Original Research Article

Objective Evaluation of Efficacy of Decortication in Chronic Pleural Empyema in Adult Patients

Abstract

Background: Chronic pleural empyema (CPE) is the last phase of the triphasic process of pleural empyema development. Lung decortication is the corner stone in management of chronic empyema. The aim of this study was to evaluate objectively the efficacy of conventional decortication operation in chronic pleural empyema in adult patients. Also to prove that decortication of variable sizes of chronic empyema thoracis lesions is followed by improvement considering respiratory impairment.

Methods: This prospective clinical study was conducted on 103 patients undergoing elective lung decortication operation for management of chronic empyema. All patients were subjected to the history taking, general examination, chest examination, computed tomography (CT), pulmonary function test and arterial blood gases. Postoperative evaluation was done in outpatient clinic 6 months post operatively including: Full clinical examination, investigations (acute phase reactants, CT chest, PFT and arterial blood gases.

Results: Total leucocytic count, ESR 1st hour, ESR 2nd hour and CRP were significantly decreased in post than pre. FEV1 and FVC were significantly increased in post than pre (P <0.001). FEV1 / FVC Ratio was significantly decreased in post than pre (P <0.001). Transverse and antero-posterior diameters of diseased hemithorax were significantly increased in post than pre (P <0.001, 0.019 respectively). Transverse and antero-posterior diameters of normal hemithorax were insignificantly different between post and pre. PaO2 and SpO2 were significantly increased in post than pre (P <0.001). PaCO2 was significantly decreased in post than pre (P <0.001).

Conclusions: The improvement in the lung function, arterial blood gases, transverse and antero-posterior diameter of diseased and normal hemithorax was proposed to have resulted from the decortication in chronic empyema thoracis. Decortication of variable sizes of chronic pleural empyema lesions is followed by objective improvement considering respiratory impairment.

Keywords: Objective Evaluation, Efficacy, Decortication, Chronic Pleural Empyema, Adult Patients

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 [1].

Para pneumonic empyema is one of the main causes of prolonged hospitalization, and approximately 50% of cases of bacterial pneumonias result in pleural effusion, with one-third developing the late fibrotic phase that leads to chronic empyema [2].

The development of chronic disease will lead to permanent constriction by a fibrous tissue which causes stiffness of the thoracic wall and further constriction of large areas of the lung. In addition to that, residues of the empyema are responsible for general malaise and septicemia. Also, some authors reported significant reduction of oxygen uptake in the atelectatic lung, which resolved significantly after re-expansion. Therefore, this condition cannot be dealt with by conservative means. This lead to the fact that lung decortication is the corner stone in management of chronic empyema [3].

Lung decortication is a surgical procedure that involves; removal of parietal pleura, complete mobilization of lung and complete rectification of fissures, removal of fibrous peels over visceral pleura and complete suctioning of pleural space. Lung decortication is usually followed by a significant improvement in Spirometric parameters, such as vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in 1^{st} second(FEV_1) [4].

The aim of this study was to evaluate objectively the efficacy of conventional decortication operation in chronic pleural empyema in adult patients. Also to prove that decortication of variable sizes of chronic empyema thoracis lesions is followed by improvement considering respiratory impairment.

Patients and Methods:

This prospective clinical study was conducted at the Cardiothoracic surgery department, Tanta University Hospital on 103 patients over 18 years old undergoing elective lung decortication after chronic empyema for management of chronic empyema from April 2019 to April 2020.

Patients below 18 years old, Patients who underwent decortication for post resectional empyema or empyema with any malignancy or recurrent empyema, Patients with another pathology irrelevant to empyema that can alter postoperative spirometric parameters (chronic obstructive pulmonary disease (COPD), interstitial lung disease (ILD), corpulmonale , cardiac patients), Patients who are unable or refusing to give written informed consent and tuberculous patients were excluded.

The study was approved by the Ethics committee of faculty of medicine, Tanta university. Written informed consent regarding the procedure and possible complications was obtained for all patients involved in this study.

