Original Article

Video-assisted thoracoscopic decortication for the management of late stage pleural empyema, is it feasible?

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Abstract:

BACKGROUND: Video-assisted thoracoscopic surgical decortication (VATSD) is widely applicable in fibrinopurulent Stage II empyema. While, more chronic thick walled Stage III empyema (organizing stage) needs conversion to open thoracotomy, and existing reports reveal a lacuna in the realm of late stage empyema patient's management through VATS utilization, particularly Stage III empyema. We prospectively evaluated the application of VATSD regardless of the stage of pleural empyema for the effective management of late stage empyema in comparison to open decortications (ODs) to minimize the adverse effects of the disease.

METHODS: All patients with pyogenic pleural empyema (Stage II and Stage III) in King Khalid University Hospital (KKUH) (admitted from January 2009 to December 2013) who did not respond to chest tube/pigtail drainage and/or antibiotic therapy were treated with VATSD and/or open thoracotomy. Prospective evaluation was carried out, and the effect of this technique on perioperative outcomes was appraised to evaluate our technical learning with the passage of time and experience with VATS for late stage empyema management.

RESULTS: Out of total 63 patients, 26 had Stage II empyema and 37 had Stage III empyema. VATSD was employed on all empyema patients admitted in the KKUH. VATSD was successful in all patients with Stage II empyema. Twenty-five patients (67.6%) with Stage III empyema completed VATSD successfully. However, only 12 cases (32.4%) required conversions to open (thoracotomy) drainage (OD). The median hospital stay for Stage III VATSD required 9.65 ± 4.1 days. Whereas, patients who underwent open thoracotomy took longer time (21.82 ± 16.35 days). Similarly, Stage III VATSD and Stage III open surgery cases showed significance difference among chest tube duration (7.84 ± 3.33 days for VATS and 15.92 ± 8.2 days for open thoracotomy). Significantly, lower postoperative complications were detected in patients treated with VATSD in terms of atelectasis, prolonged air leak, wound infection, etc.

CONCLUSION: VATSD facilitates the management of fibrinopurulent, organized pyogenic pleural empyema with less postoperative discomfort, reduced hospitalization, and have fewer postoperative complications. VATSD can be an effective, safe first option for patients with Stage II pleural empyema, and feasible in most patients with Stage III pleural empyema.

Key words:

Decortication, late stage empyema, pleural empyema, video-assisted thoracoscopic surgical decortication

Thoracic empyema is one of the general thoracic diseases, and its incidence is increasing worldwide.[1-6] It shows a significant cause of morbidity and prolonged hospitalization.[1,5,6]

Generally, the most common cause of empyema is pneumonia. Other causes include lung abscess, bronchopleural fistula, esophageal perforation, postsurgical complications, and trauma.[7] Empyema can be differentiated into three phases, exudative (Stage I), fibrinopurulent (Stage II), and organizing (Stage III), representing a continuously evolving process that can be arrested by therapeutic intervention.[8] The acute or exudative stage (Stage I), has been

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characterized by a thin serous fluid with minimal debris, pH over 7.2, lactate dehydrogenase below 1000 IU/L, glucose over 60 mg/dl, negative culture, and no loculations. The fibrinopurulent stage (Stage II), has been characterized by a thick fluid and thick fibrin strands, pH below 7.2, lactate dehydrogenase over 1000 IU/I, glucose below 60 mg/dl, positive culture or presence of suppuration, and increased loculations in the pleural cavity. The organizing stage (Stage III), in addition to Stage II, is characterized by a thick fibrous peel and scar formation and with a history of symptoms for 3 weeks or more.[2,8]

The initial exudative stage can often be managed either by antibiotic treatment or by surgical placement of a large drainage tube.[1] But, is not effective in the fibrinopurulent or organizing stages (Stage II and III), because fibrin deposits generate a pleural peel and loculation of fluid restricts the expansion of the lung.[1,8,9]

Failure of primary treatment or patient delay in seeking health care treatment in Stage I empyema demands surgical intervention, traditionally involving thoracotomy, and decortication. Early diagnosis and management of empyema offers rapid relief from sepsis and may reduce the hospital stay.[10,11]

The later stage empyema (Stage III) is mainly controlled by open decortication (OD). With the advancements in video-assisted endoscopic techniques, video-assisted thoracoscopic surgery (VATS) facilitates the management of fibrinopurulent or even organized pleural empyema with less postoperative discomfort and a reduced hospitalization than that seen in patients who have a thoracotomy as a primary surgical procedure.[1,3-6,12-16]

Hence, in this report, we discuss our technical learning with the course of time and experience gained with VATS for effective management of pyogenic late stage pleural empyema in comparison to ODs to decrease the adverse effects and complications of this pathology.

