

Thoracotomy versus Video-Assisted Thoracoscopy in Pediatric Empyema

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Background: To compare the outcomes of video-assisted thoracoscopic surgery (VATS) in comparison to open thoracic surgery in pediatric patients suffering from empyema. **Methods:** A prospective study was carried out in 80 patients referred to the Department of Pediatric Surgery between 2015 and 2018. The patients were randomly divided into thoracotomy and VATS groups (groups I and II, respectively). Forty patients were in the thoracotomy group (16 males [40%], 24 females [60%]; average age, 5.77±4.08 years) and 40 patients were in the VATS group (18 males [45%], 22 females [55%]; average age, 6.27±3.67 years). There were no significant differences in age ($p=0.61$) or sex ($p=0.26$). Routine preliminary workups for all patients were ordered, and the patients were followed up for 90 days at regular intervals. **Results:** The average length of hospital stay (16.28±7.83 days vs. 15.83±9.44 days, $p=0.04$) and the duration of treatment needed for pain relief (10 days vs. 5 days, $p=0.004$) were longer in the thoracotomy group than in the VATS group. Thoracotomy patients had surgical wound infections in 27.3% of cases, whereas no cases of infection were reported in the VATS group ($p=0.04$). **Conclusion:** Our results indicate that VATS was not only less invasive than thoracotomy, but also showed promising results, such as an earlier discharge from the hospital and fewer postoperative complications.

Key words: 1. Empyema
2. Video-assisted thoracic surgery
3. Thoracotomy

Introduction

Pleural empyema is defined as purulent fluid accumulation in the pleural cavity. Common conditions associated with this disease include pneumonic processes in patients with pulmonary and malignant diseases, heart disease, diabetes mellitus, drug and alcohol abuse, neurological disorders, post-thoracotomy

problems, and immunological disorders [1].

The main contributing factors to empyema are severe pneumonia and parapneumonic effusions [2]. Mortality due to empyema is commonly associated with its severity. The incidence of empyema is 0.6%, but a mortality rate as high as 8% has also been reported [3].

In the 1960s, the American Thoracic Society (ATS)

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introduced 3 pathobiological stages of empyema. Treatment varies by stage. Stage 1, which is commonly referred to as the exudative stage, is associated with parapneumonic effusion in the first 24 to 72 hours of the disease process and can typically be treated by using simple drainage (including thoracentesis or placement of a chest tube) and administration of broad-spectrum intravenous antibiotics. The second stage, which is referred to as the fibrinopurulent phase, lasts 7 to 10 days and is characterized by the presence of fibrin and watery fluid containing a large number of polymorphonuclear cells [4]. The third stage, or the organized stage, typically occurs within 2 to 4 weeks after initial symptom onset [5,6]. This stage is characterized by thickening of visceral and parietal pleura as a result of significant fibroblast proliferation, resulting in the formation of a pus or peel that ultimately comes into contact with the visceral pleura, causing lung parenchymal entrapment [7]. Tube thoracotomy might not properly drain the pleural cavity in a child who has progressed to the advanced stage of the disease [2].

Pediatric surgeons have developed a thoracoscopic procedure to treat such patients. This less intrusive method allows complete discharge and washing of the debris from the pleural cavity [8]. Additional advantages of this method may include a lower postoperative complication rate and a shorter length of hospital stay [3].

The aim of this study was to evaluate the advantages and disadvantages of the video-assisted thoracoscopic surgery (VATS) approach compared to thoracotomy in pediatric patients with empyema.

Methods

1) Patients

Over 3 years (2015–2018), 80 pediatric empyema patients who were referred to the Department of Pediatric Surgery of Mofid Children's Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran were studied. The inclusion criteria were children with pleural empyema due to pneumonia, reaction to subphrenic abscesses, and the extension of mediastinal, retropharyngeal, or paravertebral infections, in whom the course of pleural empyema had lasted for fewer than 3 weeks. The exclusion criteria were children in whom pleural empyema had lasted for more

than 3 weeks, and those in whom pleural empyema had been caused by trauma. The children who met the inclusion criteria were enrolled in this prospective study after obtaining informed consent from their parents. The included patients were randomly divided into a thoracotomy group and a VATS group, each containing 40 patients. The thoracotomy group included 16 male patients (40%) and 24 female patients (60%), with an average age of 5.77 ± 4.08 years, and the VATS group included 18 male patients (45%) and 22 female patients (55%), with an average age of 6.27 ± 3.67 years. No significant differences between groups were found for age ($p=0.61$) or sex ($p=0.26$). The diagnosis of empyema was based on clinical symptoms (purulent cough, fever, chest pain, and respiratory distress), thoracentesis findings ($pH < 7$, glucose < 40 mg/dL, lactate dehydrogenase $> 1,000$ IU/L, and a white blood cell count above 10,000), and chest high-resolution computed tomography (HRCT) findings supporting the diagnosis of a loculated complex.