All patients were subjected to the following: Preoperative evaluation included; History taking (age, sex, complaint, comorbidities, surgical history), Clinical examination: General examination [Vital signs (Blood pressure, Temperature, Heart rate, Respiratory rate) and signs of (Pallor, Cyanosis, Jaundice, and Lymph node enlargement)] and Chest Examination [inspection, palpation, percussion, and auscultation] and Investigations: Acute phase reactants (total leucocytes count, erythrocyte sedimentation rate (ESR), C reactive protein (CRP)).

Chest x-ray (CXR): Radiographically, empyema appears as pleural fluid that is usually unilateral. When there are bilateral effusions, the infected side is much larger. An effusion that is not loculated has homogeneous opacity. Loculated effusions are defined as effusions that do not shift freely in the pleural space and occur in patients with empyema when there

are adhesions between the visceral and parietal pleura. If the fluid is loculated, thick pus or contains particulate material, there is very little change in the X-ray appearances of the fluid with changes in the position. Loculated effusions can appear confusing on chest X-ray and may be difficult to distinguish from a peripheral lung abscess. Loculated fluid appears lenticular in shape and the opacity has a different appearance on frontal and lateral chest radiographs. Helpful radiographic signs of loculated pleural fluid on chest X-ray include incomplete layering on decubitus films, scalloped effusion contours and fixed apical fluid. Pleural based opacities form obtuse angles with the chest wall, whereas a lung abscess is usually round, appears the same shape on X-rays taken at right angles to each other and forms an acute angle to the chest wall. Free pleural fluid accumulates in the apex of the chest in supine patients because this is the most dependent part of the thorax.

Computed tomography (CT) chest; transverse and anteroposterior diameters. Although this distinction is based on analysis of pleural fluid, certain CT features have been described as being highly suggestive of empyema. These include findings of enhancement and thickening of the parietal and visceral pleura, thickening of the extra-pleural subcostal tissues and increased density of the extra-pleural subcostal fat. These features on CT were described as being highly suggestive but non-specific for empyema rather than sterile pleural effusion. CT is accurate for detecting pleural effusions and loculations in the fluid. It was the best method to differentiate peripheral lung abscess from empyema and, CT generally used in instances where an underlying disorder of the lung was suspected. It may be necessary to use CT if a pleural collection is difficult to define on ultrasound because of the presence of pleural air. It was sometimes helpful to demonstrate poor chest tube position or failure of lung re-expansion.

Pulmonary function test (PFT): forced expiratory volume in 1 s (FEV1), forced vital capacity (FVC) and maximal mid-expiratory flow (MMEF).

All cases were diagnosed as chronic empyema based on clinical and radiological basis. Diagnosis of empyema: It was confirmed by one of the following criteria: drainage of grossly purulent pleural fluid, pleural fluid culture or Gram stain showing bacteria or biochemical parameters of empyema (pH < 7.2, lactate dehydrogenase level > 1,000 IU/L, glucose level < 40 mg/dl.). Chronic empyema was defined in accordance with the American Thoracic Society staging system, where stage III empyema corresponds to chronic empyema or the organizing stage. Fibroblasts migrate into the pleural cavity and produce an inelastic membrane, entrapping the lung and rendering it essentially functionless. This diagnosis was corroborated by illness durations of more than 15 days before definitive treatment as well as supportive imaging findings, such as constriction of the chest cavity. Some cases were indicated for lung decortication after failure of complete drainage of pus and complete lung expansion using intercostal tube while others carried on lung decortication from beginning due to multi loculated empyema or sever thickened fibrous peel over pleura that alter complete lung expansion. All patients underwent lung decortication through a posterolateral thoracotomy. The lung is gradually freed in an extra pleural plane from the chest wall, the apex, the diaphragm and the anterior and posterior mediastinum. Dissection with a swab may be especially helpful at the level of the vena cava superior and the anterior mediastinum in order to prevent venous lacerations or injury to the phrenic nerve. It is important to be aware of the proper dissection plane between the lung surface and the peel. This is achieved by gentle ventilation of the lung with low tidal volumes which facilitates the identification of the proper dissection plane between the peel and the lung. An inadequate dissection plane will prevent the lung from proper expansion during ventilation and carries the risk of late restriction and recurrent infection. The parietal wall of the empyema sac was detached from chest wall. Thickened fibrous peel was completely removed from parietal wall and visceral pleura. Any resultant tiny or large air leakage was repaired by suturing closely followed by irrigation.

