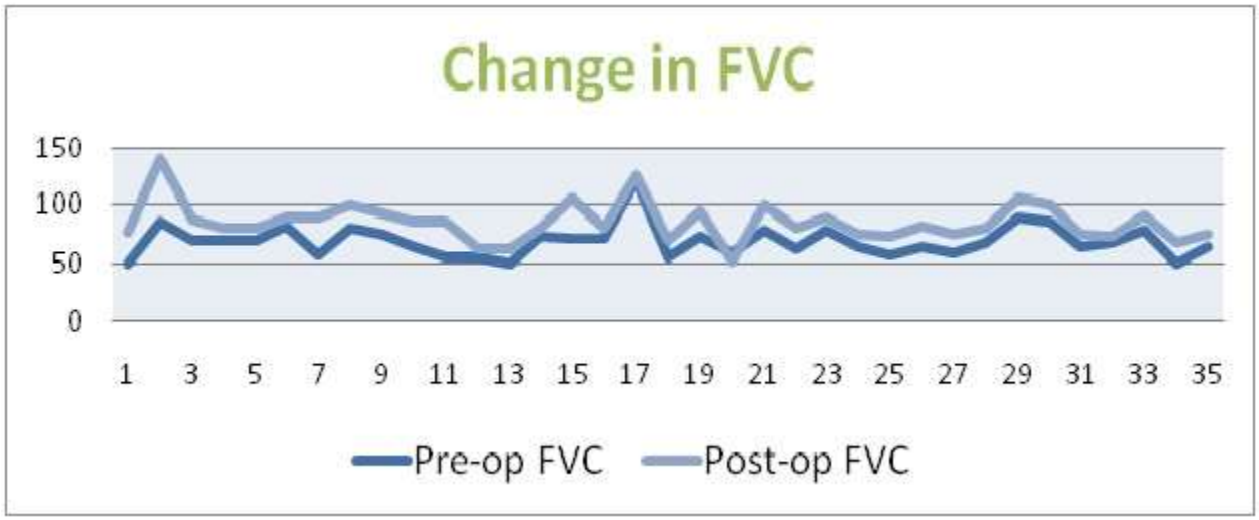

Figure 3.

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