Methods

Ethical statement

The Institutional Review Board of the College of Medicine, King Saud University (KSU), Riyadh, Saudi Arabia, granted official approval for this prospective study, and it was conducted in accordance with the declaration of Helsinki for human studies.

Patients and study design

The numerical and statistical data for the present study was derived, based on adult cases of thoracic empyema admitted in the Division of Thoracic Surgery in our hospital. This hospital is among the biggest tertiary referral hospitals of Riyadh city with a major primary health care outpatient/inpatient department that deliver its services to all socio-demographic levels of the city and other nearby provinces of the Saudi kingdom. Thus, every individual in Saudi Arabia can use its services, without restriction to a specific catchment area. Hence, it can be assumed that patients of this hospital represent a random sample of the Riyadh community and the country in general. All patients who underwent the surgical management of pyogenic late stage pleural empyema (Stage II and Stage III) from January 2009 to December 2013 were included in this study. Sixty-three patients underwent the surgical management of pleural empyema at King Khalid University Hospital within this duration. Primarily, VATS procedure was attempted in all empyema patients irrespective of the etiology or empyema stage and afterward converted to thoracotomy and OD if VATS did not manage it successfully.

A detailed history and clinical examination was carried out. Investigations included complete blood count, pleural fluid analysis, and microbiological exam which include Gram stain, culture and sensitivity, acid-fast bacilli (AFB) stain, and culture for TB, while radiological investigations, including chest X-ray, ultrasound chest, and enhanced computed tomography (CT) scanning of the chest to confirm the loculation or complex pleural effusion preoperatively, and the cortical thickness of both pleura [Figure 1]. Decision for decortication was taken based on duration of symptoms, poor response to antibiotic, intercostal drainage, persistence of empyema cavity, and thick pleural peel observed on radiological investigations, However, all the patients who have tested positive for *Mycobacterium tuberculosis* on the pleural fluid analysis have been excluded from the study as their management is completely different, as they should receive minimum of 3-6 weeks of anti-tuberculous therapy.

Data pertaining to patients include demographic details (age, gender), symptoms, pre- and post-operative radiological data, preoperative morbidity, dyspnea score according to Medical Research Council (MRC) dyspnea scale, etiology of the disease, type of surgical treatment (VATS or OD), time spent in surgery, pre- and post-operative culture data, thoracotomy tube drainage, postoperative chest tube time, length of postoperative hospital stay, occurrence of complications, re-interventions in the pleural space, 30 days mortality, and outpatient clinic (OPC) follow-up.

Surgical technique

All surgical procedures were done under general anesthesia using with a double lumen endotracheal intubation and single lung ventilation. The patient was placed in a postero-lateral thoracotomy position with the side to be explored position up.