Adequate hemostasis must be ensured. Diathermy or bipolar forceps may be quite handy to achieve hemostasis. The intercostal drain is inserted in the thoracic interspace. Some surgeons insert two drains-one in the base (posterior) and one in the apex (anterior). These tubes remain in place until the appearance of signs (clinical and radiological) of lung expansion. The closure of thoracotomy must be water- and air-tight, and this is achieved by adapting the ribs using pericostal Vicryl sutures. Subsequently, a layered chest wall closure is done. Intraoperative injection of local anesthesia around the wound will help to diminish postoperative pain if the insertion of an epidural catheter is contraindicated. Chest tube was removed after cease of air leak and the amount of drainage decreased to less than 100 mL per day.

Postoperative evaluation was done in outpatient clinic 6 months post operatively including: Full clinical examination, Investigations (Acute phase reactants (total leucocytes count, ESR, CRP), CT chest and PFT was done on fasting patient in the morning and it included following values (forced expiratory volume in 1 s (FEV1), forced vital capacity (FVC) and maximal mid-expiratory flow (MMEF) and arterial blood gases (PCO_2, PO_2, SaO_2).

Statistical analysis

Statistical analysis was done by SPSS v25 (IBM Inc., Chicago, IL, USA). Numerical variables were presented as mean and standard deviation (SD) and compared between pre and post measurements by utilizing paired Student's t- test. Categorical variables were presented as frequency and percentage (%). A two tailed P value < 0.05 was considered significant.

Results:

The age of patients ranged from 18-65y with mean value 40.14 ± 15.41. There were 66 (64.08%) male patients and 37 (35.93%) female patients. Empyema was right sided in 55 (53.40%) patients and left in 48 (46%) patients. **[Table 1]**

Table 1: Characteristics and affected side of all patients

		Patients (n = 103)
Age (y)	**Mean ± SD**	40.14 ± 15.41
	Range	18-65
Sex	**Male**	66 (64.08%)
	Female	37 (35.93%)
Side	**Right**	55 (53.4%)
	Left	48 (46.6%)

Total leucocytic count, ESR 1st hour, ESR 2nd hour and CRP were significantly decreased in post than pre operative evaluation (P <0.001). **[Table 2]**

Table 2: Acute phase reactants (total leucocytes count, ESR, CRP) in all patients

		Pre	Post	P value
Total leucocytic count (thousands/cmm)	Mean ± SD	80.46 ± 11.89	13.47 ± 4.87	**<0.001***
	Range	60-100	5-20	
ESR 1st hour (mm)	Mean ± SD	113.8 ± 20.6	14.82 ± 2.82	**<0.001***
	Range	81-150	10-20	
ESR 2nd hour (mm)	Mean ± SD	129.3 ± 20.50	29.54 ± 4.05	**<0.001***
	Range	93-166	20-39	
CRP (mg/dL)	Mean ± SD	80.46 ± 11.89	13.47 ± 4.87	**<0.001***
	Range	60-100	5-20	

ESR: Erythrocyte Sedimentation Rate, CRP: C-reactive protein.

FEV1 and FVC were significantly increased in post than pre operative evaluation (P <0.001). FEV1 / FVC Ratio was significantly decreased in post than pre operative evaluation (P <0.001).

Table 3: Pulmonary function tests (FEV1, FVC and ratio) in all patients

		Pre	Post	P value
FEV1 %	**Mean ± SD**	61.96 ± 6.49	77.36 ± 7.00	**<0.001***
	Range	51-73	65-91	
FVC %	**Mean ± SD**	57.85 ± 7.54	81.35 ± 7.29	**<0.001***
	Range	42-74	66-98	
FEV1 / FVC Ratio	**Mean ± SD**	1.08 ± 0.07	0.95 ± 0.05	**<0.001***
	Range	0.96-1.22	0.87-1.03	

FEV: Forced Expiratory Volume, FVC: Forced vital capacity

Transverse and antero-posterior diameters of diseased hemithorax were significantly increased in post than pre (P <0.001, 0.019 respectively). Transverse and antero-posterior diameters of normal hemithorax were insignificantly different between both groups. **[Table 4]**

Table 4: CT chest (Transverse and antero-posterior diameter of diseased and normal hemithorax) in all patients

