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Pleural empyema management: The impact of Video-assisted thoracoscopic surgery

Baris Hekimoglu[1], Muhammet Ali Beyoglu[2]

[1]Ordu University, Faculty of Medicine, Department of Thoracic Surgery, Ordu, Türkiye
[2]University of Health Sciences, Department of Thoracic Surgery, Ankara City Hospital, Ankara, Türkiye

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Abstract

In recent years, Video-assisted Thoracoscopic Surgery (VATS) has caused many changes in thoracic surgery practice. This study aimed to analyze the results of early VATS surgery in patients with empyema. Thirty-two cases of empyema who underwent VATS drainage, debridement, pleural pouch jointing, and partial decortication between November 2018 and June 2022 were included in the study retrospectively. The cases were examined for demographic information, the duration of symptoms, the stages of empyema, treatment outcomes, and complications. Twenty-three (79.9%) cases were male, 9 (28.1%) were female, and the mean age was 46.4±19.9. Preoperative symptom duration was 2.68±1.46 weeks. 28 (87.5%) cases were in stage 2 and 4 (12.5%) cases were in stage 3 empyema. A single incision VATS was performed in 23 (71.9%) cases, and double incision VATS was performed in 9 (28.1%) cases. Postoperative hospital stay was 12.1±3.3 days. Acceptable symptomatic and radiological improvement was observed in 28 (87.5%) cases after VATS. Pleural decortication with thoracotomy was used in four (12.5%) cases of stage 3 empyema. In cases of stage 2 empyema, which occurs within the first four weeks of the onset of symptoms, the VATS procedure with drainage, debridement, pouch jointing, and partial decortication provides curative results. We recommend evaluating VATS as the first-line therapy in treating early-stage empyema.

Keywords: Early stage, empyema, video-assisted thoracoscopic surgery

Introduction

The terms pleural empyema, thoracic empyema, and empyema are often used interchangeably. Empyema is the presence of pus in the thoracic cavity, and the most common cause is parapneumonic effusions. Approximately one-tenth of such pleural effusions require drainage. If fibrin deposits and empyema accumulated in the effusion are not drained, they cause septation and pouches [1,2]. This causes prolonged hospitalization, morbidity, and mortality [3].

Pleural empyema formation occurs in 3 stages. Stage 1 (acute-exudative phase) is the serous phase with a few debris; stage 2 (fibrinopurulent phase) is characterized by dense pus and fibrin deposition, pleural peels, and loculations occur. Stage 3 (organization phase) is when a thick fibrin peel and scar develops, and the movement of the lung, diaphragm, and thorax is restricted [4]. Stage 2 empyema occurs within 1 to 3 weeks from the onset of symptoms, and stage 3 empyema occurs after 3-4 weeks due to inappropriate treatment [2,5].

The classical management of empyema starts with antibiotic therapy and drainage with tube thoracostomy and extends to decortication with thoracotomy in the case of stage 3 empyema. Current research on pleural empyema is scarce in the literature. This shortage may be due to the frequent use of traditional treatment approaches in empyema patients. In recent years, fibrinolytic treatment and early Video-assisted Thoracoscopic Surgery (VATS) procedures have come to the fore [1,6,7]. Parallel to the significant impact of VATS in thoracic surgery practice, it is expected result that its use in the treatment of empyema will increase [8]. Management of pleural empyema with VATS may be a more comfortable option for both the surgeon and the patient. VATS procedure provides the surgeon with a less invasive operation than thoracotomy while providing a more comfortable postoperative process for the patient.

This study aimed to demonstrate the efficacy of VATS drainage in patients with stage 2 and 3 empyema, combining the pouches to form a single cavity, namely deloculation and fibrin cleaning, debridement treatment, and partial decortication surgery procedure.

***Corresponding Author:** Baris Hekimoglu, Ordu University, Faculty of Medicine, Department of Thoracic Surgery, Ordu, Türkiye
E-mail: drbarishekimoglu@yahoo.com

Materials and Methods

This study was designed as a retrospective and observational study. The approval of the local ethics committee was obtained (Approval number: 2022/143). The authors confirmed compliance with the World Medical Association Declaration of Helsinki on the ethical conduct of research involving human subjects.