The preoperative preparations included intravenous antibiotic therapy, laboratory tests, and chest HRCT, which was performed to determine the status of the lung, mediastinum, and pleural loculations. In patients with respiratory distress and high fever, intercostal drainage (ICD) was also performed before the operation.

Intravenous antibiotics and antipyretics (e.g., paracetamol) were administered postoperatively, continuing until complete resolution of the fever. ICD was discontinued, and a chest X-ray exam was obtained by the second postoperative day, at which time regular chest physiotherapy sessions were initiated. The patients were followed up for 90 days at fixed intervals to evaluate the results of the treatment and the incidence of complications and death.

This study was approved by the ethics committee of Shahid Beheshti University of Medical Sciences, as an MD degree thesis project (thesis no., 326). Informed consents were obtained from the parents or legal guardians for children under 6 years of age. For patients above 6 years of age the informed consents were taken from both children themselves and their parents or legal guardians.

2) Surgical technique

All patients underwent general anesthesia using a

double-lumen endotracheal tube. In the thoracotomy group, patients were approached through a posterolateral thoracotomy by an incision in the fifth intercostal space. Then, the surgeon proceeded down to the parietal pleura, using a blade between the curved hemostats to open the parietal pleura and a Finochietto rib spreader (Sklar Instruments, West Chester, PA, USA) to gain clear access to the surgical field. Manual exploration was performed to destroy pleural septae and to eliminate all fissures. After complete decortication and full expansion of the lungs, a large-bore chest tube was inserted.

In the VATS group, with the patient in lateral decubitus position, the first trocar was inserted from the fifth intercostal space along the mid-clavicular line or from the entrance site of the previous chest tube. Two or three additional trocars were placed depending on the lung loculations. The gas pressure was adjusted to 5 mm Hg at a rate of 1 L/min. After dividing the adhesions with dissecting forceps and using high-pressure suction to remove fibrin clots from all tissues and recesses and ensuring complete lung opening, a large-bore chest tube was inserted through the site of the first input port under endoscopic vision. All patients in both groups were then sent to the pediatric intensive care unit (PICU) until their clinical condition stabilized.

Results

1) Preoperative findings

Among all patients, parapneumonic effusion was the main cause of empyema. There was no significant difference between the 2 groups regarding the cause of empyema ($p=0.40$).

The mean duration of clinical symptoms in patients in the thoracotomy group was 10.95 ± 5.13 days, whereas in the VATS group it was 11.08 ± 5.40 days ($p=0.20$). In the thoracotomy group, 22 patients (55%) had right lung involvement, 17 patients (42.5%) showed left lung involvement, and 1 patient (2.5%) had bilateral involvement. In the VATS group, 27 patients (67.5%) had right-side involvement, 12 patients (30%) had left-side involvement and only 1 patient (2.5%) had bilateral involvement. There was no significant difference between the 2 groups regarding the side of involvement ($p=0.50$).

The length of hospital stay prior to surgery was

3.55 ± 3.22 days for the thoracotomy group and 5.41 ± 2.78 days for the VATS group, with no significant difference between the 2 groups ($p=0.25$).

In the thoracotomy group, the pleural thickness was less than 1 cm in 24 patients (60%) and greater than 1 cm in 16 patients (40%). In the VATS group, 26 patients (65%) had a pleural thickness less than 1 cm, whereas 14 cases (35%) had a pleural thickness more than 1 cm. The groups did not show a significant difference in terms of pleural thickness ($p=0.81$). On preoperative chest computed tomography scans, multiple loculations were found in 13 patients (32.5%) in the thoracotomy group and in 9 patients (22.5%) in the VATS group, which was likewise a non-significant difference ($p=0.45$). Table 1 additionally presents the other preoperative factors in both groups.

