Original Article

Clinical outcome of urgent thoracoscopic surgery on complicated parapneumonic infection with short-term preoperative antibiotic usage

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Background: Prompt initiation of antibiotics and drainage of infection source is essential in the management of pleural cavity infection. Although surgical drainage is considered a gold standard of treatment for unresolved parapneumonic infection, optimal timing for surgical intervention is still under debate. Thus, we seek to analyze the clinical outcomes of urgent thoracoscopic surgery for complicated parapneumonic effusion regarding the duration of preoperative antibiotic usage.

Methods: Medical records were retrospectively reviewed for patients who received thoracoscopic surgery for complicated parapneumonic effusion or empyema. Patients were grouped according to the preoperative antibiotic durations and compared. Group A consists of the patients with less than 3 days of preoperative antibiotics usage and Group B consists of those with more than 3 days of preoperative antibiotic coverage. Basic demographics, preoperative chest computed tomography (CT) findings, antibiotics usage, duration until surgery and treatment outcomes were evaluated.

Results: From February 2008 to November 2018, a total of 180 patients underwent video-assisted thoracoscopic surgery (VATS) for pleural drainage or decortication of lung. Group A patients had higher C-reactive protein value (240 *vs.* 192 mg/L, P=0.003) and were given significantly shorter duration of total antibiotics (9 *vs.* 14 days, P<0.001). The median duration of postoperative chest tube indwelling time (5 *vs.* 5 days, P=0.38), postoperative hospital stays (8 *vs.* 8 days, P=0.56), operation time (105 *vs.* 105 min, P=0.88) showed no significant difference between the groups. CT images of Group A patients showed a significantly higher rate of multi-loculation (83 *vs.* 59, P=0.008) and interlobar effusions (64 *vs.* 42, P=0.02). There were two postoperative mortalities and four recurrences.

Conclusions: Faster and relatively safe and successful clinical outcomes can be achieved with urgent thoracoscopic surgery on patients with complicated parapneumonic effusion despite limited duration of antibiotics coverage.

Keywords: Parapneumonic; empyema; video-assisted thoracoscopic surgery (VATS); antibiotics

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Introduction

Parapneumonic effusion or empyema refers to the accumulation of fluid or pus in the pleural cavity secondary to pneumonia. In 2019, it was estimated that approximately 2.5 million deaths globally were caused by pneumonia, with nearly 20–50% of these patients developing parapneumonic effusion, which reportedly increases mortality by approximately 3–6 times (1). If prompt treatment is delayed, it can lead to high complication rates, prolonged hospital stays, and increased medical costs, making it a significant social health issue.

Fortunately, most cases of parapneumonic effusion tend to improve with early administration of appropriate antibiotics, with recommended antibiotics treatment duration of 2–6 weeks but still about 10% of effusion cases progress to empyema due to bacterial invasion, at which stage effective treatment requires timely invasive drainage procedures such as closed thoracostomy, surgical drainage or pleural decortication alongside medical treatment (2). Yet, there is still no clear evidence as to the exact timing during antibiotic treatment when surgical intervention should be coupled. Reported mortality is approximately 15% and requirement for surgical intervention is reported to be up to 30% in empyema patients (3,4).

With advancement of surgical technique, video-assisted thoracoscopic surgery (VATS) is widely utilized for treatment of empyema for less invasive and lower operative mortality (5). Alongside this technical advancement, safety and effectiveness of early surgical drainage for parapneumonic effusion and empyema has been proven through many studies. According to these studies, delaying surgical treatment even after the failure of antibiotic therapy can lead to prolonged treatment durations, delayed recovery post-surgery, and worsening of the patient's condition. However, proceeding with surgery without adequate management of the systemic infection may lead to relapse of the infectious condition during the post-operative stages but, there is still a lack of sufficient scientific evidence in this regard.

Therefore, we aim to investigate the clinical impact of the urgent thoracoscopic surgical despite limited period of preoperative antibiotic treatment and look for any clinical factors that may contribute to better clinical outcomes in patients diagnosed with parapneumonic effusion. Further we seek to evaluate whether urgent thoracoscopic surgery is feasible and applicable. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1331/rc).

Highlight box

Key findings

- In patients with complicated parapneumonic effusion, urgent thoracoscopic surgery with limited antibiotic coverage allowed for a relatively safe and shorter overall hospital stays.

What is known and what is new?

