Uniportal video-assisted thoracoscopy is a safe approach in patients with empyema requiring surgery

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Introduction

Empyema is a well-known complication of pneumonia prolonging hospital stay and often requires chest tube drainage or surgical evacuation of the pleural fluid (1). It is divided into three stages. Stage I is the exudative stage. Stage II is the fibrinopurulent stage, where the pleural fluid is thick or purulent and fibrin deposits develop over the pleural surface. This leads to the development of a pleural peel and loculation of fluid. Stage III is the well-organized
and chronic phase with a thick peel of fibrin across the pleura (2). In stage I, chest tube drainage and treatment with systemic antibiotics is often sufficient to resolve the empyema. In this stage the lung is still compliant and can re-expand when the pleural fluid is evacuated. Surgical treatment is usually reserved for stage II and stage III, since the fibrin layer that is formed prevents the lung from re-expanding (3). Although no conclusive evidence is available of improved outcome regarding morbidity or mortality, the duration of chest drainage appears to be improved by surgical therapy in comparison to conservative treatment. Depending on the thickness of the pleural peel, decortication is required to free the trapped lung. Early surgical intervention can improve prognosis and shorten hospital stay (4). However non-surgical treatment of these ill patients is demanding, with high morbidity and mortality rates. Complication rates of surgical intervention vary around 20% and mortality rates as high as 13% have been reported (5,6). Video-assisted thoracoscopic surgery (VATS) is currently the preferred approach for stage II empyema and is as effective as the classic open transthoracic approach (7,8). Due to its less invasive nature, it has been suggested that VATS should be considered earlier in the treatment of empyema (9). Among the proposed benefits of a minimally invasive approach are reduced blood loss, decreased pain, shorter length of hospital stay and fewer complications (10,11). Complete VATS (cVATS) has evolved from the standard 3 to 4 surgical ports, towards uniportal VATS (uVATS) in which a thoracoscopic procedure can be performed via a single small incision. In 2004 uVATS was introduced for a pulmonary wedge resection. Subsequently more complex procedures were performed and the technique gained in popularity (12). uVATS lobectomy already has similar postoperative outcomes as the multiportal approach and may be advantageous in postoperative pain control, mobility, length of chest tube duration and length of hospital stay (13,14). In the current study we review our experience with uVATS treatment for empyema complicating pneumonia.

**Methods**

Data were retrospectively collected from the registry of our Thoracic Surgery Department. Approval was obtained from the local ethical committee. All cases of stage II and stage III empyema that were treated surgically between 2006 and 2019 were included. Patients with an uncomplicated parapneumonic effusion or stage I empyema, were treated conservatively and were excluded from analysis. Indication for surgery was deterioration of uncomplicated parapneumonic effusion into grade II or grade III empyema. This was based on either persistent pleural effusion despite chest tube drainage and antibiotic treatment, or signs of complicated effusion on CT or via transthoracic aspiration. Important CT findings included; signs of entrapped lung, atelectasis, loculated effusion, pleural thickening and persistent effusion despite chest tube drainage. Exclusion criteria were non-parapneumonic effusions, such as seen in Boerhaave syndrome or after a thoracic trauma, and empyemas treated with thoracotomy.

**Surgical technique**

There were no absolute contra-indications for cVATS or uVATS apart from general contra-indications for surgery. The preferential surgical approach for an empyema changed from cVATS in the period from 2006 to 2015 towards uVATS from 2016 and on, based on the experience of the surgical team. In all cases, the pleural cavity was thoroughly debrided and adhesions were removed in order to fully re-expand the lung. Indication for decortication (resection of the pleural peel) was a peroperative decision when trapped lung was found in the presence of a significant fibrous layer on the visceral pleura of one or more lobes.

**Data collection**

The following parameters were evaluated: (I) epidemiological data; age, sex, smoking habit, antibiotic treatment, chest tube and relevant co-morbidities such as diabetes mellitus, chronic obstructive pulmonary disease, cardiovascular diseases, malignancies and renal failure. (II) Postoperative characteristics; hospital stay, chest tube duration, any major postoperative complications including re-operations. (III) Peroperative characteristics including operating time, conversion rate to cVATS or thoracotomy and intra-operative complications. (IV) Laboratory results of the day prior to surgery, the first, third and fifth postoperative day.