		Pre	Post	P value
Transverse diameter of diseased hemithorax (cm)	Mean ± SD	11.34 ± 1.11	11.99 ± 1.11	**<0.001***
	Range	9-13	9.5-13.7	
Transverse diameter of normal hemithorax (cm)	Mean ± SD	12.57 ± 1.12	12.61 ± 1.16	0.827
	Range	9.7-14.8	9.9-15	
Antero-posterior diameter of diseased hemithorax (cm)	Mean ± SD	15.29 ± 3.06	16.30 ± 3.05	**0.019***
	Range	10.8-20.7	11.4-22.2	
Antero-posterior diameter of normal hemithorax (cm)	Mean ± SD	17.56 ± 2.96	18.07 ± 2.99	0.212
	Range	13-22	13.7-22.7	

PaO_2 and SpO_2 were significantly increased in post than pre operative evaluation (P <0.001). $PaCO_2$ was significantly decreased in post than pre operative evaluation (P <0.001). **[Table 5]**

Table 5: Arterial blood gases (PaO2, PaCO2 and SaO2) in all patients.

		Pre	Post	P value
PaO_2 (mmHg)	Mean ± SD	78.27 ± 5.37	81.20 ± 5.30	**<0.001***
	Range	70-88	74-92	
$PaCO_2$ (mmHg)	Mean ± SD	43.01 ± 3.03	41.00 ± 3.20	**<0.001***
	Range	39-48	36-47	
SpO_2 (mmHg)	Mean ± SD	93.88 ± 2.10	96.44 ± 2.18	**<0.001***
	Range	91-97	93-100	

Discussion

In our study, FEV1 and FVC were significantly increased in post than pre (P <0.001). FEV1 / FVC ratio was significantly decreased in post than pre (P <0.001). In agreement with our results, **(Abraham and Chikkahonnaiah 2020)**[5] included 35 patients with chronic pleural empyema who underwent decortication via a posterolateral thoracotomy were reviewed and followed-up for 6±3 months after surgery. The mean FEV1 and FVC values improved significantly during the follow-up period, 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 showed a mild decrease in FVC due to post-thoracotomy empyema. In agreement with our results, **(Rzyman et al., 2002)**[6] included 26 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. The preoperative vital capacity (VC) was reduced to 62.3% (±13.8%) of the predicted value and forced expiratory volume in 1s (FEV1) to 50% (±15.5%) of the predicted value. Postoperatively, slight improvement was achieved to 79.8 % (±12.9%) for VC and 69.2% (±12.7%) for FEV1. Patients were classified into two groups based on etiology: 21 patients (60%) in Group A (tuberculous) and 14 patients (40%) in Group B (non-tuberculous). The mean FEV1 and FVC values before and after surgery were compared between tuberculous and non-tuberculous patients, which showed significant improvement. After decortication in tuberculous patients in the late period, the mean preoperative FEV1 and FVC values improved to 14.24% and 17.10%, respectively. On the other hand, the FEV1 and FVC values improved only to 10.93% and 13.50%, respectively, among non-tuberculous patients. Although, the improvement in pulmonary function that is measured by calculating the difference between preoperative and postoperative values is slightly higher for tuberculous patients, these differences were not statistically significant. 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, as confirmed by histo-pathologically examining the decortication specimen. In agreement with our results, **(Gokce et al., 2009)**[7] included a total of 50 patients who underwent standard open decortication for empyema were included. The PFTs and computed tomographic (CT) scans of the chest were analyzed in all patients after 6—58 months postoperatively. The mean preoperative forced expiratory volume in first second (FEV1) and forced vital capacity (FVC) increased from 61.40% and 60.89% to 78.92% and 77.48%, respectively, in the late postoperative period ($p < 0.001$). In agreement with our results, **(Rzyman et al., 2005)**[8] included 20 men (71.4%) and 8 women (28.6%) to determine the lung function after lung decortication in a prospective