Thirty-two cases of empyema who underwent VATS drainage, debridement, pouch jointing, and partial decortication between November 2018 and June 2022 were included in the study retrospectively. All of the cases consisted of empyema developing in the parapneumonic process. Three cases with extrathoracic organ malignancy were included in the study because the empyema developed after pneumonia following chemotherapy. In addition, two trauma patients who developed empyema in the parapneumonic process were included in the study. Empyema cases other than parapneumonic process (empyema developing based on primary lung malignancy, empyema due to metastatic lung diseases, empyema due to direct contaminated instrument injury or postoperative thoracic surgery-cardio surgery, etc.), stage 1 empyema (phase in which antibiotic therapy alone is sufficient), patients under 18, patients who underwent decortication with only tube thoracostomy (drainage-fibrinolytic therapy) or direct thoracotomy were excluded from the study.

Stage 2 and 3 empyemas were included in the study according to The American Association for Thoracic Surgery (AATS) consensus guideline 2017 classification. According to this classification, in the stage 2 phase (fibrinopurulent), the parietal pleura begins to be covered with fibrin, and loculations occur (Figure-1). There are criteria for pH<7.20, glucose<40mg/dL, and Lactate Dehydrogenase Level (LDH) >1000 U/L in pleural effusion sample. There may be bacterial growth in the pleural effusion. In stage 3 (organizational) empyema, there are fibrous thickenings, intrapleural loculations, and pus [2,9]. The pleural peel (sclerotic cover) prevents lung and diaphragm movements, and the hemithorax begins to narrow [2,9]. The data of the cases were obtained from electronic documents. Age, gender, date of onset of symptoms, accompanying diseases, presence of etiological factors causing empyema, antibiotic use before admission, LDH, acidity (pH), glucose level, bacterial growth, and tuberculosis culture of pleural fluid samples and sputum AFP (acid-fast bacillus) test, stage of empyema (according to AATS classification), number of ports in which VATS procedure was applied, results of thoracotomy and decortication operation performed in VATS procedure success and failure, postoperative complication development, after VATS procedure length of hospital stay (LOS) and recovery at the first month postoperatively for every case were noted. While evaluating the recovery status of the patients, the presence of symptoms and changes in the chest X-ray was taken into account in the first-month control.

The patients were staged with chest X-ray, thorax computed tomography (CT), and pH, glucose, and LDH values of the pleural fluid samples obtained in thoracentesis. The criteria for pH<7.20, glucose<40mg/dL, and LDH>1000 U/L were met in the pleural fluids of all stage 2 and 3 cases included in the study. The date of symptom onset was also taken into account, but the differentiation of stages 2 and 3 could not be made clearly in all cases. Due to the development mechanism of empyema, it was thought that it would be the right approach to classify the cases with stage 2 and stage 3 empyema features as stage 3, with symptoms lasting four weeks or more, and the cases were staged accordingly.

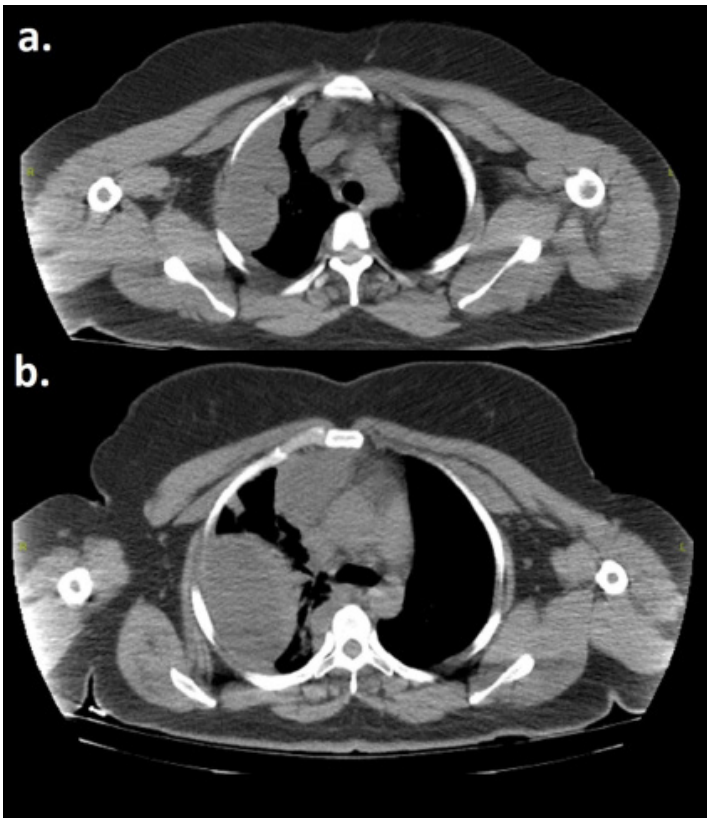

Figure 1. (a, b) Chest computed tomography reveals dense multiloculated pleural effusion in the right hemithorax