- Surgical drainage is treatment of choice for complicated parapneumonic effusion after antibiotics coverage of at least 2 to 4 weeks.
- Urgent surgical drainage after limited duration of antibiotics coverage can be performed with relatively safe and successful outcome at shorter admission duration.

What is the implication, and what should change now?

- Considering earlier surgical drainage should be considered for certain group of patients with complicated parapneumonic effusion.

Methods

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The Institutional Review Board of Korea University Anam Hospital approved this study (No. 2023AN0183) and individual consent for this retrospective analysis was waived.

Study cohort

This was a retrospective review of the medical records of patients who underwent VATS pleural decortication or drainage after being newly diagnosed and received antibiotic treatment for parapneumonic effusion or empyema at Korea University Anam Hospital between February 2008 to November 2018. Patients diagnosed with tuberculosis pleurisy, effusion secondary to other surgery, and tumors pleural cavity were excluded.

Initial diagnosis and management

All study subjects underwent a preoperative chest computed tomography (CT) scan and plain chest roentgenogram. A patient with loculated pleural effusion, insufficient drainage of pleural fluid after performing drainage procedures such as thoracentesis or closed thoracostomy, complicated effusion and increased infection markers such as C-reactive protein (CRP), and white blood cell (WBC) were considered for

urgent thoracoscopic surgery. Antibiotics were administered from the day of hospital visits and types of empirical antibiotics were chosen based on guidelines by Sanford Guide and consultation to infectious disease department.

Surgical criteria and procedure

Our inclusion criteria for surgical intervention were based on the American Association for Thoracic Surgery consensus guidelines (5,6) which included a diagnosis of empyema and loculated effusion or effusion with thickened parietal pleura. Persistent fever with remnant pleural effusion despite initial chest drainage, and septic conditions with pleural infection were also included in our surgical indication. Patients with ongoing or uncontrolled fever despite antifebrile agents, interlobar and multiloculated pleural effusions on chest CT which suggests high probability of inefficient drainage were immediately decided for urgent surgical intervention regardless of shorter preoperative antibiotics treatment duration.

All patients were operated via VATS under general anesthesia with one-lung ventilation and in lateral decubitus position. Three 10 to 20 mm thoracoports were made for operation and 10 mm scope was used. Under direct vision, evacuation of the infected fluid, disruption of all loculations, and debridement of pleural peels using suction devices and long-handled ring forceps were performed. After massive irrigation of the pleural cavity, the lung was inflated under direct vision to determine the need for decortication in case a thick, inflammatory peel was preventing lung re-expansion. If necessary, careful decortication was performed. The lack of air leakage and lung re-expansion were confirmed, and the operation was ended by leaving two 28-Fr chest tubes through the previously made trocar sites.

Group comparison

Data on sex, age, underlying diseases, types of symptoms and first onsets, chest CT findings, antibiotics duration, drainage durations, treatment details were collected for evaluation.

Every patient who visited emergency department and diagnosed of parapneumonic effusion were immediately started with intravenous infusion of empirical antibiotics and patients were grouped according to the day of surgery from admission or from the start of preoperative antibiotics.

Group A or urgent surgery group consists of patients whose preoperative antibiotics treatment duration is between 0 to 3 days, and Group B or late surgery group consists of those with more than 3 days of antibiotics administration.

Previous studies have shown that surgical treatment was performed at varying time intervals ranging from 48 hours to 2 weeks after diagnosis, depending on the literature (7,8). However, there is no established definition for the precise distinction between early and late surgery. Therefore, we identified the minimum number of days necessary to prepare for elective surgery and defined patients who underwent surgery within 3 days of admission as Group A, and those who underwent surgery after 3 days as Group B. We then conducted a comparative analysis based on this classification.

Postoperative hospital duration and antibiotics duration

Although some guidelines recommend antibiotic coverage of 2–6 weeks, termination of the antibiotic treatment is also at the discretion of the clinician. Considering the possible adverse effects of long administration of antibiotics, authors have hypothesized that perioperative antibiotics might be sufficient if the patient's clinical symptoms and signs show no abnormalities regardless of the total perioperative duration. All patients included in this study received antibiotics until discharge, regardless of the timing of the surgery, and antibiotic therapy was discontinued after discharge. The criteria for determining the discharge timing were as follows: absence of abnormal symptoms such as dyspnea, palpitation, and etc., sufficient lung expansion maintained on daily postoperative chest X-ray (CXR), stabilization of the drain color and amount ensuring safe timing for drainage removal, absence of fever with stable vital signs and finally, a downward trend in of infection markers in serial postoperative blood tests.