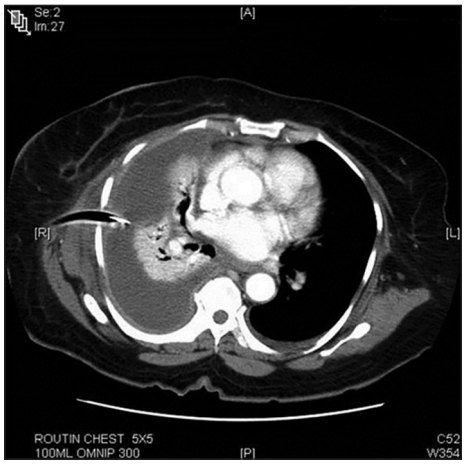

Figure 1: Computed tomography scan chest showing right side empyema

The number of the ports and there position was dependent on the presentation of the case and location of the pathology. The operator's index finger was introduced into the chest cavity. This digital exploration was found to be helpful to assess the chronicity of empyema. Ten millimeters thoracoscope with a 30° angle was used to facilitate the visualization of pleural cavity. The pleural space was freed circumferentially by finger dissection and with a curved large-bore suction device. Fluid, loculations, and septa were removed under endoscopic vision by use of the suction device and endoscopic Kaiser Forceps. Material for microbiologic analysis was collected in all patients. The lung was freed circumferentially from the apex to the diaphragm and the fissures were released. After completion of the debridement and maximum possible decortication of the parietal and visceral pleura, the pleural cavity was rinsed with several liters of warm saline solution, and the lung was re-expanded. Two large-bore chest tubes were inserted through the ventral ports and placed under endoscopic vision, one at base and second at the apex to drain the fluid and air. Suction applied immediately to prevent clogging of the tubes. Postoperative respiratory physiotherapy was instituted.

Whereas, OD was done by using a standard posterolateral or muscle-sparing thoracotomy with rib spreading and placement of a ribs retractor [Figure 2].

Postoperative care

Postoperatively, patients were extubated in the operation theater and transferred to thoracic surgery recovery rooms, where postoperative laboratory samples and chest roentgenogram were obtained. After being monitored for 1-2 h, patients not previously in the Intensive Care Unit were transferred either to the step-down unit for the duration of 1 or 2 days or to the general ward. Chest tubes were maintained on suction with (−20) cm of H_2O for 48-72 h postoperatively. Criteria for removal included the absence of air-leak and <50 ml of clear drainage during 24 h. Patients were seen in the OPC within 2 weeks of discharge, where a follow-up chest roentgenogram was obtained. Afterward, patients were monitored regularly for up to 24 months in the OPC as assessment done clinically, radiologically, and with pulmonary function test (PFT). For patients, discharged home with chest tube or Heimlich valve, close follow-up was performed every 3-5 days until the air-leak resolved, and the chest tube was removed.

Data and statistical analysis

The patients' data were collected and entered into computer using standardized entry codes. For all tests, statistical significance level was maintained at $P < 0.05$. Descriptive statistics was employed to present means, standard deviations, and percentages. Also, Student's *t*-test and Chi-squared/Fisher's exact tests were utilized to compare the group variables. Analysis was done for comparisons between VATS of Stage II empyema and VATS of Stage III empyema, and VATS of Stage III empyema with ODs of Stage III empyema surgery, hospital stay, co-morbidities, etc. The application of VATS in Stage III empyema management was the most concerned. The obtained data were tabulated, processed accordingly, and analyzed statistically by using SPSS IBM program (version 21), 2013 (SPSS, Inc., Chicago, IL, USA) by considering significance level $P < 0.05$.

Results

Patient's statistics

Between January 2009 and December 2013, 63 patients (47 males and 16 females) underwent surgical management of pyogenic late stage pleural empyema [Table 1]. Twenty-six (41.3%) patients with Stage II empyema were managed effectively by VATS [Figure 3]. No case of Stage II empyema was converted to open thoracotomy [Table 1 and Figure 3]. While, 37 (58.7%) patients were diagnosed as a Stage III empyema. Out of 37 Stage III patients, 25 (67.6%) patients underwent a successful VATS, whereas, 12 (32.4%) patients required conversion to open thoracotomy [Figure 3]. Also, the number of overall empyema cases was increased year by year, which were 6 (9.5%) in 2009 to 3 times more, that is, 18 (28.6%) patients in 2013. Most of the cases in this study were belong to Stage III empyema, especially in the year 2011, it was 12 (32.4%) out of total 17 cases and there was a significant increase in the number of patients who had video-assisted thoracoscopic surgical decortication (VATSD) (Stage III) in 5 years' time ($P = 0.0080$) [Table 1].

