Predictors of conversion from thoracoscopic to open surgery in management of postpneumonic empyema

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Received 5 July 2016; revised 12 August 2016; accepted 12 August 2016
Available online 20 August 2016

Abstract

Background: Video-assisted thoracoscopic surgery (VATS) has an important role in management of pleural empyema. The objective of this study was to assess the predictors for conversion from VATS to open thoracotomy in an assumed stage II postpneumonic empyema.

Methods: This prospective randomized study included 120 patients admitted to cardio-thoracic surgery department, Benha University, between 2011 and 2016. All cases were enrolled for thoracoscopic debridement for an assumed stage II postpneumonic empyema. If stage III empyema was diagnosed during thoracoscopy, conversion to thoracotomy became indicated. Predictors for conversion to thoracotomy were assessed in a univariate, a bivariate correlation and a multivariate analysis using several variables like age, sex, associated comorbidities, duration of symptoms, pleural fluid analysis, and pleural thickness measured by CT scan.

Results: Out of 120 patients, thoracoscopic management was successful in 82 (68%) patients, while conversion to thoracotomy was done in 38 (32%) patients. Conversion to thoracotomy was higher in patients with long duration of symptoms ($p < 0.001$) with cutoff value at 18.1 days, increased pleural thickness ($p < 0.001$) with cutoff value at 3.95 mm, increased LDH with cutoff value at 1854 IU/L, and Gram-negative infection of pleural fluid ($p < 0.001$). Multivariate analysis identified that the duration of symptoms, gram-negative bacteria, LDH and pleural thickness were the significant predictors for conversion from VATS to thoracotomy.

Conclusion: Predictive factors for conversion to thoracotomy in an assumed stage II postpneumonic empyema include long duration, Gram-negative bacterial infection, increased LDH, and increased pleural thickness.

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Keywords: Pleura; Thoracoscopy; VATS; Open surgery; Empyema

1. Introduction

Parapneumonic effusion is a pleural fluid accumulation in the presence of pulmonary infection. 10–20% of cases with parapneumonic effusion develop complicated parapneumonic effusion or postpneumonic empyema [1]. Postpneumonic empyema has high morbidity in spite of its low incidence because of the effective antibiotic management
The mainstay of management of postpneumonic empyema is the eradication of ongoing infection and the prevention of recurrent infection and subsequent restrictions. Inadequate drainage of this empyema with persistent signs of infection is the indication for surgery. Any delay in this surgical management will increase the morbidity and mortality.

Guidelines for management of empyema depend upon the stage of empyema. During stage I empyema, there is an exudative fluid without any encystations which usually responds to antibiotics and thoracocentesis or chest tube drainage. The fibrinopurulent phase or stage II disease is characterized by turbid or frankly purulent pleural fluid associated with fibrin deposits over visceral and parietal pleurae. CT scan findings include pleural enhancement and encysted effusion without any restriction. Stage II empyema can be managed by fibrinolytic therapy or video-assisted thoracoscopic debridement. In stage III empyema, there is an increased thickness of pleura with signs of restriction on CT scan. Freeing the trapped lung with prevention of recurrence or late restriction can be achieved by decortication.

Recently, VATS pleural adhesiolysis and decortication have also been proven to serve as an effective treatment modality in the early stages of empyema, especially during the fibrinopurulent stage. Although still in debate, many authors have reported that the effectiveness of VATS drainage and decortication is at least equivalent to that of open decortication in terms of resolution, even in the advanced stages of empyema. New technical advances in endoscopic instruments have increased the role of VATS in management of many thoracic surgical diseases which were previously treated by thoracotomy only. Choosing the best surgical approach is a confusing clinical problem due to lack of specific clinical, radiological and laboratory indicators for a precise preoperative staging of empyema.