Follow-up

Every patient visited the outpatient department after 1 week and 1 month after discharges and radiological examinations were reviewed on the day of the visits.

Statistical analysis

All data were entered into an Excel spreadsheet (Microsoft, Bellevue, WA, USA). Baseline characteristics are shown as the mean with standard deviation (SD) or median with

interquartile range (IQR) for continuous variables or number (%) for categorical variables. Mean with SD is chosen for normally distributed data without significant outliers while median with IQR is used on variable data with outliers or skewed distribution. Basic patient characteristics were analyzed using Chi-squared and Fisher's exact tests for categorical variables, and continuous variables were analyzed using the Mann-Whitney *U* test. A linear regression model was used to determine the effects of urgent surgery on the length of the postoperative hospital stay, of post-operative tube indwelling duration and length of operation time. P values <0.05 were considered statistically significant.

All statistical analyses were performed using RexPro (http://rexsoft.org/, Version 3.6.3, RexSoft Inc., Seoul, Republic of Korea) an Excel plug-in based on the R Statistical Software (version 3.6.1; R Foundation for Statistical Computing, Vienna, Austria).

Application of artificial intelligence (AI) tools

This manuscript utilized ChatGPT, a language model developed by OpenAI (GPT-4, August 2023 version), for the purposes of English language proofreading. No other functions or capabilities of the model were employed beyond language refinement.

Results

A total of 180 patients received VATS for complicated parapneumonic effusion during the study period. Among them, 96 patients underwent surgery within 3 days of admission (Group A) while 84 red surgery more than 3 days after the hospital admission (Group B). Basic patient characteristics are presented in *Table 1*. The general patient characteristics including the gender and ages were similar in both groups.

Patients in Group A showed higher preoperative CRP levels (240.46 *vs.* 192.12 mg/L, P=0.003). Additionally, a higher proportion of these patients exhibited multiple loculated effusions (86.5% *vs.* 70.2%, P=0.008) and interlobar loculation (66.7% *vs.* 50.0%, P=0.02) on preoperative chest CT. Furthermore, Group A patients had a lower rate of drainage performed after admission (16.7% *vs.* 53.6%, P<0.001) and significantly shorter durations from initial symptom onset to surgery (8.5 *vs.* 20 days, P<0.001), from admission to surgery (2 *vs.* 7 days, P<0.001), and total antibiotic administration period (9 *vs.* 14 days, P<0.001). *Figure 1* presents a CT image of a patient from Group A. As demonstrated in this figure, patients within this group exhibited a notable frequency of complicated parapneumonic effusion.

In contrast, patients from Group B showed significantly higher incidence of pleural thickening on preoperative chest CT (6.3% *vs.* 19.0%, P=0.009) while showing lower rate of complicated effusions (86.5% *vs.* 70.2%, P=0.008). *Figure 2* shows a CT image of a patient from Group B. Patients in this group demonstrated the aforementioned CT characteristics, leading to a significantly higher frequency of preoperative chest tube drainage interventions (16.7% *vs.* 53.6%, P<0.001).

Group A patients had higher CRP value (240 *vs.* 192 mg/L, P=0.003) and were given significantly shorter duration of total antibiotics (9 *vs.* 14 days, P<0.001). The median duration of postoperative chest tube indwelling time (5 *vs.* 5 days, P=0.38), postoperative hospital stays (8 *vs.* 8 days, P=0.56), operation time (105 *vs.* 105 min, P=0.88) showed no significant difference between the groups. A significantly higher proportion of patients in Group B had comorbidities, including chronic kidney disease (CKD) (1.0% *vs.* 7.1%, P=0.050) and hepatitis (4.2% *vs.* 13.1%, P=0.03).

There were four recurrences (2.2%) in total, and three cases were from group A (3.1%) while one case was from group B (1.2%) however, no statistical significance was noted. There were two 30-day mortality cases among the total patients, with one in each patient group (1.0% *vs.* 1.2%, P>0.99).