**Statistical analysis**

Data were analysed using the statistical software package SPSS (version 25.0; SPSS Inc., Chicago, IL, USA). Descriptive statistical analysis is expressed as frequency, mean and standard deviation. Categorical variables were
compared with Chi-square-test. Continuous variables were compared with independent \( t \)-test. Values of \( P < 0.05 \) were considered significant.

**Results**

In the period studied, 186 patients were surgically treated for empyema. Of these patients, 137 were treated with cVATS and 49 were approached via uVATS. Baseline characteristics are depicted in \*Table 1\*. Except for a slightly reduced kidney function in the uVATS group (57.3±6.3 vs. 71.4±17.2 mL/min/1.73 m\(^2\), \( P \leq 0.001 \)), no significant differences were noted.

**Peroperative results**

The peroperative characteristics are listed in \*Table 2\*. The duration of uVATS was comparable to a cVATS procedure and number of peroperative complications was equal. In the uVATS group, no conversion towards cVATS or thoracotomy was performed. In the cVATS group a low number of procedures were converted towards a posterolateral thoracotomy. In the uVATS group, more decortications were performed. Furthermore, in the cVATS group two chest tubes were placed, while in the uVATS group usually only one chest tube was used.

**Postoperative results**

Patients had a mean hospital stay of between two and three weeks (\*Table 3\*, no difference between groups). Duration of chest tube drainage was also similar in both groups. Complications ranged from a local wound infection towards respiratory insufficiency and even severe sepsis. Numbers are small and were not statistically different between groups. In both groups, re-interventions because of persisting empyema were low and not significantly different. Postoperative laboratory results were more or less

<table>
<thead>
<tr>
<th>Table 1 Baseline characteristics</th>
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</thead>
<tbody>
<tr>
<td><strong>Baseline characteristics</strong></td>
</tr>
<tr>
<td>Age (years)</td>
</tr>
<tr>
<td>Sex (male)</td>
</tr>
<tr>
<td>Smoking</td>
</tr>
<tr>
<td>Antibiotics</td>
</tr>
<tr>
<td>Side (left)</td>
</tr>
<tr>
<td>Diabetes Mellitus</td>
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<tr>
<td>COPD</td>
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<tr>
<td>Asthma</td>
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<tr>
<td>Hypertension</td>
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<tr>
<td>Myocardial infarction</td>
</tr>
<tr>
<td>CVA/TIA</td>
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<tr>
<td>Malignancy</td>
</tr>
<tr>
<td>MDRD &gt;60 mL/min</td>
</tr>
<tr>
<td>MDRD 30–60 mL/min</td>
</tr>
<tr>
<td>MDRD &lt;30 mL/min</td>
</tr>
<tr>
<td>Hb (mmol/L)</td>
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<tr>
<td>Leucocytes (×10(^9)/L)</td>
</tr>
<tr>
<td>CRP (mg/L)</td>
</tr>
</tbody>
</table>

uVATS, unportal video assisted thoracoscopy; cVATS, complete video assisted thoracoscopy; COPD, chronic obstructive pulmonary disease; CVA/TIA, cerebrovascular accident/transient ischemic attack.
Table 2 Postoperative characteristics

<table>
<thead>
<tr>
<th>Peroperative data</th>
<th>uVATS (n=49)</th>
<th>cVATS (n=137)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion</td>
<td>0 (0%)</td>
<td>4 (3%)</td>
<td>0.396</td>
</tr>
<tr>
<td>Duration (min)</td>
<td>65.3±17.9</td>
<td>56.4±23.2</td>
<td>0.290</td>
</tr>
<tr>
<td>Complications</td>
<td>2 (4%)</td>
<td>12 (9%)</td>
<td>0.287</td>
</tr>
<tr>
<td>Decortication</td>
<td>22 (45%)</td>
<td>24 (18%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Drains</td>
<td>1.1±0.3</td>
<td>2.0±0.3</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

uVATS, uniportal video assisted thoracoscopy; cVATS, complete video assisted thoracoscopy.