Preoperative characteristics of empyema patients

Table 2 represents the preoperative characteristics and empyema management associated with both groups of the study. The two groups in Stage III empyema (VATS and OD) were statistically indifferent and not significant in terms of their

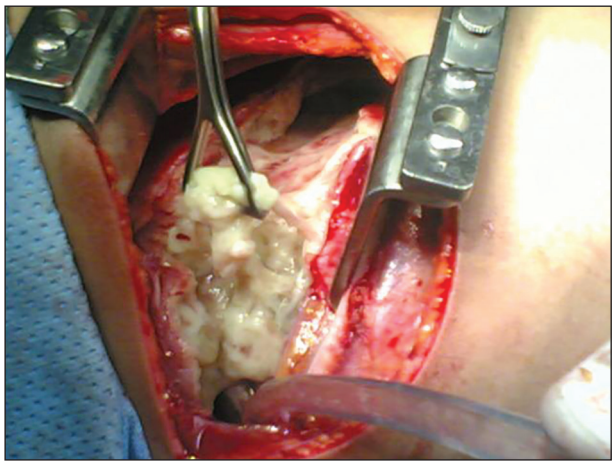

Figure 2: Empyema treated with open thoracotomy and decortication

Table 1: Empyema patients' statistics included in this study

Year	Total *n* (%)	Stage II (VATSD) *n* (%)	Stage III *n* (%)		
			Total	VATSD	Open surgery
2009	6 (9.5)	3 (11.5)	3 (8.1)	2 (8)	1 (8.3)
2010	11 (17.5)	7 (26.9)	4 (10.8)	1 (4)	3 (25)
2011	17 (27)	5 (19.2)	12 (32.4)	7 (28)	5 (41.65)
2012	11 (17.5)	4 (15.4)	7 (18.9)	5 (20)	2 (16.67)
2013	18 (28.6)	7 (26.9)	11 (29.7)	10 (40)	1 (8.3)
Total	*n*=63	26 (41.3)	37 (58.7)	25 (67.6)	12 (32.4)

There was a significant increase in the number of patients who had VATSD (Stage III) in 5 years' time ($P = 0.0080$). However, the increase in the number of patients who underwent VATSD (Stage II) and who underwent open surgery (Stage III) was not significant over 5 years ($P = 0.1585$ and $P = 1$, respectively). VATSD = Video-assisted thoracoscopic surgical decortication

mean age, preoperative symptoms, dyspnea score according to MRC dyspnea scale as most of them score two in 44 patients (69.84%) and the rest score one in 19 patients (30.16%), effusion side, CT findings, white blood cell (WBC), and co-morbid medical conditions. On the other hand, similarly, no significant differences were observed for the Stage II and Stage III empyema. All patients with Stage III presented with symptoms that lasted more than 3 weeks, while, Stage II patients presented in <3 weeks duration. The effusion side was noticed more on the right side in 33 cases. Enhanced chest CT findings with pleural effusion, multi-loculations, and thickened both pleura were found in 50 patients (79.36%), along with a pleural enhancement in patients with long duration of symptoms. No significant differences were noticed in WBC counts among all the three groups, and it ranged between 10.48-19.76 for Stage II and 9.63-21.87 for Stage III empyema cases. Co-morbidities were detected only in 26 cases (41.26%) with no significant differences among all the three groups.

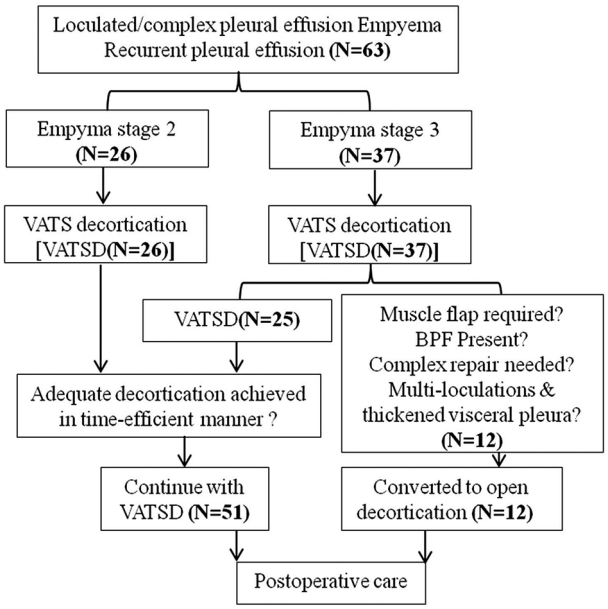

Figure 3: Flow diagram showing patient selection and decision-making in video-assisted thoracoscopic surgical decortication for empyema management

