Early Video-assisted Thoracic Surgery in the Management of Empyema

Harsh Grewal, MD*; Richard J. Jackson, MD‡; Charles W. Wagner, MD‡; and Samuel D. Smith, MD‡

ABSTRACT. Objective. The appropriate timing, as well as the type of intervention, for the treatment of empyema in children is controversial. The advent of video-assisted thoracic surgery (VATS) has changed the way we treat these children. Therefore, we reviewed our experience with the early use of VATS in the treatment of empyema and formulated a treatment algorithm.

Methods. We retrospectively reviewed medical records of all patients undergoing VATS for empyema at Arkansas Children’s Hospital from December 1994 to February 1997. All patients were treated by the pediatric surgical service and had the diagnosis of empyema confirmed at surgery. Results are reported as means, unless otherwise noted.

Results. Twenty-five children with empyema were treated with VATS during the review period. Their age was 48.3 months, and the duration of symptoms was 7.4 days. All the patients had parapneumonic empyemas and had received preoperative antibiotics for 10.1 days. Preoperative imaging included chest radiography in 25 (100%), ultrasonography in 20 (80%), and computed tomography in 10 (40%). All patients with documented loculated parapneumonic fluid collections underwent VATS within a mean of 2 days of hospitalization. Chest tubes were removed in 3.2 days, resulting in a postoperative length of stay of 7.3 days. One patient required conversion to minithoracotomy and required a transfusion. There were no other complications or deaths. Follow-up was available for 22 (88%) children, and there was resolution of symptoms in all children with no recurrences.

Conclusions. Earlier intervention with VATS in the treatment of empyema in children is safe and may reduce hospital charges by shortening hospital stay. A treatment algorithm based on early use of VATS is also described.

METHODS

We reviewed retrospectively medical records of all patients undergoing VATS for empyema at Arkansas Children’s Hospital from December 1994 to February 1997. All patients were treated by the pediatric surgical service. The diagnosis of empyema was considered in all patients with parapneumonic effusions on chest radiography, ultrasonography, or computed tomography (CT). If thoracentesis was performed, a diagnosis was made if there was frank pus, positive Gram stain, or culture of pleural fluid. Additional diagnostic criteria were pleural fluid pH <7.0, pleural fluid glucose <40 mg/dL, and pleural fluid LDH >1000 IU/dL. All patients had the diagnosis of loculated empyema confirmed at surgery.

All patients had to have evidence of loculated fluid on a radiographic or sonographic imaging study before undergoing VATS. We preferred chest ultrasonography as the imaging modality of choice. It allows adequate imaging of the pleural space, shows the presence of loculated areas, and does not expose the child to radiation. If an imaging study revealed loculated pleural fluid, thoracentesis or chest tube placement was not required before surgery.

VATS was performed using general anesthesia; a single lumen endotracheal tube was used in the majority of patients, with selective bronchial intubation if possible. Arterial or central lines were not used routinely. The patient was positioned in the lateral decubitus position with the involved side up. Trocar placement was dictated by the location of the loculated empyema; usually one laparoscopic trocar (which allows carbon dioxide insufflation if the lung does not collapse) was used for the telescope, and this was placed in the 6th intercostal space in the mid- or posterior axillary line. A 5- or 10-mm 0° or 30° telescope was used. Before insufflation, pleural fluid or pus should be aspirated with a large bore suction aspirator. After pneumothorax is induced and the lung is collapsed, additional incisions in the intercostal space are made under thoroscopic visualization to allow placement of instruments directly into the thoracic cavity. These skin incisions should be placed so that they can be incorporated in a formal thoracotomy incision, if needed. A variety of curved and straight, ring, stone, and dressing forceps can be used. The pleural cavity is debrided of all fibrinous and purulent material. All treatment options exist. They include intravenous antibiotics with repeated thoracentesis, chest tube drainage, image-directed drainage, fibrinolytic therapy, video-assisted thoracic surgery (VATS), minithoracotomy, open drainage, and formal thoracotomy with decortication. The timing and type of surgical intervention are controversial as well. There are no randomized, controlled trials in children with empyema that resolve these questions.

The advent of minimally invasive VATS in adults has resulted in the adoption of these techniques by pediatric surgeons. We have utilized this technique increasingly in our practice. In addition, we have intervened earlier in the course of the disease. Therefore we reviewed our experience with VATS to evaluate its safety and efficacy in the treatment of empyema in children and formulated a treatment algorithm.

From the *Department of Surgery, University of Kansas School of Medicine–Wichita, Wichita, Kansas; and the ‡Department of Pediatric Surgery, Arkansas Children’s Hospital and University of Arkansas for Medical Sciences, Little Rock, Arkansas.

Received for publication Jul 6, 1998; accepted Dec 18, 1998.