Table 2 compares the preoperative differences and postoperative outcomes according to the empyema stages. Patients in Stage 3 (chronic) showed lowest rate of early surgical treatment (43.3% *vs.* 60.2% *vs.* 27.3%, P=0.008), while having highest rate of comorbidity with hepatitis (6.7% *vs.* 6.3% *vs.* 22.7%, P=0.050), the longest treatment durations from initial symptom onset to surgery (16.5 *vs.* 11 *vs.* 21.5 days, P<0.001) and postoperative drainage indwelling durations (5 *vs.* 5 *vs.* 6 days, P=0.01).

Tables 3-5 present univariate analyses of the risk factors influencing postoperative hospital stay, tube indwelling duration, and total operation time. The variables included in the tables are all significant risk factors for prolonged hospital days, tube indwelling time and operation time.

Discussion

The advancement of VATS has lowered postoperative morbidities and studies have shown that the success rate of VATS lies between 82–92% (9,10). Further, when

Table 1 Basic patient characteristics

Variables	Total (n=180)	Group A (n=96)	Group B (n=84)	P value
Age (years)	58.71±12.45	57.40±12.31	60.21±12.52	0.13
Gender				
Male	152 (84.4)	83 (86.5)	69 (82.1)	0.43
Comorbidities				
Hypertension	70 (38.9)	33 (34.4)	37 (44.0)	0.18
Diabetes	49 (27.2)	25 (26.0)	24 (28.6)	0.70
Cardiovascular	16 (8.9)	6 (6.3)	10 (11.9)	0.18
Cerebrovascular	8 (4.4)	3 (3.1)	5 (6.0)	0.48
CKD	7 (3.9)	1 (1.0)	6 (7.1)	0.050
Hepatitis	15 (8.3)	4 (4.2)	11 (13.1)	0.03
ILD or COPD	12 (6.7)	5 (5.2)	7 (8.3)	0.40
Initial symptom				
Fever	36 (20.0)	17 (17.7)	19 (22.6)	0.41
Cough	32 (17.8)	15 (15.6)	17 (20.2)	0.42
Chest pain	133 (73.9)	74 (77.1)	59 (70.2)	0.30
Dyspnea	58 (32.2)	29 (30.2)	29 (34.5)	0.54
Multiple Sx.	68 (37.8)	32 (33.3)	36 (42.9)	0.19
Pre OP blood test				
Hemoglobin (g/dL)	12.9±1.73	12.93±1.71	12.87±1.76	0.83
WBC ($\times 10^3$/μL)	15,772.89±6,875.17	16,399.79±6,484.81	15,056.43±7,268.61	0.20
CRP (mg/L)	217.81±108.96	240.46±99.79	192.12±113.74	0.003
BUN (mg/dL)	16.95±11.5	15.76±11.54	18.31±11.37	0.14
Creatinine (mg/dL)	0.97±0.44	0.91±0.2	1.05±0.61	0.06
CT findings				
Loculation, yes	176 (97.8)	95 (99.0)	81 (96.4)	0.34
Multiple sites	142 (78.9)	83 (86.5)	59 (70.2)	0.008
Interlobar	106 (58.9)	64 (66.7)	42 (50.0)	0.02
Pleural thickening	22 (12.2)	6 (6.3)	16 (19.0)	0.009
Pre OP drainage	61 (33.9)	16 (16.7)	45 (53.6)	<0.001
Symptom to OP (days)	12.00 [8.00, 20.25]	8.50 [6.00, 11.00]	20.00 [14.75, 26.00]	<0.001
Admission to OP (days)	3.50 [2.00, 6.00]	2.00 [1.00, 3.00]	7.00 [5.00, 9.00]	<0.001
Pre OP antibiotics (days)	3.00 [2.00, 6.00]	2.00 [1.00, 3.00]	6.00 [5.00, 9.00]	<0.001
Total duration of antibiotics (days)	11.00 [8.00, 16.00]	9.00 [7.00, 12.00]	14.00 [11.00, 21.00]	<0.001
ICU stay (days)	1.00 [0.00, 2.00]	1.00 [0.00, 2.00]	1.00 [0.00, 2.00]	0.69
Post OP hospital stay (days)	8.00 [6.00, 11.25]	8.00 [6.00, 10.25]	8.00 [6.00, 13.00]	0.56

Table 1 (*continued*)

Table 1 (*continued*)