Postoperative performance/technique based characteristics

No statistically significant difference between Stage II and Stage III VATS was observed for operation time, chest tubes removal, postoperative hospital stay, and 30 days mortality [Table 3]. However, these parameters were statistically significant and higher for Stage III open surgery cases [Table 3]. Short operation time was noticed for Stage III VATS followed by Stage II VATS cases [Table 3]. Stage III empyema patients who underwent open thoracotomy took longer operation time (mean 222.42 min). Chest tubes were removed postoperatively quite earlier in case of VATS of both the groups than open thoracotomy cases. Comparison of Stage III VATS and Stage III open surgery cases showed significance difference for the chest tube duration (7.84 ± 3.33 days for VATS and 15.92 ± 8.2 days for cases of open thoracotomy).

Postoperative complications

Postoperative hospital stay for Stage III VATS required 9.65 ± 4.1 days. Whereas, patients who underwent open thoracotomy took a longer time of 21.82 ± 16.35 days. One patient of Stage III VATS was died due to other co-morbidities, including myocardial infarction (MI). The major surgical complications observed were atelectasis, which occurred in 11 patients (17.46%), 7 of them were in Stage III, as a result of open thoracotomy [Table 4]. Air-leak was detected in 3 patients (4.76%); air space was noticed in 1 patient (1.58%); wound infection in 2 patients (3.17%); and acute respiratory distress syndrome (ARDS) occurred in two cases (3.17%) [Table 4]. There were no complications noticed for Stage II VATS except one case of atelectasis. Most complications were found in Stage III for both type of surgeries (VATSD or open thoracotomy).

Postoperative microbiological analysis

Postoperative microbiological analysis showed that 39 (61.9%) empyema cases had no microbial infection etiology, the majority of these cases 22 (59.5%) were found in Stage III empyema, [Table 5]. A total of 24 (38.1%) patients were detected for microbial infections, 9 cases were from Stage II, and 15 cases from Stage III empyema (10 cases for VATS and 5 cases for open thoracotomy).

Table 2: Preoperative empyema patients' characteristics

Variables	Total (*n* = 63)	Stage II (VATSD) (*n* = 26)	Stage III (*n* = 37)				*P** (between Stage II VATSD vs. Stage III VATSD)
			Total (*n* = 37)	VATSD (*n* = 25)	Open surgery (*n* = 12)	*P** (between Stage III VATSD vs. Stage III open surgery)	
Gender (male/female)	47/16	22/4	25/12	15/10	10/2	0.156	0.049
Age (years)	41.86±16.6	43.25±12.34	40.64±19.32	42.72±21.93	36.76±12.89	0.517	0.584
Age range (years)	14-82	23-65	14-82	14-82	20-58	—	—
Preoperative symptoms duration (<3 weeks/>3 weeks)	26/37	26/0	0/37	0/25	0/12	0.676	<0.001
MRC dyspnea scale (one/two)	44/19	18/8	26/11	17/8	9/3	0.514	0.356
Effusion side (left/right)	30/33	12/14	17/20	10/15	7/5	0.414	0.668
CT findings (multi-loculated with thickened both pleura/ pleural effusion only)	50/13	23/3	28/ 9	18/7	10/2	0.384	0.295
WBC blood	15.51±5.5	15.12±4.64	15.75±6.12	14.96±5.7	17.27±6.87	0.289	0.992
Co-morbidity (yes/no)	26/37	10/16	12/25	9/16	6/6	0.417	0.645

*Statistical (*t*-test for continuous variables and Chi-square/Fisher exact test for categorical variables) analysis of the mean value at 95% ($P < 0.05$) CI. VATSD = Video-assisted thoracoscopic surgical decortication, MRC = Medical research council, WBC = White blood cell, CT = Computed tomography, CI = Confidence interval

Most of the cases were infected by *Streptococcus pneumoniae* 10 (41.66%) followed by *Staphylococcus aureus* 5 (20.8%) and interestingly *M. tuberculosis* cultured in 5 patients (20.8%) despite the initial negative AFB stain, However, these patients started on anti-tuberculosis therapy and treated according to the guidelines. An unidentified culture (Gram-negative) was also found in 1 patient of Stage III [Table 5]. While, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa* were identified only in 1 and 2 patients, respectively, for Stage III cases.