Address correspondence to Harsh Grewal, MD, UKSM-W, Pediatric Surgery, Wichita Clinic, 3311 E Murdock, Wichita, KS 67208. E-mail: hrgrewal@worldnet.att.net

PEDIATRICS (ISSN 0031-4005). Copyright © 1999 by the American Academy of Pediatrics.
adhesions are lysed, and the lung is inspected. If the lung is enca
ced and does not expand, the lung must be decorticated. A plane is developed between the lung and the pleural peel using a sponge or peanut, and decortication is performed. If there is exces
tive bleeding and visualization is inadequate, VATS should be
converted to a formal thoracotomy. After irrigation and he-
mostasis, either one or two chest tubes are placed through the
trocar incisions.

For the majority of patients, postoperative recovery was on the
pediatric surgery ward. Chest tubes were removed when they
stopped draining or drainage was <50 mL/day, and chest radi-
graphy confirmed lung expansion. Intravenous antibiotics were
continued until the patient was afebrile (temperature ≤38.5°C).
Patients were discharged from the hospital when they were afe-
brile and had their chest tubes removed. Patients were discharged
on oral antibiotics (except one child with a lung abscess who
required home intravenous antibiotics for 21 days). Follow-up
took place 3 to 4 weeks postoperatively, and all patients had a
follow-up chest radiography.

Data collected included preoperative symptoms, antibiotics,
therapies, chest tube charges, and laboratory results. Additional-
ly, operative findings, cultures, pathology, and length of stay
were collected. Results are reported as means ± SD, unless noted otherwise.

RESULTS

Twenty-five children with empyema were treated
with VATS during the review period of 27 months. The mean age was 48.3 months (1 month to 14 years),
two were males and 12 females. The most common symptoms were fever (96%), cough (92%), and
respiratory distress (60%). The duration of symptoms was 7.4 ± 4.2 days before hospitalization. All
the patients had parapneumonic empyemas and had received antibiotics for 10.1 ± 7.5 days before sur-
gery.

Preoperative evaluation revealed a white blood cell
count of 17 ± 9.2 thousand/mm³. Thoracentesis was performed in 12 patients. Gram stain was positive in
3, and cultures grew Streptococcus pneumoniae in all 3. Pleural fluid white blood cell count was 3826 ±
4105/mm³. Mean pleural fluid pH was 7.8, LDH was
2769 IU/dL, and glucose was 35 mg/dL. Blood cul-
tures were positive in 4 of 13 patients (cultures grew
Streptococcus pneumoniae). The bacteriology results,
including one intraoperative culture, thus showed growth in cultures from only 8 patients (32%), all
which grew Streptococcus pneumoniae.

Preoperative imaging included chest radiography in
25 (100%); the most common findings were para-
pneumonic pleural effusion in 17 (68%), loculated fluid in 7 (28%), and complete opacification of the
hemithorax in 1 (4%). Ultrasonography was performed in 20 (80%) and was the most accurate in
imaging loculated pleural fluid, identifying locula-
tions or fibrinous septations in all 20 (100%). Ultra-
sonography was not as accurate as computed tomog-
raphy in imaging the underlying lung. Computed tomography was performed in 10 (40%) children. It
showed pleural fluid in all 10, but it did not show loculations in 5 (30%). However, it was more accu-
rate, compared with ultrasonography, in identifying an underlying lung abscess in 1 patient.

Preoperative chest tubes inserted in only 5 patients
before surgical consultation were present for 2 ± 1.6
days. Seven patients were admitted directly to the-intensive care unit for respiratory distress. All pa-
tients with documented loculated parapneumonic
fluid collections underwent VATS. The preoperative
LOS was 2.2 ± 2 days (median, 1 day). All patients
underwent VATS within 2 weeks of the onset of
symptoms.

The operative time was 80 ± 42 minutes. Three
patients (12%) had associated lung resection or bi-
opsy performed. One patient with a lung abscess had
an infection line placed. One patient (4%) had conver-
sion of VATS to thoracotomy secondary to inade-
quate visualization because of bleeding along the
chest wall; this also was the only patient who needed a
blood transfusion. Only one operative culture re-
sult was positive, and all specimens for which pa-
thology examination was performed were consistent
with inflammatory tissue, peel, or empyema. Two
patients (8%) required postoperative ventilation (for
<24 hours) and were admitted to the intensive care
unit for a mean of 1.8 days. Postoperative supple-
mental oxygen was required for 2.3 ± 2 days. Chest
tubes were removed in 3.2 ± 2.2 days, resulting in a
postoperative LOS of 4.9 ± 2.7 days (median, 5 days).

There were no postoperative complications, returns
the operating room, or deaths. All patients were
afebrile before discharge, and 24 (96%) were dis-
charged on oral antibiotics (usually clindamycin).
One patient with a lung abscess was discharged on
home intravenous antibiotics for 21 days. Total LOS
for the entire group was 7.3 ± 4 days (median, 7
days).