2. Patients and methods

This prospective study included 120 patients admitted to cardiothoracic surgery department, Benha University, between 2011 and 2016. All patients were informed that a VATS approach will be attempted and informed consent was obtained to proceed to thoracotomy if a stage III empyema was found at exploration by VATS. Samples of pleural fluid were collected for biochemical, cytological and bacteriological examination. The predictors for conversion from VATS to open thoracotomy in an assumed stage II postpneumonic empyema were evaluated.

2.1. Patient selection

According to the American Thoracic Society, patients with assumed stage II empyema and history of recent pneumonia (postpneumonic empyema) were enrolled in this study. Enrollment criteria consisted of the presence of encysted pleural effusion with pleural enhancement on CT scan in addition to the presence of signs of infection, weight loss and chest pain. Pleural fluid was examined after either thoracocentesis or chest tube drainage. Any item of the following criteria was applied for the diagnosis of thoracic empyema:

1. Frank pus obtained by thoracocentesis.
2. Presence of bacteria detected by Gram stain or by culture.
3. Or pleural fluid analysis with all of the following: pH below 7.2, glucose level less than 40 mg/dl, LDH above 1000 IU/L, protein level above 30 gm/L and WBC over 15,000 cells/mm³.

Exclusion criteria for a primary VATS approach were:

1. Other causes of empyema (other than postpneumonic empyema).
2. An assumed stage III empyema with signs of lung restriction on CT scan.
3. Suspicion of bronchopleural fistula, lung abscess, or tumor.

2.2. Data collection

All patients were studied for the following variables: age, sex, associated comorbidities (diabetes mellitus, hypertension, liver and kidney diseases), duration between onset of symptoms and surgery, laboratory analysis of pleural fluid (pH, LDH, protein, glucose and involved bacteria), and pleural thickness measured by CT scan.
2.3. Statistical analysis

Using SPSS 22, summaries of continuous variables were given as mean ± standard deviation, whereas summaries of binary variables were given as counts and percentages. To determine the predictors for conversion to thoracotomy in an assumed stage II postpneumonic empyema, many factors were studied such as age, sex, associated comorbidities (diabetes mellitus, hypertension, liver and kidney diseases), duration between onset of symptoms and surgery, laboratory analysis of pleural fluid (pH, LDH, protein, glucose and involved microorganisms), and pleural thickness measured by CT scan. Univariate and then multivariate analysis with a multiple logistic regression model were used. Significance was accepted at \( p \) less than 0.05.

3. Results

Between 2011 and 2016, 120 patients underwent surgery for an assumed stage II pleural empyema. All patients had been initially treated with antibiotics. There were 87 men and 33 women, with a mean age of 45.7 years (range, 20–67 years).

3.1. Surgical procedure

120 patients with an assumed stage II postpneumonic empyema according to the American Thoracic Society underwent VATS decortications. 38 patients (32%) had been converted to open decortications because of chronicity of disease (thick pus, thickened pleura or multiple adhesions). VATS decortication without conversion to thoracotomy was achieved in 82 patients (68%).

3.2. Microbiological evaluation

Bacteriological assessment of the samples obtained during surgery revealed no growth in 29 patients (24.1%). Previous culture results obtained from samples taken by thoracocentesis before operation were considered to be the causative microorganisms in 66 patients. Gram negative microorganisms were found in 56% of all patients (in 37 patients with VATS only, and in 30 patients with thoracotomy). Infection caused by Gram-negative microorganisms was mainly by *Haemophilus influenzae*, *Escherichia coli*, *Pseudomonas aeruginosa*. Infection with Gram-positive microorganisms was found in 46.6% of all patients (in 45 patients with VATS only, and in 11 patients with thoracotomy). Infections caused by Gram-positive microorganisms were mainly by *Streptococcus pneumoniae* and *Staphylococcus aureus*. Anaerobic microorganisms were not detected in this study.