Implementing video-assisted thoracoscopic surgical decortication in Stage III and conversion of Stage III video-assisted thoracoscopic surgical decortication into Stage III open thoracotomy

Most of the late stage empyema (i.e., Stage III) cases were successfully treated by employing VATS technique [Table 1 and Figure 4]. Figure 4 demonstrates the improvement in the learning capacity and handling of technique with the passage of time for implementation of VATS in Stage III empyema. This success is consistent with the declining rate of conversion of open thoracotomy for the Stage III pleural empyema as noticed.

Discussion

The mainstay of treatment of pyogenic pleural empyema is control of on-going infection and the prevention of recurrent infection and late restriction. The complicated pleural

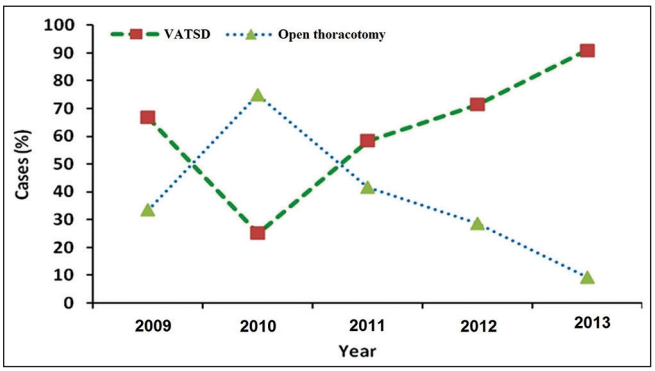

Figure 4: Success rate for implementing video-assisted thoracoscopic surgical decortication in Stage III empyema and conversion of Stage III video-assisted thoracoscopic surgical decortication to open surgery cases

Table 3: Postoperative patients' characteristics (performance/technique based)

Variables	Total (*n* = 63)	Stage II (VATSD) (*n* = 26)	Stage III (*n* = 37)				*P** (between Stage II VATSD vs. Stage III VATSD)
			Total	VATSD	Open surgery	*P** (between Stage III VATSD vs. Stage III open surgery)	
Operation time (min)	134.92±59.2	122.54±45.15	144.55±67.15	103.94±24.29	222.42±51.95	<0.001	0.097
Chest tube removal	9.13±5.69	7.15±3.43	10.67±6.6	7.84±3.33	15.92±8.2	<0.001	0.552
Postoperation hospital stay	11.48±9.34	8.47±3.87	13.85±11.5	9.65±4.1	21.82±16.35	0.001	0.421
30 days mortality (yes/no)	1/62	0/26	1/37	1/25	0/12	0.482	0.490

*Statistical (*t*-test) analysis of the mean value at 95% ($P < 0.05$) CI. VATSD = Video-assisted thoracoscopic surgical decortication, CI = Confidence interval

Table 4: Postoperative complications

Variables	Total *n* (%)	Stage II (VATSD) *n* (%)	Stage III *n* (%)				*P** (Stage II VATSD vs. Stage III VATSD)
			VATSD	Open surgery	Total	*P** (between Stage III VATSD vs. Stage III open surgery)	
Atelectasis (yes/no)	11/52	1/25	3/25	7/12	10/37	0.008	0.347
Air leak >5 days (yes/no)	3/60	0/26	1/25	2/12	3/37	0.241	0.357
Air space (yes/no)	1/62	0/26	1/25	0/12	1/37	0.676	0.490
Wound infection (yes/no)	2/61	0/26	0/25	2/12	2/37	0.036	—
ARDS (yes/no)	2/61	0/26	1/25	1/12	2/37	0.585	0.303
Total (%)	*n*=63	26 (41.3)	25 (67.7)	12 (32.4)	37 (58.7)		

ARDS = Acute respiratory distress syndrome, VATSD = Video-assisted thoracoscopic surgical decortication