Table 3 Post-operative characteristics

<table>
<thead>
<tr>
<th>Postoperative data</th>
<th>uVATS (n=49)</th>
<th>cVATS (n=137)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital stay (days)</td>
<td>18.9±12.8</td>
<td>20.1±14.7</td>
<td>0.618</td>
</tr>
<tr>
<td>Chest tube (days)</td>
<td>6.4±4.3</td>
<td>8.9±6.2</td>
<td>0.016</td>
</tr>
<tr>
<td>Complications</td>
<td>9 (18%)</td>
<td>14 (10%)</td>
<td>0.068</td>
</tr>
<tr>
<td>Death</td>
<td>4 (8%)</td>
<td>8 (6%)</td>
<td>0.530</td>
</tr>
<tr>
<td>Re-operation</td>
<td>2 (4%)</td>
<td>11 (8%)</td>
<td>0.368</td>
</tr>
</tbody>
</table>

uVATS, uniportal video assisted thoracoscopy; cVATS, complete video assisted thoracoscopy.

Table 4 Post-operative laboratory results

<table>
<thead>
<tr>
<th>Laboratory results</th>
<th>Day 1</th>
<th>Day 3</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>uVATS (n=49)</td>
<td>cVATS (n=137)</td>
<td>P value</td>
</tr>
<tr>
<td>Hb (mmol/L)</td>
<td>6.4±0.9</td>
<td>6.4±1.4</td>
<td>0.947</td>
</tr>
<tr>
<td>Leucocytes (×10^9/L)</td>
<td>17.7±8.8</td>
<td>15.2±5.6</td>
<td>0.053</td>
</tr>
<tr>
<td>CRP (mg/L)</td>
<td>226±94</td>
<td>189±90</td>
<td>0.045</td>
</tr>
</tbody>
</table>

uVATS, uniportal video assisted thoracoscopy; cVATS, complete video assisted thoracoscopy.

equal between the groups, with high inflammatory values directly postoperative and a steady decline towards day 5 postoperative (Table 4).

Death of any cause was slightly higher in the uVATS group although not significantly different (8%; n=4 vs. 6%; n=8). Median ASA score was 3 in both groups. There were two major causes of death in both groups, namely uncontrolled infection and cardiac related mortality. In the cVATS group five patients died of an ongoing infection, while two died because of a cardiac event. One patient died due to multi-organ failure. In the uVATS group two patients died of a cardiac event and one patient due to ongoing infection. One patient in the uVATS group was diagnosed postoperatively with stage IV lung carcinoma and wished no further treatment.

Discussion

The goal of treatment for pleural empyema is infection control, prevention of persistent or recurrent disease, and maintenance or restoration of pulmonary function. Incomplete drainage of the pleural space by chest tube in stage I empyema with signs of ongoing infection warrants surgical intervention. However, pre-operative staging of empyema can be difficult and this complicates timing of surgical procedures (15). Traditionally, these procedures mandated a thoracotomy. VATS added a minimally invasive alternative to the traditional approach. Early in the VATS
era a complex pleural space was considered a contra-
indication, but as experience grew, cVATS proved to be
as good as the classic approach and is adequate even in
the most inflamed pleural spaces (7,8,10,11). Despite the
advantages, the use of cVATS is still debated in literature.
A recent expert consensus of the European academy of
cardiothoracic surgery stated that cVATS should be the
primary approach, but that decortication can be technically
demanding and a high rate of conversion to thoracotomy
can be expected. Furthermore, they stated that in well-
organized empyema (symptoms >5 weeks) a primary
thoracotomy should be considered (16). In this current
study we show that cVATS is technically feasible with a
low complication rate of 10%. Only a small number of
patients required a re-operation, mainly due to persistent
empyema. These numbers are comparable to those found
in literature (7,17,18). In only four patients a conversion
to a thoracotomy was necessary due to technical reasons.
This shows that with the growing experience with cVATS
almost all empyema’s can be treated with a minimal invasive
approach.