3.3. Predictors for conversion to thoracotomy in the 120 patients with an assumed stage II postpneumonic empyema

Univariate analysis showed that conversion to thoracotomy was higher in patients with long duration between onset of symptoms and surgery \((p < 0.001)\) with cutoff value at 18.1 days (86% sensitivity and 87% specificity), increased pleural thickness in CT scan \((p < 0.001)\) with cutoff value at 3.95 mm of pleural thickness (100% sensitivity and 76% specificity), LDH \((p < 0.001)\) with cutoff value at 1854 IU/L (93% sensitivity and 84% specificity) and the presence of Gram-negative bacteria in the pleural fluid \((p < 0.001)\). The time duration between onset of symptoms and surgery was 17.27 ± 1.9 days for the patients who underwent thoracoscopic decortication in comparison with 22.31 ± 2.49 days in the patients with conversion to thoracotomy (Tables 1 and 2).

Multivariate analysis using a stepwise logistic regression model identified the duration between onset of symptoms and surgery \((p < 0.001)\), Gram-negative bacteria \((p = 0.001)\), LDH \((p = 0.003)\) and pleural thickness \((p = 0.012)\) as the significant predictors for conversion from VATS to thoracotomy in an assumed stage II postpneumonic empyema, whereas age, sex, associated comorbidities (diabetes mellitus, hypertension, liver and kidney diseases) pleural pH, protein and glucose were not (Table 3).

There was a significant correlation between pleural thickness and duration between onset of symptoms and surgery \((p < 0.001)\) with correlation coefficient = 0.601. There was a significant correlation between gram negative bacteria and duration between onset of symptoms and surgery \((p = 0.022)\) with correlation coefficient = 0.327. There was a significant correlation between LDH and time interval between onset of symptoms and surgery \((p < 0.001)\) with
correlation coefficient = 0.583. There was a significant correlation between LDH and pleural thickness ($p < 0.001$) with correlation coefficient = 0.627 (Table 4).

### 3.4. Mortality and morbidity

There was no mortality in the first 30 days postoperatively. There was no significant difference between patients with VATS only and patients with thoracotomy regarding postoperative complications.

### 4. Discussion

This study was designed to determine the predictors for conversion to thoracotomy in patients undergoing VATS for an assumed stage II postpneumonic empyema by using a multivariate analysis in 120 patients. These predictors

### Table 1

Univariate analysis of patients’ data.

<table>
<thead>
<tr>
<th>Variables</th>
<th>VATS only n = 82</th>
<th>Conversion to thoracotomy n = 38</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean ± SD)</td>
<td>48.76 ± 10.24</td>
<td>50.1 ± 9.35</td>
<td>0.684</td>
</tr>
<tr>
<td>Male/Female n (%)</td>
<td>51/31 (62.1)</td>
<td>23/15 (60.5)</td>
<td>0.477</td>
</tr>
<tr>
<td>DM n (%)</td>
<td>29 (35.3)</td>
<td>14 (36.8)</td>
<td>0.623</td>
</tr>
<tr>
<td>Hypertension n (%)</td>
<td>27 (32.9)</td>
<td>11 (28.9)</td>
<td>0.887</td>
</tr>
<tr>
<td>Liver diseases n (%)</td>
<td>12 (14.6)</td>
<td>8 (21)</td>
<td>0.588</td>
</tr>
<tr>
<td>Kidney diseases n (%)</td>
<td>3 (3)</td>
<td>2 (5.2)</td>
<td>0.602</td>
</tr>
<tr>
<td>Duration$^a$ (mean ± SD)</td>
<td>17.27 ± 1.90</td>
<td>22.31 ± 2.49</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Leucocytosis Cells/mm$^3$ (mean ± SD)</td>
<td>13.91 ± 2.02</td>
<td>14.25 ± 1.29</td>
<td>0.542</td>
</tr>
<tr>
<td>Pleural pH (mean ± SD)</td>
<td>7.05 ± 0.02</td>
<td>7.04 ± 0.04</td>
<td>0.612</td>
</tr>
<tr>
<td>Pleural LDH IU/L (mean ± SD)</td>
<td>1174.2 ± 135</td>
<td>1874.6 ± 151</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pleural protein gm/L (mean ± SD)</td>
<td>4.53 ± 3.65</td>
<td>4.69 ± 2.75</td>
<td>0.880</td>
</tr>
<tr>
<td>Pleural glucose mg/dL (mean ± SD)</td>
<td>27.33 ± 3.36</td>
<td>25.81 ± 4.73</td>
<td>0.685</td>
</tr>
<tr>
<td>Gram positive bacteria n (%)</td>
<td>45 (54.8)</td>
<td>11 (34.3)</td>
<td>0.155</td>
</tr>
<tr>
<td>Gram negative bacteria n (%)</td>
<td>37 (45.1)</td>
<td>30 (78.9)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* Duration between onset of symptoms and surgery in days.