2) Postoperative findings

Patients in the thoracotomy group stayed at the hospital for 16.28 ± 7.83 days postoperatively, while patients in the VATS group were hospitalized for 15.83 ± 9.44 days. The duration of postoperative hospitalization was significantly shorter in the VATS group ($p=0.04$).

In the course of follow-up, 11 patients (27.5%) who underwent thoracotomy had a surgical wound infection, while 4 cases were reported in the VATS group ($p=0.04$). Redo surgery, especially in multiloculated cases, was performed due to a lack of clinical improvement in 5 thoracotomy patients (12.5%) and in 9 VATS patients (37.5%). There was no significant difference between the groups in this regard ($p=0.18$). Immediate pneumothorax followed by removal of the ICD device was reported in 4 patients (10%) and 1 patient (2.5%) in the thoracotomy and VATS groups, respectively. Pneumothorax was managed by reinsertion of the ICD device.

Subcutaneous emphysema only occurred in 2 patients in the thoracotomy group and in 1 patient in the VATS group, with no significant difference ($p=0.57$). The duration of PICU admission was 5.81 ± 3.42 days for the thoracotomy group and 2.62 ± 3.19 days for the VATS group ($p=0.005$). Analgesics (e.g., non-steroidal anti-inflammatory drugs and acetaminophen) were administered for 10.67 ± 4.54 and 5.31 ± 3.90 days in the thoracotomy and VATS groups, respectively ($p=0.004$). Intraoperative bleeding that

Table 1. Preoperative findings in the thoracotomy and VATS groups

Characteristic	Thoracotomy	VATS	p-value
Stage of empyema			0.41
Stage 2	17	19	
Stage 3	23	21	
pH			0.66
<7	31	29	
>7	9	11	
WBC	11.600±5.700	11.300±6.100	0.51
LDH (IU/L)			0.66
>1,000	32	30	
<1,000	8	10	
Glucose (mg/dL)			0.38
<40	34	36	
>40	8	4	
Respiratory distress			0.31
Yes	25	28	
No	15	12	
Malaise			0.50
Yes	22	23	
No	18	17	
Persistent fever			0.50
Yes	36	35	
No	4	5	
Diminished breath sounds			0.12
Yes	13	19	
No	27	21	
Multiple loculations on chest computed tomography			0.22
Yes	13	9	
No	27	31	
Pleural thickness (cm)			0.40
<1	24	26	
>1	16	14	
Pleuritic chest pain			0.29
Yes	7	10	
No	33	30	

Values are presented as number (%) or mean±standard deviation. pH, WBC, LDH, and glucose levels were obtained from thoracentesis. VATS, video-assisted thoracoscopic surgery; WBC, white blood cells; LDH, lactate dehydrogenase.

necessitated blood transfusion was only reported in 7 patients in the thoracotomy group (p=0.006). Mortality due to respiratory failure during the first 30 days after surgery occurred in a single case in the thoracotomy group (Table 2).

Table 2. Postoperative findings in the thoracotomy and VATS groups

Variable	Thoracotomy	VATS	p-value
Hospital stay (day)	16.28±7.83	15.83±9.44	0.04
Surgical wound infection	11	4	0.04
Redo surgery	5	9	0.18
Pediatric intensive care unit admission duration (day)	5.81±3.42	2.62±3.19	0.005
Analgesics consumption duration (day)	10.67±4.54	5.31±3.90	0.004
Transfusion in operating room.	7	0	0.006
Subcutaneous emphysema	2	1	0.57
Death	1	0	0.50

Values are presented as mean±standard deviation or number of cases.

VATS, video-assisted thoracoscopic surgery.

Discussion

Pleural empyema is defined as purulent fluid accumulation in the pleural cavity. Its main causes include severe pneumonia and parapneumonic effusion. Other predisposing conditions include the spread of an infection through the mediastinal, retropharyngeal, or paravertebral spaces. Furthermore, direct chest trauma has been proposed as a possible cause of empyema [1].

Mortality due to empyema is commonly associated with its severity, and has been reported to range from less than 1% to more than 40% in immunosuppressed patients [9]. In the 1960s, the ATS introduced 3 pathobiological stages of empyema: the exudative phase, the fibrinopurulent phase, and the organized stage [10,11].