evaluation of blood gases, spirometry, lung perfusion, ventilation, and alveolar permeability were performed 28 weeks (15–60 weeks) after the operation. Eight patients (28.6%) had a predicted VC below 70%, which is the lowest reference value for a healthy population in Poland. Fifteen (53.6%) had a FEV1 value below the normal limits. In 8 patients (28.6%) both predicted spirometric values were below 70%. Median VC% for the whole group was 76.7% (range: 48.6–100%) and FEV1% was 67.8 (range: 17.7–105%). In agreement with our results, **(Bagheri et al., 2016)**[9] included 50 patients (42 males, mean age 49.1 ± 19.46 years) with chronic empyema who underwent lung decortication via a posterolateral thoracotomy. The mean % of predicted FEV1 was 62.5% ± 13.61% before surgery vs. 77.3% ± 13.31% after surgery ($p < 0.001$). The mean % of predicted FVC was 60.6% ± 14.38% before surgery vs. 78.5% ± 12.64% after surgery ($p < 0.001$). In agreement with our results, **(Choi et al., 2004)**[10] included 163 cases involving lung decortication were seen at their institution. Sixty-five cases received empyemectomy and decortication, and all the cases had preoperative and postoperative pulmonary function tests performed. 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 PVC, 64.9% and 71.8% in %PVC, respectively.

A study done by **(Rai et al., 2006)**[11] included 25 patients of chronic empyema who were subjected to decortication at their tertiary care hospital were evaluated prospectively. Patients were subjected to detailed clinical, radiological and other diagnostic evaluation for etiology, duration of treatment and response. They showed that preoperative spirometry showed moderate restriction (FVC -53%, FEV 1 -61.7%). Postoperatively all patients showed good recovery. Spirometry after decortication showed satisfactory improvement (FVC-68%, FEV 1 -72.8%). 25 patients of chronic empyema who were subjected to decortication at our tertiary care hospital in India were evaluated prospectively. Decision for decortication was taken on the basis of long duration of treatment, poor response to antibiotics, intercostal tube

drainage, thrombolytic therapy and thickness of pleural peel. All the patients were followed up for six months.

Patients with tuberculous etiology are prone to worse surgical outcome in terms of morbidity and mortality. When tuberculosis is the etiology, spirometry parameters will not show any improvement after decortication. Based on their studies, **(Petro et al., 1982)**[12] and **(Toomes et al., 1983)**[13] concluded that the measured spirometry parameters did not improve after treatment. Their studies also pointed out that patients with a preoperative vital capacity decrease of more than 40% of their predicted value experience functional benefits.

In our study, transverse, and antero-posterior diameters of diseased hemithorax were significantly increased in post than pre (P <0.001, 0.019 respectively). Transverse and antero-posterior diameters of normal hemithorax were insignificantly different between both groups. In agreement with our results, **(Bagheri et al., 2016)**[9] revealed that the mean preoperative transverse diameter of affected hemithorax increased from 11.2 cm to 11.8 cm ($p < 0.001$). The mean preoperative antero-posterior chest diameter improved from 15.4 cm to 16.3 cm ($p < 0.001$). In agreement with our results, **(Gokce et al., 2009)**[7] revealed that the mean preoperative transverse diameter of affected hemithorax increased from 11.22 cm to 11.98 cm ($p < 0.001$) and, the transverse asymmetry improved from 11.52% to 5.94%, postoperatively ($p < 0.001$). The mean preoperative antero-posterior chest diameter improved from 15.58 cm to 16.67 cm ($p < 0.001$), and the antero-posterior asymmetry improved from 11.42% to 5.42% ($p < 0.001$) in the late postoperative period.

In our study, PaO2 and SpO2 were significantly increased in post than pre (P <0.001). PaCO2 was significantly decreased in post than pre (P <0.001). In agreement with our results, **(Rzyman et al., 2002)**[6] revealed that blood gas analysis showed decreased values in majority of the patients before operation and significant improvement in postoperative

evaluation. In disagreement with our results, **(Rzyman et al., 2005)**[8] showed that blood gas parameters were within normal ranges in almost all patients.

The limitations of this study are the relatively low patient number, and we did not study variables such as, ventilation, and pulmonary perfusion parameters because FEV1, FVC and blood gases were the only tests routinely performed before decortication.

Conclusions:

In conclusion, the improvement in the lung function, arterial blood gases, transverse and antero-posterior diameter of diseased and normal hemithorax was proposed to have resulted from the decortication in chronic empyema thoracis. Decortication of variable sizes of chronic pleural empyema lesions is followed by objective improvement considering respiratory impairment.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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