Thoracentesis and pleural fluid sampling were performed in all cases treated with stage 2 and 3 empyema diagnoses. Depending on the pleural pouch condition, 1 or 2 tube thoracostomy and an underwater drainage system were applied. Silicone chest tubes or pezzer drains with a diameter of at least 28 french (F) were applied. Pleural fluid parameters and microbiological examinations were studied on the first samples. All but one of the cases had come to us with oral or intravenous empirical antibiotic therapy before admission. In the follow-up, the culture results of the cases with bacterial growth in the pleural fluid samples were continued with specific antibiotic therapy. Intravenous empirical antibiotics were continued with the same regimen for patients with no growth in the pleural fluid culture. Preoperative hemogram, biochemistry and coagulation parameters, chest X-ray, and thorax CT scans were performed on the patients.

All operations were performed under general anesthesia and in the lateral decubitus position with video thoracoscopy. Selective lung ventilation was preferred primarily. However, in patients who failed to place the double-lumen intubation tube or did not tolerate single-lung ventilation, the operation was started after single-lumen intubation. While VATS was performed through the same incisions with a double port in cases of two-tube thoracostomy, uniportal VATS was performed through the same incision in cases of a single tube thoracostomy (Figure-2a). Loculating bands were removed with blunt and sharp dissections with the help of conventional thoracotomy instruments and hand tools specially produced for VATS and using energy devices (Figure-2b and c).

While eliminating pleural adhesions and loculations and turning them into a single cavity, fibrin fragments, debris, and dense pus were cleaned of the thorax (Figure-2d). The thorax was cleaned with physiological saline washing. The top of the diaphragm and the phrenic recesses were freed from fibrin and bands as much as possible. To the greatest extent possible, the thickened parietal pleura was peeled away. Round atelectasis areas in the lung parenchyma were tried to be peeled off, trying to avoid parenchymal damage. After these procedures, the hemithorax was irrigated with saline and heated to 38-40 Celsius (C). In this way, debris and fibrin removal was completed, and detailed bleeding control was performed. Obvious air leaks in parenchyma areas where peeling was applied were repaired with 2-0 multifilament absorbable sutures. No additional application was made except for applying a hot sponge (heated to 80^0C) to the leak areas caused by minimal visceral pleural peeling. It was monitored whether the lung filled the thoracic cavity after ventilation.

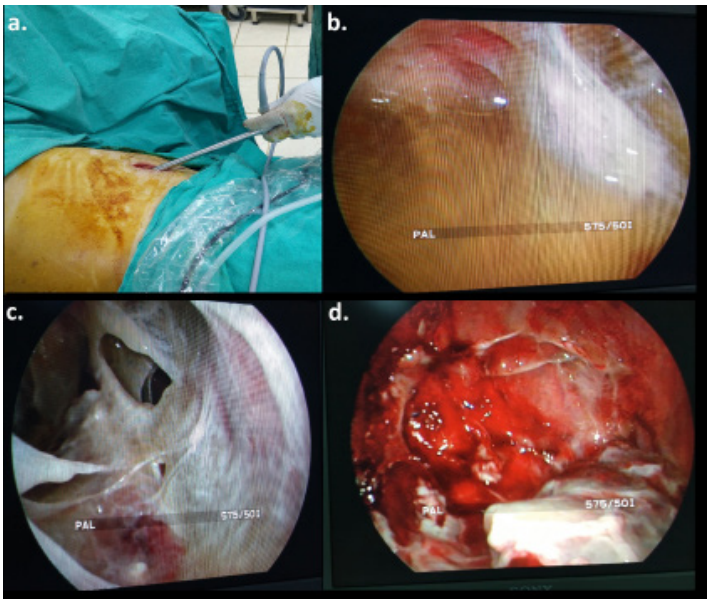

Figure-2. Figures of patients who underwent Video-assisted thoracoscopic surgery (VATS) for empyema. (a) Application of uniportal VATS technique, (b,c) appearance of pus and multiloculations in the thoracic cavity with VATS, (d) Thoracic view after drainage, debridement and loculation removal with VATS