Variables	Total (n=180)	Group A (n=96)	Group B (n=84)	P value
Post OP tube indwelling (days)	5.00 [4.00, 7.00]	5.00 [4.00, 6.00]	5.00 [4.00, 7.00]	0.38
Successful lung re-expansion	178 (98.9)	96 (100.0)	82 (97.6)	0.22
Prolonged air leakage (>7 days)	2 (1.1)	0 (0.0)	2 (2.4)	0.22
OP time (min)	105 [80, 135]	102 [82, 132.5]	105 [80, 140]	0.88
Recurrence	4 (2.2)	3 (3.1)	1 (1.2)	0.62
30-day mortality	2 (1.1)	1 (1.0)	1 (1.2)	>0.99

Data are presented as mean ± SD, number (%), or median [IQR]. Group A: urgent surgery group with preoperative antibiotic administration ≤3 days. Group B: late surgery group with preoperative antibiotic administration >3 days. CKD, chronic kidney disease; ILD, interstitial lung disease; COPD, chronic obstructive pulmonary disease; Sx., symptom; OP, operation; WBC, white blood cell; CRP, C-reactive protein; BUN, blood urea nitrogen; CT, computed tomography; ICU, intensive care unit; SD, standard deviation; IQR, interquartile range.

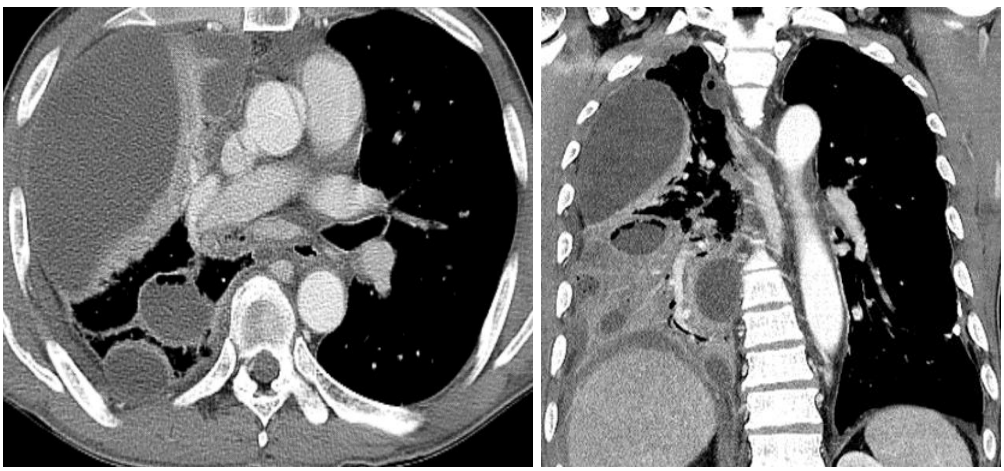

Figure 1 Contrast-enhanced chest CT images of a 47-year-old male with right-sided empyema showing multiloculated effusion. The patient underwent urgent thoracoscopic surgery (Group A). Group A: urgent surgery group with preoperative antibiotic administration ≤3 days. CT, computed tomography.

comparing VATS with chest tube drainage, VATS has shown significantly better treatment outcomes. A meta-analysis of studies involving pediatric patients with empyema also demonstrated that VATS achieved similar treatment outcomes when compared to the use of chest tubes with fibrinolytic agents or thoracotomy with decortication (11-13). Despite such technological advancements, the optimal timing of surgery varies by literatures and decisions for transition to surgery is primarily made at the discretion of the physician. In previous literatures, some recommend surgery as primary treatment of choice while others recommend surgery as a rescue therapy after medical therapy (5,6). Although several previous studies advocate early surgical drainage, it is still unclear whether insufficient or absence of preoperative antibiotics treatment may result in late postoperative recovery from infection, longer postoperative hospital stays, or even relapse of parapneumonic effusion requiring additional drainage procedure or surgery. However, it is very clear that delay in surgical drainage may result in aggravation of septic condition which may possibly impair the necessary surgical treatment, and it was noted as an independent predictor of thoracotomy conversion, increase in operative time and postoperative complication (7).

Fortunately, the development of antibiotics and surgical techniques may have lowered the mortality rate

of empyema; however, issues such as the deterioration of patients' quality of life, prolonged hospitalization, or the inability to discharge home remain significant challenges. These must be addressed by promoting more effective treatment protocols. Thus, reducing mortality should not be the sole focus in the treatment objectives for complicated parapneumonic effusion.