### Table 2

Cutoff values using receiver operating characteristic (ROC) curve.

<table>
<thead>
<tr>
<th>Variables</th>
<th>AUC$^b$</th>
<th>Cutoff value</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration$^a$</td>
<td>0.953</td>
<td>18.1</td>
<td>86%</td>
<td>87%</td>
</tr>
<tr>
<td>Pleural thickness (mm)</td>
<td>0.932</td>
<td>3.95</td>
<td>100%</td>
<td>76%</td>
</tr>
<tr>
<td>LDH (IU/L)</td>
<td>0.986</td>
<td>1854</td>
<td>93%</td>
<td>84%</td>
</tr>
</tbody>
</table>

AUC > 0.9 = excellent test results.

$^a$ Duration between onset of symptoms and surgery in days.

$^b$ Area under the curve. AUC > 0.9 = excellent test results.

correlation coefficient = 0.583. There was a significant correlation between LDH and pleural thickness ($p < 0.001$) with correlation coefficient = 0.627 (Table 4).

### Table 3

Multivariate analysis with a multiple stepwise logistic regression.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unstandardized coefficients B</th>
<th>95.0% confidence interval for B (lower bound)</th>
<th>95.0% confidence interval for B (upper bound)</th>
<th>Standardized coefficients beta</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration$^a$</td>
<td>0.037</td>
<td>0.014</td>
<td>0.061</td>
<td>0.550</td>
<td>0.000</td>
</tr>
<tr>
<td>Gram-negative bacteria</td>
<td>0.201</td>
<td>0.088</td>
<td>0.315</td>
<td>0.214</td>
<td>0.001</td>
</tr>
<tr>
<td>LDH</td>
<td>0.054</td>
<td>0.011</td>
<td>0.078</td>
<td>0.230</td>
<td>0.003</td>
</tr>
<tr>
<td>Pleural thickness in mm</td>
<td>0.106</td>
<td>0.024</td>
<td>0.187</td>
<td>0.204</td>
<td>0.012</td>
</tr>
</tbody>
</table>

* Duration between onset of symptoms and surgery in days.
included long duration between onset of symptoms and surgery, the presence of Gram-negative bacteria, LDH, and pleural thickness.

Of the 120 patients, conversion to thoracotomy was indicated only in 38 (32%) patients due to chronicity of the disease. VATS decortication was successful in 82 (68%) of our all patients. These results are better than the results obtained from earlier report in which 38% of the patients with empyema were managed by VATS and 62% by open decortication [15].

Many reports have discussed the effect of increased duration between onset of symptoms and surgery on the chronicity of empyema and on the possibility of a successful treatment by VATS [10,14,16–19]. VATS decortication can be performed successfully when the duration between onset of symptoms and surgery is between 1 and 2 weeks. This is because patients with stage III disease usually have a long duration between onset of symptoms and surgery (>3 weeks) and usually present with a thickened enhanced pleura with signs of restriction on CT scan [19]. The duration between onset of symptoms and surgery was the most important predictor for conversion to thoracotomy in a multivariate analysis performed for this purpose. The rate of conversion from VATS to thoracotomy in patients with postpneumonic empyema has been analyzed in many reports and it was ranging from 18% to 59% [10,18,20–22]. This discrepancy may be explained by the different timing of referral for surgery between the reported series and the different policies of medical treatment before surgery.