In case of full or minimal space expansion, the operation was completed and extubated with 28-32 F tube drainage systems at the port sites. The cases were transferred to the postoperative inpatient service. Effective analgesic treatment was applied to the cases, and they were encouraged for effective breathing exercises. No additional pleural washing was performed in patients with postoperative serous drainage, and saline (500 cc) irrigation was performed in patients with serous-purulent drainage until serous drainage was achieved. Tube thoracostomies of the patients whose drainage was serous and decreased below 100 cc/day were terminated. Antibiotherapy periods were completed by intravenous administration for 14 days, including the preoperative period. In the home follow-ups, treatment was continued with oral antibiotherapy for 14-28 days compared to serum inflammatory marker follow-up (leukocytosis, C-reactive protein, and procalcitonin). Outpatient controls were performed on the 10^{th} day and 1^{st} month postoperatively. Asymptomatic cases with full expansion, moderate blunting of costo-phrenic or cardio-phrenic sinuses, and local thickening of the lateral pleura on chest radiographs at the first-month follow-up were accepted as successful results (Figure-3a). In the 1st month of follow-ups, the cases that still did not have lung expansion had trapped lungs, and repeated loculations were accepted as unsuccessful results and were admitted to the ward for a thoracotomy and decortication operation (Figure-3b).

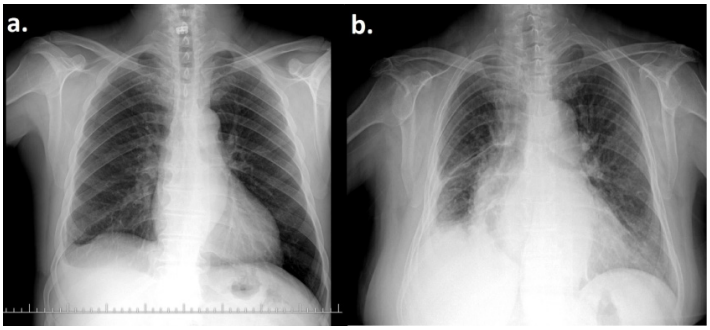

Figure-3. (a) The first-month follow-up chest X-ray reveals right sinus bluntness with mild costal pleural thickening of the right hemithorax, (b) Another patient's first-month follow-up chest X-ray observed excessive thickening of the right costal pleura, narrowing of the intercostal spaces, and effacement of the diaphragmatic borders. In this patient, video thoracoscopic surgery was considered unsuccessful, and total pleural decortication with thoracotomy was performed

Statistical Analysis

Statistical analysis was performed using the "IBM SPSS Statistics for Windows Version 22.0 (Statistical Package for the Social Sciences, IBM Corp., Armonk, NY, USA)" program. Descriptive statistics of the study were presented with frequency and percentage for categorical variables and mean and standard deviations for numerical variables.

Results

Of the cases, 23 (79.9%) were male, and 9 (28.1%) were female. The mean age was 46.4±19.9 years. The most common comorbidities accompanying empyema cases were 9 (28.1%) diabetes mellitus cases, 5 (15.6%) obesity cases, and 3 (9.3%) extrapulmonary malignancies. In addition, alcohol addiction was accompanied in 5 (15.6%) cases, mental retardation in 4 (12.5%) cases, and Down Syndrome in 2 (6.2%) cases as an additional disease. The most common etiological factor in 27 cases (84.3%) was parapneumonic empyema. Other demographic data about the patients are given in Table-1.

The mean duration of symptom onset before admission was 2.68±1.46 weeks. Thirty-one (96.8%) cases had received broad-spectrum empirical antibiotic therapy orally or intravenously before admission or referral for thoracic surgery. (Table-2)

In pleural fluid samples, mean pH 7.08±0.1, glucose 24.12±11.3 mg/dL, and LDH 1127.8±139.0 U/I were determined. These data met the criteria for stage 2 and 3 empyema. In the bacteriological culture examinations of pleural fluid samples, there was no growth in the pleural fluid in 24 (75%) cases, Streptococcus Pneumoniae in 4 (12.5%) cases, Methicillin-resistant Staphylococcus Aureus in 2 cases (6.2%), and Klebsiella Pneumoniae and Staphylococcus Aureus in 1 case each. There was no positive finding for tuberculosis in the culture and sputum AFB test of any patient for tuberculosis. According to the AATS empyema staging system, 28 (87.5%) cases were classified as stage 2 and 4 (12.5%) cases as stage 3 empyema. While 23 (71.9%) of 32 cases were uniportal, 9