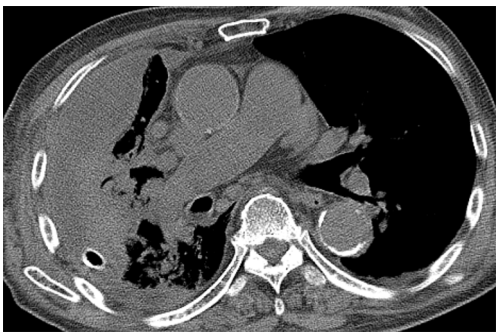

Figure 2 Non-enhanced chest CT images of a 83-year-old male with right-sided empyema showing pneumonia and pleural effusion. The patient underwent surgery at 22 hospital days after receiving chest tube drainage (Group B). Group B: late surgery group with preoperative antibiotic administration >3 days. CT, computed tomography.

In this study, we investigated whether urgent surgical intervention could not only reduce morbidity and mortality but also lead to a reduction in the duration of postoperative chest tube drainage and antibiotic treatment, as well as overall hospital stay. While overall mortality did not show statistical difference, patients with a history of cerebral diseases, lung parenchyma disorders, and hepatitis tended to have longer hospital stays.

The proportion of preoperative chest drainage for Group A was 16.7% while Group B was 53.6% as highlighted in *Table 1*. While this proportion may seem low, it likely reflects the specific clinical considerations and individualized patient preferences. Such clinical considerations include cases where multiple loculations or interlobar loculations were present, making accurate tube placement challenging thereby effective drainage could not be guaranteed. In other cases, significant adhesions were anticipated from initial chest CT images thereby the risk of inducing lung injury outweighed the potential benefits of drainage insertion.

In *Table 1*, it was observed that patients who underwent preoperative drainage had significantly longer postoperative hospital stays. The fact that patients who received chest tube treatment prior to surgery required longer postoperative hospital stays suggests that the initial treatment may have been insufficient or failed which may have led to

Table 2 Preoperative characteristics and postoperative outcomes according to empyema stages

Variables	Stage I (n=30, 16.7%)	Stage II (n=128, 71.1%)	Stage III (n=22, 12.2%)	P value
Urgent OP	13 (43.3)	77 (60.2)	6 (27.3)	0.008
Comorbidities				
Hypertension	12 (40.0)	51 (39.8)	7 (31.8)	0.77
Diabetes	4 (13.3)	37 (28.9)	8 (36.4)	0.13
Cerebrovascular	1 (3.3)	6 (4.7)	1 (4.5)	>0.99
Cardiovascular	3 (10.0)	13 (10.2)	0 (0.0)	0.63
ILD or COPD	3 (10.0)	8 (6.3)	1 (4.5)	0.63
Hepatitis	2 (6.7)	8 (6.3)	5 (22.7)	0.045
CKD	3 (10.0)	4 (3.1)	0 (0.0)	0.16
Symptoms to OP (days)	16.5 [9.5, 24.5]	11 [7, 16.25]	21.5 [16.25, 28.75]	<0.001
Admission to OP (days)	4 [2.25, 8]	3 [2, 5.25]	5 [4, 10.75]	0.003
Post OP hospital stay (days)	7.5 [6, 10]	8 [6, 11]	8 [7, 17]	0.28
Post OP tube indwelling (days)	5 [4, 6.75]	5 [4, 6.25]	6 [5, 10.75]	0.01

Data are presented as number (%) or median [IQR]. OP, operation; ILD, interstitial lung disease; COPD, chronic obstructive pulmonary disease; CKD, chronic kidney disease; IQR, interquartile range.

Table 3 Univariate analysis of risk factors associated with the length of post-operative hospital stays

Variables	Group A (n=96)	Group B (n=84)	Beta	P value
OP >3 days	0 (0.0)	84 (100.0)	3.263	0.07
Age (years)	57.40±12.31	60.21±12.52	0.169	0.02
Comorbidities				
Cerebrovascular	3 (3.1)	5 (6.0)	17.363	<0.001
ILD or COPD	5 (5.2)	7 (8.3)	7.018	0.050
Hepatitis	4 (4.2)	11 (13.1)	8.345	0.01
Initial symptom				
Fever	17 (17.7)	19 (22.6)	4.403	0.050
Chest pain	74 (77.1)	59 (70.2)	–8.946	<0.001
CT finding				
Interlobar loculation	64 (66.7)	42 (50.0)	–4.476	0.01
Pre OP blood tests				
Hemoglobin (g/dL)	12.93±1.71	12.87±1.76	–2.007	<0.001
BUN (mg/dL)	15.76±11.54	18.31±11.37	0.15	0.03
Pre OP drainage	16 (16.7)	45 (53.6)	5.671	0.003
Symptoms to OP (days)	8.50 [6.00, 11.00]	20.00 [14.75, 26.00]	0.307	0.001
Admission to OP (days)	2.00 [1.00, 3.00]	7.00 [5.00, 9.00]	0.996	<0.001
ICU stay (days)	1.00 [0.00, 2.00]	1.00 [0.00, 2.00]	2.161	<0.001