Table 5: Postoperative microbiological analysis

Microorganisms	Total *n* (%)	Stage II (VATSD) *n* (%)	Stage III *n* = 37 (%)		
			Total (%)	VATSD (%)	Open surgery (%)
No microbiological growth	39 (61.9)	17 (65.4)	22 (59.5)	15 (56.0)	7 (58.3)
Gram-negative (unidentified)	1 (1.6)	0	1 (2.7)	0	1 (8.3)
Klebsiella pneumoniae	1 (1.6)	0	1 (2.7)	1 (4.0)	0
Mycobacterium tuberculosis	5 (7.9)	0	5 (13.5)	3 (12.0)	2 (16.7)
Pseudomonas aeruginosa	2 (3.2)	0	2 (5.4)	1 (4.0)	1 (8.3)
Staphylococcus aureus	5 (7.9)	2 (7.7)	3 (8.1)	2 (8.0)	1 (8.3)
Streptococcus pneumoniae	10 (15.9)	7 (26.9)	3 (8.1)	3 (12.0)	0
Total	*n*=63	26 (41.3)	37 (58.7)	25 (67.6)	12 (32.4)

VATSD = Video-assisted thoracoscopic surgical decortication

effusion or empyema conditions usually managed through early drainage, either by means of a chest tube or through a thoracotomy and OD.[1] Delaying surgical treatment in these situations or, incomplete drainage of the pleural space with persistent signs of infection is responsible for functional impairment and is associated with substantial morbidity and mortality.[17,18]

With the advancements in medical sciences, VATSD is a feasible treatment in the fibrinopurulent phase of empyema (Stage II) when pleural drainage alone is insufficient. It has shown rewarding results in several reports, and is an attractive minimally invasive approach and has made the surgical intervention a more acceptable early treatment option in this respect.[6,19-22] Employing conventional instruments in VATSD is a safe, effective, and durable method of achieving re-expansion of the trapped underlying lung by removing the visceral cortex in the same way as in open surgery.[2,23-25]

Right from our early experience in year 2009, we adopted a general policy to attempt VATSD in all cases of complicated parapneumonic effusion or empyema irrespective of chronicity of the disease, rather than being restricted to the standard procedure of an open thoracotomy and decortication for Stage III empyema. We have been able to achieve greater success to manage lung expansion by VATSD without the detrimental effects of open thoracotomy.

The classification of the disease stage depends on many determinants; a most significant factor is the duration (<3 weeks or more than 3 weeks) of the disease symptoms. Less than 3 weeks is classified as Stage II, while more than 3 weeks as Stage III empyema. We noticed that most of the cases were in Stage III empyema, possibly due to prolonged hospitalization and generally, the physicians and pulmonologists prefer conventional therapies, such as antibiotics and insertion of the pig-tail catheter over surgery. This may cause late referral and further complications of the empyema cases. Demographical data of all three group patients' did not show any significant differences, while, patients being predominantly were belonging to middle-age males. A similar type of demographical details for empyema patients are very common and reported previously.[4] Majority of pleural effusions in the present study were found on the right side, and they were congruent with previous findings.[8] The CT findings were almost similarly distributed among all the patients, while the majority of them 50 patients (79.36%), were multi-loculated empyema cases.

Various postoperative characteristics determine the success of VATSD, that is, shortening of operation time, chest tubes duration, postoperative hospital stay, and less perioperative mortality.[2,23-25] Our postoperative results showed that there is a huge difference in operation time duration between VATSD and open thoracotomy for late Stage (III) empyema patients. It was found almost the double in open thoracotomy as compared to VATSD. It is well-established fact that with an increase in technical usage of the surgical expertise, surgeons get used to with new instruments and mastered the technique over time.[1,11] Additionally, chest tube durations and postoperative hospital stay was shorter in Stage III patients who underwent VATSD as compared to open thoracotomy. These outcomes reflected positively on the patients' health status in terms of less postoperative pain, faster healing, and less wound infection. Similar findings have been reported by earlier researchers those observed that VATSD has several advantages over open thoracotomy, which include shorter postoperative hospital stay, rapid healing and early return to work, reduced thoracostomy tube drainage time, decreased surgical time, less postoperative pain, and reduced complication rate and mortality.[2,26]