(28.1%) were performed with two port attempts. After one month of post-discharge follow-up, a total decortication operation with complementary thoracotomy was performed because radiological and symptomatic improvement could not be achieved in four (12.5%) cases, all of whom were operated on at stage 3 empyema. (Table-2)

Table 1. Baseline patient characteristics

Baseline characteristic	mean	SD
	n	%
Gender		
Female	9	28.1
Male	23	79.9
Age	**46.4**	**19.9**
Co-morbidities		
Diabetes mellitus	9	28.1
Obesity (BMI>30)	5	15.6
Malignity	3	9.3
ASHD	2	6.2
Hypertension	2	6.2
COPD	2	6.2
Asthma	**1**	**3.1**
Arrhythmia	1	3.1
Mental retardation	4	12.5
Down syndrome	2	6.2
Alcohol abuse	5	15.6
Etiology		
Parapneumonic empyema	27	84.3
Following chemotherapy	3	9.3
Complicated post-traumatic atelectasis	2	6.2

BMI: Body mass index, ASHD: Atherosclerotic hearth disease, COPD: Chronic Obstructive Pulmonary Disease

Postoperative complications were persistent chest pain in 7 (21.9%) cases and infection at the incision site in 4 (12.5%) cases. These complications were resolved in the patients' first month of postoperative follow-up. No mortality was observed in any case. The mean postoperative LOS was 12.1±3.3 days. (Table-3) Pathology evaluation results in all cases were reported in accordance with benign infectious processes.

When the patients' chest X-rays were evaluated in the first month after discharge, it was discovered that 16 (50%) had normal X-ray features, 7 (21.9%) had blunt costo and cardio-phrenic sinus, 5 (15.6%) had costal pleural thickness, and 4 (12.5%) had trapped lung. Findings other than the trapped lung appearance were evaluated as successful, and it was determined that none of these patients had symptoms and the empyema pouch appearance did not recur. All 4 cases with trapped lung appearance after discharge were undergone VATS operation due to stage 3 empyema. VATS operation was considered unsuccessful in these cases, and total pleural decortication was performed with lateral muscle-sparing thoracotomy. A normal appearance in the chest X-ray was obtained in two cases during the first month of control of thoracotomy and decortication operations. The other 2 cases had a blunt costo and cardio-phrenic sinus appearance.

Table 2. Data table showing the duration of symptoms, the rate of taking antibiotics before admission, pleural fluid characteristics and bacteriological data, distribution according to empyema stages, and surgical method rates.

Variable	mean	SD
	n	%
Symptom duration (weeks)	2.68	1.46
Antibiotic usage before empyema detection	31	96.8
Pleural fluid		
pH	7.08	0.1
LDH (U/l)	1127.8	139.0
Glucose (mg/dL)	24.12	11.3
Bacteriology		
Streptococcus Pneumoniae	4	12.5
MRSA	2	6.2
Klebsiella Pneumoniae	1	3.1
Staphylococcus Aureus	1	3.1
Not detected	24	75
Empyema Grade		
Grade 2	28	87.5
Grade 3	4	12.5
Surgical treatment		
VATS	32	100
Single port	23	71.9
Two ports	9	28.1
Subsequent thoracotomy	4	12.5

LDH: Lactate Dehydrogenase Level, MRSA: methicillin resistance staphylococcus aureus, VATS: Video-assisted thoracoscopic surgery

Table 3. Postoperative hospital stay, complications and 1-month follow-up X-ray results

Variable	mean	SD
	N	%
Length of hospital stay (after surgery)	12.1	3.3
Post-operative complication		
Wound infection	4	12.5
Chest pain	7	21.9
Follow-up chest graphy (First month)		
Normal	16	50.0
Blunt costo-cardiophrenic sinuses	7	21.9
Costal pleural thickness	5	15.6
Trapped lung	4	12.5

Discussion

The goal in the treatment of pleural empyema is to diagnose empyema at the earliest possible stage and to provide full expansion of the lung without leaving a pouch in the thoracic cavity by using the most appropriate method before it reaches the fibrothorax stage [9]. When loculated pleural effusions occur, surgical interventions should be used aggressively to ensure lung expansion [9,10]. It has been demonstrated that lung expansion can be achieved successfully and with a less invasive surgery compared to thoracotomy, with rapid decision-making and early VATS application, primarily in stage 2 empyema when lung expansion cannot be achieved after tube thoracostomy [9-13]. In addition, studies are reporting that thoracoscopic debridement reduces morbidity by providing early

recovery in the treatment of advanced empyema [14]. Moreover, using VATS in stage 2 empyema may result in shorter drainage, hospital stay, and morbidity than tube thoracostomy alone and fibrinolytic therapy with tube thoracostomy [9,12]. Studies have reported a failure rate of 36-65% with tube thoracostomy alone [12,15,16]. The most important result of our study; In stage 2 empyema, it was determined that the surgical results were successful with the VATS procedure in the early period, and it provided a cure by preventing the progression of stage 2 empyema to stage 3 empyema in all cases.