Data are presented as number (%), mean ± SD or median [IQR]. Group A: urgent surgery group with preoperative antibiotic administration ≤3 days. Group B: late surgery group with preoperative antibiotic administration >3 days. OP, operation; ILD, interstitial lung disease; COPD, chronic obstructive pulmonary disease; CT, computed tomography; BUN, blood urea nitrogen; ICU, intensive care unit; SD, standard deviation; IQR, interquartile range.

progression to the chronic stages of parapneumonic effusion which may have required more extensive level of surgical decortication indicating treatment with just chest tube drainage or antibiotics alone may not be sufficient and some group of patients may require earlier decision for surgical intervention.

Our findings showed that Group A patients tended to have higher level of infection markers on preoperative blood tests. This patient population also had more complicated preoperative chest CT findings such as multiple and interlobar loculation. It is speculated that this subset of patients was selected for earlier surgical treatment in concern of higher possibility of progression to septic condition and drainage via chest tube or thoracentesis could be anatomically challenging.

The presence of interlobar effusion has also been mentioned in the study by Shiroshita *et al.*, which reported that patients with interlobar effusion had a lower 90-day mortality rate, regardless of early thoracic surgery (14). Similarly, our study result showed that despite insufficient preoperative antibiotic coverage in this subset of patients, the postoperative morbidity and mortality did not show significant difference thus urgent surgical drainage could be safe and effective treatment option.

Restricted physical and medical condition has shown significant influence for empyema treatment period. Based on our study results, it appears that patients with physical restrictions due to cerebrovascular disease experience prolonged postoperative recovery periods (P=0.02), likely due to ineffective pulmonary mobilization. Additionally, hepatitis has shown to prolong treatment duration possibly due to decreased physiological reserves caused by systemic nutritional imbalances (P=0.03). This finding aligns with research by Semmelmann *et al.*, as well as other studies,

Table 4 Univariate analysis of risk factors associated with the length of post-operative tube indwelling duration

Variables	Group A (n=96)	Group B (n=84)	Beta	P value
Comorbidities				
Cerebrovascular	3 (3.1)	5 (6.0)	3.407	0.02
Hepatitis	4 (4.2)	11 (13.1)	2.297	0.03
Initial symptom				
Chest pain	74 (77.1)	59 (70.2)	–2.182	<0.001
CT finding				
Pleural thickening	6 (6.3)	16 (19.0)	1.871	0.04
Pre OP blood tests				
Hemoglobin (g/dL)	12.93±1.71	12.87±1.76	–0.373	0.03
BUN (mg/dL)	15.76±11.54	18.31±11.37	0.072	0.005
Creatinine (mg/dL)	0.91±0.2	1.05±0.61	1.877	0.005
Symptom to OP (days)	8.50 [6.00, 11.00]	20.00 [14.75, 26.00]	0.065	0.04
ICU stay (days)	1.00 [0.00, 2.00]	1.00 [0.00, 2.00]	0.54	<0.001

Data are presented as number (%), mean ± SD or median [IQR]. Group A: urgent surgery group with preoperative antibiotic administration ≤3 days. Group B: late surgery group with preoperative antibiotic administration >3 days. CT, computed tomography; OP, operation; BUN, blood urea nitrogen; ICU, intensive care unit; SD, standard deviation; IQR, interquartile range.

Table 5 Univariate analysis of risk factors associated with the length of OP time

Variables	Group A (n=96)	Group B (n=84)	Beta	P value
Symptom to OP (days)	8.50 [6.00, 11.00]	20.00 [14.75, 26.00]	1.631	<0.001
Admission to OP (days)	2.00 [1.00, 3.00]	7.00 [5.00, 9.00]	2.992	0.003
Pre OP antibiotics (days)	2.00 [1.00, 3.00]	6.00 [5.00, 9.00]	2.788	0.007
Pre OP drainage	16 (16.7)	45 (53.6)	26.644	0.004

Data are presented as median [IQR] or number (%). Group A: urgent surgery group with preoperative antibiotic administration ≤3 days. Group B: late surgery group with preoperative antibiotic administration >3 days. OP, operation; IQR, interquartile range.

which consistently highlight that chronic limitations in physiological reserves and mobility, along with subsequent additional comorbidities, are associated with a higher likelihood of post-pulmonary complications, extended intensive care unit (ICU) stays, and increased mortality following thoracic surgery (15,16).