In the quest for further minimization of surgical
trauma, uVATS is the latest evolution. By limiting surgical
trauma to only one intercostal space, it aims to reduce
postoperative pain and enhance recovery (13,14). Although
uVATS has been increasingly adapted for the management
of recurrent uncomplicated pleural effusions, preoperative
staging in lung cancer, treatment of primitive spontaneous
pneumothorax, palmar hyperhidrosis and even for complex
anatomic lung resections (19,20), surprisingly little is
published about its use in empyema. An early publication by
Song et al., reported that a uniportal approach in empyema
was difficult and resulted in a 50% conversion rate to
cVATS or thoracotomy (21). Subsequent studies showed
lower conversion rates of around 10% (22).

A recent retrospective study by Ismail et al. included 35
patients from two centres. Postoperative results were good,
with only minor complications in 17% of the patients (23).
Furthermore, there was no conversion towards multiportal
VATS or thoracotomy. Even though they removed the
thickened visceral pleura to ensure to fully expand the
lung. This data is comparable to our results, with no
conversion necessary and low postoperative complications.
The postoperative complication rate of 16% is comparable
to outcomes reported in patients with empyema treated
with the multiportal approach. Despite numbers are small,
peri-operative mortality was higher in the uVATS than in
the cVATS group (8%; n=4 vs. 6%; n=8). The difference
between groups can partially be explained by the one
abstained patient with a stage IV lung carcinoma in the
uVATS group. This death cannot be related to a surgical
technique or ongoing infection. Furthermore, in almost
half of the patients a decortication was performed to fully
expand the lung, without the need for reintervention,
showing that it is technically feasible to treat even the more
complex pleural cavities via a uniportal technique.

uVATS is a novel technique that requires additional skills
and training. Our experience is that the learning curve can
be steep for surgical teams that are already experienced in
cVATS. This current database represents the transition
a standard surgical technique in our hospital. This may
explain the slightly longer surgical time in the uVATS
group. After the learning curve, we expect that the duration
of uVATS will soon be comparable to cVATS.

In the cVATS group, at baseline, more patients had
pathologically proven malignancies. With that in mind,
the higher rate of decortication in the uVATS group is
peculiar. It might be explained by better registration of that
part of the procedure, or by a higher percentage of stage
III empyema in the uVATS group. Unfortunately, in this
retrospective database, peropartive judgement of the stages
of empyema was not well documented. It illustrates however
that decortication is feasible during a uniportal approach,
without the need for further re-interventions or conversion.

In the cVATS group two chest tubes were placed, while
in the uVATS group only one chest tube was used. The
application of one or more chest tubes after pulmonary
surgery appears highly various between practices (24).
A motive for placement of multiple chest tubes is the
assumption of more adequate drainage and the option
of draining the whole pleural cavity. However, when all
pockets are cleared surgically, one communicating space
remains for which one chest tube should in theory be
sufficient to abduct pleural fluid. The transition to the
placement of only one tube is the result of minimal invasive
character of the uVATS approach in which the chest tube is
placed via the single incision working port. From our data
it appears that insertion of only one chest tube has similar
good clinical outcomes as multiple tubes.

Postoperative hospital stay and chest tube drainage was
relatively long in relation to that found in literature (range,
7–16 days for hospital stay) (6). A possible explanation is
the wide variation in postoperative care for patients with
empyema between practices. In some hospitals, patients
stay on the surgical ward until they are fit enough to go
home, whereas in other hospitals rehabilitation is taken over by the pulmonology department at discharge from the surgical department. Due to this variation, the differences in hospital stay between publications from different centres should be interpreted with caution.

The possible drawback of minimal invasive surgery for empyema could be that less thorough evacuation of infectious fibrinopurulent discharge can be performed. Theoretically, this should result in more re-interventions. However, that is contradicted by our current data and data from others in literature (6, 7), demonstrating that surgical treatment for empyema with cVATS and even with uVATS is appropriate.

**Conclusions**

Uniportal VATS is a feasible technique in all patients with pleural empyema requiring surgery. Even if decortication in stage III empyema is required this can be performed by uniportal VATS, without the need for re-interventions. Larger series are required to define the place of uniportal VATS in the treatment of parapneumonic empyemas.

**Acknowledgments**

None.

**Footnote**

_Conflicts of Interest:_ The authors have no conflicts of interest to declare.

_Ethical Statement:_ The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. Approval was obtained from the local ethical committee, and informed consent was waived due to the retrospective nature of this study.

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