The main difference between the first and second stages is that the fluid is often compartmentalized due to multiple septations in stage 2; additionally, the fluid is relatively acidic compared to the exudative phase. The third stage typically occurs within 2 to 4 weeks after the onset of the initial process [5]. The organized stage is characterized by thickening of visceral and parietal pleura as a result of significant fibroblast proliferation, leading to the formation of a peel or organized pus, which ultimately comes into contact with the visceral pleura, causing lung paren-

chymal entrapment [1,7].

1) Video-assisted thoracoscopic surgery

VATS is a semi-invasive technique that provides a wide-range view for the surgeon, in contrast to classical thoracotomy, as a way to examine and treat pathologic processes of the mediastinum, lungs, and pleura with fewer complications [12,13].

VATS might be indicated for the treatment of the second stage of empyema, as it tends to be more effective than conservative treatments with antibiotics and drainage, while having fewer complications than more invasive treatments such as thoracotomy [7]. The first comparative studies between VATS and thoracotomy were conducted in the 1990s, when Angelillo Mackinlay et al. [14] examined VATS and thoracotomy in patients with empyema in the fibrinopurulent phase after pneumonia, concluding that the 2 treatments had the same success rate. However, VATS had some advantages in terms of limiting the disease progression, minimizing the hospitalization duration, and yielding more favorable cosmetic outcomes [14].

In the present study, the wound infection rate was significantly higher in the thoracotomy group than in the VATS group ($p=0.04$), and complications such as pneumothorax after discontinuing the ICD were likewise more common in the thoracotomy group.

Minchev et al. [15] reviewed 359 empyema patients who had undergone thoracotomy and VATS between 1996 and 2003. In their study, VATS was associated with a shorter duration of chest tube drainage and a shorter duration of hospitalization compared to thoracotomy [15]. In the present study, the hospital stay was shorter in the VATS group than in the thoracotomy group ($p=0.04$).

In a retrospective study by Goldschlager et al. [16] among children who underwent drainage and decortication using thoracoscopy and thoracotomy between 2000 and 2002, it was shown that drainage by thoracoscopy was effective for the treatment of empyema in pediatric patients.

In another study by Stefani et al. [17] in 2013, the preoperative conditions for choosing between VATS and thoracotomy were reviewed, and it was concluded that delays in surgery, fever, and pleural thickness might be utilized as predictive factors of a subsequent thoracotomy procedure.

In our study, the VATS group showed a higher rate of re-operation due to lack of improvement of clinical symptoms caused by thickening of the pleural membranes and incomplete lung expansion; however, this trend was not significant.

Another study by Shojaee and Lee [3] that compared medical and surgical treatments for the treatment of pleural diseases presented thoracoscopy as a more effective method than thoracotomy, especially in intubated patients, in whom a reduced time of operation and lower likelihood of other complications improve the survival rate. In the present study, the mortality rate following surgical complications was higher in the thoracotomy group. The fact that only one death occurred limits our results regarding mortality as an outcome.

The duration of the hospital stay, PICU stay, and analgesic administration were longer in the thoracotomy group, and the infection rate was higher; thus, VATS appears to be safer and more efficient than thoracotomy for the treatment of patients with empyema.

2) Conclusion

Based on a comparison of the advantages and disadvantages of thoracotomy and VATS for the treatment of empyema, it seems that the less invasive VATS technique is suitable for the management of pediatric patients with empyema, since it was associated with a shorter hospital stay, a lower rate of postoperative complications, and less bleeding during the operation. However, especially in multiloculated cases, it was more often necessary to perform a second operation in the VATS group, although this trend was not significant. Our findings could be valuable for thoracic surgeons and for pediatric surgeons interested in minimally invasive thoracic surgery.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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Author contributions

Clinical appraisal of executive steps including primary physical examination and the meticulous surgical procedure was done by Mohajerzadeh L. Patients were evaluated medically by Farahbakhsh N at the beginning of the study. Further executive process including documentation and administrative tasks, also the report design and manuscript writing were managed by Lotfollahzadeh S, and Atqiaee K. Primary statistical calculations were done by Harirforoosh I. After revision, collecting further data, performing new analysis and revising manuscript was carried out by Parsay S, Amirifar H, and Vosoughi A.

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