Follow-up data were available for 22 (88%) chil-
dren. Symptoms had resolved in all the children
followed. Chest radiography also showed marked
resolution of previous radiographic abnormalities. There were no recurrences and no hospitalizations
of discharged patients.

DISCUSSION

Childhood empyema usually is secondary to di-
rect spread of infection to a parapneumonic effu-
sion. Approximately 0.6% of pneumonias in chil-
dren are complicated by empyema, and the inci-
dence of parapneumonic empyema in children
ranges from 0.4 to 6 per 1000 admissions. The de-
finite of empyema is the presence of pus in the
pleural space, and various criterion exist to define
and classify parapneumonic pleural effusions and
empyema. Traditionally, empyemas have been di-
vided into three stages: 1) the exudative stage, char-
acterized by a thin, sterile, pleural exudate; 2) the
fibrinopurulent stage in which the fluid is now tur-
bid and loculated, with a fibrinous, pleural peel; and
3) the organizing stage, with a thick exudate and an
organized, pleural peel, encasing the lung and ren-
dering it immobile.

The microbiology of childhood empyema dictates
appropriate antibiotic selection. Haemophilus influen-
zae, Staphylococcus aureus, and Streptococcus pneumoniae remain the most common pathogens cultured in
empyema. In our patients, Streptococcus pneumoniae
was the only pathogen isolated. A majority of
our patients (68%) did not have any positive culture
results, and this may be explained by the fact that all
our patients had been receiving antibiotics before
obtaining cultures. In our patients, the most com-

2 of 5  EARLY VIDEO-ASSISTED THORACIC SURGERY IN THE MANAGEMENT OF EMPYEMA
Downloaded from by guest on May 29, 2017
monly chosen antibiotic for empirical treatment was clindamycin; this gave adequate coverage against the most common pathogens and addressed the problem of drug-resistant *Streptococcus pneumoniae* as well.

In addition to using antibiotics to sterilize the pleural cavity, the goal of treating empyema is to drain and obliterate the pleural space, thus allowing the lung to expand and function normally. The timing and method of attaining these goals is controversial. During the initial exudative stage, the fluid is thin and free-flowing, and its removal by thoracentesis or chest tube drainage may result in cure.5,8,11,13-15

However, most patients are managed initially with antibiotics by their primary care physicians and, in our experience, they have treated them for a mean of 10 days before presenting to us. Thus, by the time they are admitted to the hospital, the empyema usually has progressed to the loculated, fibrinopurulent, or organizing stage. It is therefore crucial to document the presence of free-flowing pleural fluid before embarking on pleural drainage. We recommend initial chest ultrasonography rather than CT to image the pleural cavity for the presence or absence of loculations. Park and associates have shown sonography to be superior to CT in evaluating the nature of pleural fluid in their study of 31 patients.16 Another recent study in children has shown that CT is not specific in diagnosing empyema.17 Although chest tube drainage may be successful in some patients in the fibrinopurulent or loculated stage, this usually results in prolonged hospital stay. Hoff and colleagues reported a mean hospital LOS of 20.7 days in patients treated with chest tube drainage.11 McLaughlin and co-workers treated 11 of 16 patients with chest tube drainage and had an average hospital LOS of 22.6 days.9 A recent report from Montreal Children’s Hospital showed an average hospital LOS of 27 days for children with acute empyema.13 If there are loculations on imaging, we proceed to VATS, as outlined in our treatment algorithm (Fig 1).

In an attempt to improve drainage of the pleural cavity and decrease treatment failures, especially once loculations have developed, intrapleural fibrinolytic agents (streptokinase and urokinase) have been used.18-21 In addition, percutaneous catheters for the instillation of fibrinolytics have been placed under CT or ultrasound guidance to obtain more complete drainage.16,21,22 Despite success in treating 50% to 90% of their patients nonoperatively, the mean hospital LOS in these studies has been ~21 days, with a failure rate of 10% to 50%.20,21

Another approach to hasten recovery is to perform open surgical drainage or decortication earlier in the course of the disease, usually within 3 to 5 days of hospitalization, in children not responding to conventional therapy.23-26 Although most patients improved with this approach, there was significant morbidity, including wound infections, persistent air leaks, recurrent empyema, and bleeding, resulting in postoperative hospital LOS of 9 days to 6 weeks.23-25 Some sur-

---

**Fig 1.** Treatment algorithm for the management of empyema in children.

---
geons have used a ministhoracotomy or muscle-sparing thoracotomy to minimize morbidity.27

Kern and Rodgers were among the first to report the use of thoracoscopy and VATS in the management of children with empyema.4 They treated 9 children and had 1 death, unrelated to the procedure; the survivors had a mean postoperative LOS of 13.4 ± 2.9 days and did not require any other intervention. In another study that reported 12 children who had VATS for parapneumonic empyema, there was no mortality and the postoperative LOS was 6 to 8 days, resulting in a total hospital LOS of 10 to 14 days.28 Silen and Weber reported success using VATS in 3 patients who were discharged by postoperative day 8.29 Davidoff et al successfully treated 7 of 9 children using VATS; they removed chest tubes in an average of 8.5 days.30 The data available from published results of VATS in pediatric empyema, including the present study are tabulated for comparison (Table 1).