During the stipulated study duration, 1 patient was died due to co-morbidities (MI), which was neither related to the empyema nor to the surgical procedure employed. Our results showed that no significant differences were noticed between Stage II VATSD and Stage III VATSD in terms of postoperative patients' characteristics. This suggests that the efficacy of VATSD was neither affected by the duration of symptoms prior to the surgery nor to the adversity of the disease (This suggests that the VATSD can be employed with minimal complications in empyema decortication regardless of stage of the disease.) The main complication "atelectasis" was observed in the majority of Stage III patients whether they were managed with VATSD or open thoracotomy while one case with significant atelectasis was seen in Stage II VATSD. Otherwise, no other significant complications were found in Stage II empyema patients' group. While, few cases with air-leak, superficial wound infection, air space, and ARDS complications were seen in Stage III empyema patients whether managed by VATSD or open thoracotomy. Complications found in patients after treatment in our study were in line with previous studies.[4,9,25] Minor postoperative complications in Stage II empyema patients managed with VATSD is a good indicator of improvement over the safety of VATSD employed for Stage II empyema. On the contrary, most of the complications were represented by Stage III patients. No wound infection was found in Stage III empyema patients who underwent VATSD while 2 patients (3.17%) who underwent open thoracotomy got their wounds infected. This could be considered as an advantage of VATSD application over open thoracotomy for Stage III empyema patients. In all cases, we have found significant improvement of lung re-expansion as demonstrated by radiological investigations in the OPC for middle term and long term follow-up, up to 24 months, and also no additional surgery was required and no postoperative empyema was seen in all our study during the OPC follow-up, as the patients were assessed clinically, radiologically, and with PFT, which showed also significant improvement in the quality of life in both groups. However, the vital capacity and forced expiratory volume 1 s at 6 and 12 months interval was documented as 90% or more of predicted value in Stage II and III empyema done by VASTD.

The outcomes of our study demonstrated that the majority of the postoperative microbiological analysis failed to detect any major microbial infection because all empyema patients had a preoperative antibiotics course. Previously published research articles pertinent to empyema postoperative microbiological analysis have reported similar observations.[27,28] But, the most frequently identified bacterium was *S. pneumoniae* and this microbiological analysis was concurrent with previous reports.[4,8,9] Interestingly, no *M. tuberculosis* infection related empyema was reported in Stage II patients and it was detected

only in 5 (13.5%) Stage III empyema patients despite the initial negative AFB stain; however, we did not notice any difference in this group in terms of morbidity or complications and postoperative recovery from the rest of patients.

As revealed through our findings, the success rate for implementing VATSD specifically in the Stage III empyema cases increases with respect to years (time), except the year 2010 [Figure 4], and this was a statistically significant of the patients who had VATSD (Stage III) in 5 years' time ($P = 0.0080$) [Table 1]. With the gained technical expertise and surgeons' learning from case to case, conversion to open procedure declined significantly among Stage III cases particularly in the year 2013. The present study demonstrates a lower rate of conversion to open thoracotomy as compared to previous studies, which ranged from 28% to 59%.[9,12,14,19,29-31]

In the present study, the major causes of conversion was hemorrhage in 2 patients. Another 2 cases were converted due to significant air leakage, and lung injury during removal of thickened, and adherent visceral pleural peel. 3 cases were converted due to inability to maintain adequate oxygenation with one-lung anesthesia. The rest of the converted cases (5 patients) were due to the situation of the lung with very thickened visceral pleura and were unsuitable for VAT decortication [Figure 3].

Implementing VATSD in late Stage (III) empyema management has many advantages over open surgery, as like, as some researchers have reported earlier.[4,28-30,32] As per our opinion, experience, and learning, conversion to an open surgery procedure should not be considered as a failure of thoracoscopy, but rather an exercise of mature surgical judgment. However, VATSD can be implemented safely as first-line management for all cases of Stage III empyema.[33]

Conclusion

We conclude that our study demonstrates VATSD as a feasible approach for the management of late Stage (III) organizing empyema. In comparison with open surgery, thoracoscopic decortication is more safe and effective method for the treatment of Stage III empyema in terms of multi-loculations, complex pleural effusion, recurrent pleural effusion, and hemothorax. VATSD facilitates the management of fibrinopurulent and organized pyogenic pleural empyema with less postoperative discomfort and complications and reduced hospitalization stay. On the other hand, if adequate decortication cannot be achieved in a timely and efficient manner by VATSD implementation, conversion to open thoracotomy should/can be considered.

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Conflicts of interest

There are no conflicts of interest.

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