The second predictor for conversion to thoracotomy in patients with an assumed stage II empyema was the presence of Gram-negative bacteria in pleural fluid which were associated with an increased incidence of conversion to thoracotomy. It has been suggested that the type and virulence of the involved bacteria affect the rapidity of progression and stage transition of empyema [22].

The third predictor for conversion to thoracotomy in patients with assumed stage II empyema was LDH. Lactate dehydrogenase is released during tissue damage. So, it is used as a marker of common injuries and disease. In empyema, the LDH levels will exceed 1000 IU/L [13]. In this study, LDH > 1854 IU/L was found to be a cutoff value for conversion to thoracotomy (93% sensitivity and 84% specificity). Furthermore, there was a significant correlation between LDH and duration between onset of symptoms and surgery (p < 0.001) with correlation coefficient = 0.583. In addition, there was a significant correlation between LDH and pleural thickness (p < 0.001) with correlation coefficient = 0.627.

The fourth predictor for conversion to thoracotomy in patients with an assumed stage II empyema was the pleural thickness. It can be assessed by Computer Tomography imaging (CT scan) which also detects pleural enhancement and encysted effusion. The presence of pleural thickening and signs of lung restriction on CT scan refers to stage III empyema [3] which was one of the exclusion criteria in our series. In this study, the cutoff value for conversion to thoracotomy was 3.95 mm of pleural thickness (100% sensitivity and 76% specificity). There was a significant correlation between pleural thickness and duration between onset of symptoms and surgery (p < 0.001) with correlation coefficient = 0.601. Furthermore, there was a significant correlation between LDH and pleural thickness (p < 0.001) with correlation coefficient = 0.627.

The relative small number of patients and the absence of pediatric age group were the most important limitations of this study.

Table 4
Bivariate correlations analysis.

<table>
<thead>
<tr>
<th></th>
<th>Duration*</th>
<th>Pleural thickness in mm</th>
<th>Gram-negative bacteria</th>
<th>LDH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration*</td>
<td>Pearson correlation</td>
<td>1</td>
<td>0.601*</td>
<td>0.327*</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td>(1)</td>
<td>(0.000)</td>
<td>(0.022)</td>
</tr>
<tr>
<td>Pleural thickness in mm</td>
<td>Pearson correlation</td>
<td>0.601*</td>
<td>(1)</td>
<td>0.136</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td>(0.000)</td>
<td>(0.352)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Gram-negative bacteria</td>
<td>Pearson correlation</td>
<td>0.327*</td>
<td>0.136</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td>(0.022)</td>
<td>(0.352)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>LDH</td>
<td>Pearson correlation</td>
<td>0.583*</td>
<td>0.627*</td>
<td>0.131</td>
</tr>
<tr>
<td></td>
<td>Sig.</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.370)</td>
</tr>
</tbody>
</table>

\* Duration between onset of symptoms and surgery in days.

\* Correlation is significant at the 0.01 level.

\* Correlation is significant at the 0.05 level.
In conclusion, to achieve a high success rate with the video-assisted thoracoscopic approach, predictors for conversion to thoracotomy should be applied. These predictors included long duration between onset of symptoms and surgery (>18 days), the presence of Gram-negative bacteria, LDH > 1854 IU/L, and pleural thickness >3.95 mm.

Disclosure

This study has NOT been published elsewhere at the time of submission.

Conflict of interests

The authors declare no conflict of interests.

Acknowledgment

Special thanks to Prof. Dr. Mohamed Khairy, professor of Cardio-Thoracic Surgery department.

Many thanks to Prof. Dr. Yousry Shahin, head of Cardio-Thoracic Surgery department, Benha University, Egypt.

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