Contrary to the success of VATS in stage 2 empyema, studies show that treatment success in stage 3 empyema is low [9,17]. On the contrary, publications show a high success rate of 68-93% in stage 3 empyema [9,18]. The AATS guideline states that these different data are due to surgical experience in centers performing decortication with VATS and the low number of patients with clear stage 2 or clear stage 3 empyema [9]. Stages 2 and 3 are difficult to differentiate, and absolute markers can develop differently within the same hemithorax. In our study, stage 3 patients consisted of patients whose symptom duration exceeded four weeks and formed fibrothorax, and the VATS method could not be successful in these patients. The reason for this can be explained by the lack of experience of the practicing surgeon. In addition, we believe that the differentiation of precise stage 3 patients may also lead to low success, similar to the literature.

Another critical factor affecting the success of empyema treatment is the time from the onset of symptoms to the initiation of treatment in the thoracic surgery clinic. Many studies mention the high success of VATS in stage 2 empyemas with a symptom onset time of fewer than four weeks [2,10-12,16,17]. In our study, the VATS procedure was unsuccessful in stage 3 empyema cases with symptoms lasting more than four weeks. These patients have undergone pleural decortication with thoracotomy after the first month of follow-up.

Several studies have been conducted on fibrinolytic therapy used to treat pleural empyema via tube thoracostomy. Although the first studies showed that intrapleural fibrinolytic therapy was effective, it was reported that the success of fibrinolytic therapy was not as high as expected in double-blind or meta-analysis studies, especially involving a large number of cases [19-21]. These studies reported that intrapleural administered fibrinolytic therapy did not reduce mortality, length of hospital stay, or the rate of subsequent surgical procedures like thoracotomy [19-21]. The AATS consensus guideline does not recommend routine administration of intrapleural fibrinolytics for complicated pleural effusions and early-stage empyemas at the class 2a level of evidence [9]. Therefore, in the study patients, both possible serious complications such as hemothorax and intrapleural fibrinolytic therapy were not applied in line with the current information.

According to studies examining the results of bacterial culture of pleural fluid obtained from empyema cases, the rate of microorganism growth in culture is 40-65% in patients who received antibiotic therapy before sampling [2,3,17]. In our study, only one patient had not received antibiotic treatment before fluid sampling, and no growth was found in the pleural fluid in 75% of the patients. We believe this high rate is because the first intervention was carried out in emergency room conditions at a high rate, so sample cultivation could not be performed to detect microorganisms at the bedside. The emergency service could not create suitable conditions for anaerobic culture cultivation. We think that the fact that almost all of the cases had broad-spectrum empirical antibiotic therapy before the application was an obstacle to the production of microorganisms in the pleural effusion. However, we think that the growth rate in culture can be increased by providing optimal conditions for detecting microorganisms in the pleural effusion.

Limitations

The main factors limiting this study are that the study was retrospective, carried out in a single center, and lack of a comparison group consisting of patients treated with thoracotomy. In addition, the cases in this study, in which stage 2 empyema constituted the majority, were in better medical condition due to the nature of the disease and were less affected by the disease than stage 3 empyema. The VATS method is used in more experienced centers in stage 3 empyemas. Still, studies with a comparison group are needed to show the effectiveness of the VATS method, especially in stage 3 empyemas.

Conclusion

VATS drainage, debridement, pouch jointing, and partial decortication operations are curative in cases of stage 2 empyema, which are encountered within the first four weeks of symptoms. The critical point for the VATS procedure to be successful in these cases is early diagnosis and indication for early surgery. We recommend evaluating VATS as the first-line therapy in treating early-stage empyema.

Conflict of interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical approval
The approval of the local ethics committee was obtained (Approval number: 2022/143). The authors confirmed compliance with the World Medical Association Declaration of Helsinki on the ethical conduct of research involving human subjects.

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