Our experience with 25 patients reported here reflects the success of others using VATS for the treatment of pediatric empyema. We found that earlier intervention (median of 1 preoperative hospital day) resulted in a faster (mean, 80 minutes) and less morbid procedure (no air leaks requiring prolonged chest drainage). We removed chest tubes earlier (3.2 ± 2.2 days), as soon as drainage was <50 mL/d, than reported on other studies4,28–30 (4 to 8.5 days) without an increase in complications or recurrences. We were able to discharge our patients in a median of 5 days postoperatively, and our total LOS of 7.3 ± 4 days was significantly less than that reported in the literature.4,6,7,5,13,14,23–25,26–30

Because early intervention depends on an accurate assessment of the pleural space, we have implemented a treatment algorithm based on early imaging using chest ultrasonography (Fig 1). VATS is indicated if imaging shows the presence of loculated pleural fluid. The algorithm does not require preoperative thoracentesis or chest tube placement, unless the pleural fluid is free-flowing and without evidence of loculation. If thoracentesis is performed, the pleural fluid should be analyzed, and a chest tube should be inserted if there is frank pus or positive Gram stain or culture of pleural fluid, or pleural fluid pH <7.0, pleural fluid glucose <40 mg/dL, and pleural fluid LDH >1000 IU/dL. If there is no improvement in 48 hours with chest tube drainage, we recommend proceeding to VATS.

The implementation of this treatment algorithm, based on our experience using VATS, was 100% successful in curing the disease, resulted in a shorter postoperative stay than that reported in the literature, and was accomplished with minimal morbidity and no mortality (Table 1). Early intervention with VATS in the management of pediatric empyema is safe and is efficient in using health care resources. We recommend adoption of this treatment algorithm in the management of pediatric empyema.

**REFERENCES**


---

**TABLE 1.** Results of VATS in the Treatment of Pediatric Empyema

<table>
<thead>
<tr>
<th>Reference</th>
<th>Patients (n)</th>
<th>Preoperative Chest tube (days)</th>
<th>Postoperative Chest tube (days)</th>
<th>Postoperative LOS (days)</th>
<th>Total LOS (days)</th>
<th>Total LOS (n)</th>
<th>Recurrence, Failure or Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kern4</td>
<td>9</td>
<td>6.9 ± 1.8</td>
<td>8.4 ± 4</td>
<td>13.4 ± 2.9</td>
<td>NA*</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Stovroff28</td>
<td>12</td>
<td>4 ± 6</td>
<td>4</td>
<td>6 ± 8</td>
<td>NA</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Silen29</td>
<td>3</td>
<td>4 ± 1</td>
<td>7 ± 1</td>
<td>8 ± 1</td>
<td>NA</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Davidoff30</td>
<td>9</td>
<td>NA</td>
<td>8.5</td>
<td>NA</td>
<td>NA</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Present Series</td>
<td>25</td>
<td>2 ± 1.6</td>
<td>3.2 ± 2.2</td>
<td>4.9 ± 2.7</td>
<td>7.3 ± 4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* NA indicates data not available.
Early Video-assisted Thoracic Surgery in the Management of Empyema
Harsh Grewal, Richard J. Jackson, Charles W. Wagner and Samuel D. Smith
Pediatrics 1999;103:e63

Updated Information & Services
including high resolution figures, can be found at:
/content/103/5/e63.full.html

References
This article cites 28 articles, 3 of which can be accessed free at:
/content/103/5/e63.full.html#ref-list-1

Citations
This article has been cited by 11 HighWire-hosted articles:
/content/103/5/e63.full.html#related-urls

Subspecialty Collections
This article, along with others on similar topics, appears in the following collection(s):
Surgery
/cgi/collection/surgery_sub
Cardiology
/cgi/collection/cardiology_sub

Permissions & Licensing
Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at:
/site/misc/Permissions.xhtml

Reprints
Information about ordering reprints can be found online:
/site/misc/reprints.xhtml
Early Video-assisted Thoracic Surgery in the Management of Empyema
Harsh Grewal, Richard J. Jackson, Charles W. Wagner and Samuel D. Smith
*Pediatrics* 1999;103;e63

The online version of this article, along with updated information and services, is located on the World Wide Web at:
/content/103/5/e63.full.html