One interesting finding from our study is that the presence of interlobar loculation on preoperative CT was significantly more prevalent in Group A (66.7% *vs.* 50.0%, P=0.02) and was associated with a reduction in postoperative hospital stay (P=0.01). This correlation may have derived from the fact that presence of interlobar loculation might have led to the decision for earlier surgical intervention due to the anatomical difficulty of accessing with tube drainage. Similar result was also reported in recent literature by Shiroshita *et al.* The study reported that interlobar effusion was associated with better 90-day mortality and the authors suggested that interlobar effusion may occur at the earlier stage of empyema thus identification and treatment could commence at earlier timing (14).

Clinically, it is important to detect empyema early and determine the appropriate timing for surgical treatment, as this minimizes the risk of complications and promotes post-operative recovery, thereby improving the patient's quality of life in the long term. Additionally, the development and implementation of standardized treatment protocols for

patients with empyema are necessary, and these protocols should be designed to reduce morbidity, recurrence rate, and the need for subsequent surgical interventions.

One of the main focuses to our study was safety and feasibility of urgent surgical intervention of complicated parapneumonic effusion with limited duration of perioperative antibiotics. According to the 2010 British Thoracic Society guideline and the American Association of Thoracic Surgery, antibiotics for pleural infection treatment is recommended to be continued for 3 weeks or at least for 2 weeks from the drainage and defervescence (5,17). Similarly, some recent retrospective studies of empyema reported that the median length of antibiotic therapy were 20 and 27 days (18,19). However, it is well known that unnecessary prolongation of antibiotics therapy may result in antibiotic-associated adverse events including resistance problems (20). And based on this expectation, some recent studies suggested that shorter postoperative antibiotics treatment could be applied in parapneumonic effusion patients, if clinical stability was obtained (21,22).

Although our study did not reach a robust conclusion on whether urgent surgical intervention definitively benefits complicated parapneumonic effusion, specific factors such as the presence of comorbidities, including cerebrovascular disease, lung parenchymal disease, and hepatitis, were significantly associated with prolonged postoperative hospital stay. In contrast, urgent surgical intervention within 3 days of admission and the presence of interlobar loculation on CT were clearly associated with a reduction in postoperative hospital stay. Despite limited preoperative antibiotic coverage, there were no significant differences in terms of empyema recurrence, postoperative complications related to infection or the need for additional treatment, such as reoperation. The urgent group was able to be discharged safely with a comparatively shorter total duration of antibiotic therapy.

Limitations

This study has several limitations. This is retrospective study conducted with relatively small number of patients (n=180) at a single-center and some clinical values were missing from the medical records. Preoperative CT scan was evaluated by two thoracic surgeons thus interobserver variability could interfere with the data interpretation. Decision for urgent surgical procedure was at the discretion of the physicians thus selection bias can interfere with the power of the study analysis. Despite these limitations, our study has the strength of validating role of urgent surgical treatment and its impact on postoperative clinical outcomes as well as duration of the hospital stay. With further larger scale prospective study, we may establish more effective treatment criteria for early surgical drainage of parapneumonic effusion or empyema and reach robust conclusion on whom to perform urgent surgical treatment.

Conclusions

Medical treatment is still considered as mainstay of initial treatment for empyema in most situations. If initial treatment fails and surgical intervention is subsequently planned after prolonged treatment duration, this appears to be associated with extended hospital stays and increased surgical duration, thus the initial treatment plan is crucial for the better prognosis. This study result demonstrated that urgent surgical drainage under limited duration of preoperative antibiotic coverage showed no difference in recurrence or 30-day mortality. In conclusion, we believe urgent thoracoscopic surgery could be considered on patients with certain comorbidities and complicated loculated effusions and expect safe clinical outcomes at shorter overall hospital stay.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The Institutional Review Board of Korea University Anam Hospital approved this study (No. 2023AN0183) and individual consent for this retrospective analysis was waived.

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