Treatment of multiloculated empyema thoracis using minimally invasive methods

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ABSTRACT

Introduction: The purpose of this study was to investigate the results of minimally invasive treatment modalities in early stage multiloculated empyema thoracis.

Methods: The minimally invasive treatment modalities of 114 patients with Class 5 thoracic empyema were retrospectively reviewed. The patients' demographics, symptoms, diagnostic studies, treatment options and complications were evaluated.

Results: A total of 47 patients underwent tube thoracostomy, 23 patients underwent fibrinolytic therapy with streptokinase and 44 patients underwent video-assisted thoracoscopic surgery (VATS) deloculation and debridement. No statistical differences were found in the patients' age, gender, Gram stain and antibiotherapy before intervention among the groups. Illness days before intervention was significantly longer in the tube thoracostomy group than in the others. The VATS group had a shorter drainage time and hospital stay than the others. The VATS and fibrinolytic therapy groups had lower complication rates and less open decortication requirements than the tube thoracostomy group. Success rates were 66, 95 and 100 percent in the tube thoracostomy, fibrinolytic therapy and VATS groups, respectively. In total, there were 35 patients with complications. The most frequent complication was air space. Two in-hospital mortalities occurred.

Conclusion: In patients with early stage multiloculated empyema, VATS deloculation and debridement is superior to tube thoracostomy alone and fibrinolitic therapy in reducing drainage time and hospital stay. It has a relatively high success rate without significant morbidity. Therefore, VATS decortication may be recommended as a first-line therapy in early stage multiloculated empyema thoracis.

Keywords: decortication, fibrinolytic therapy, empyema, tube thoracostomy, VATS

Singapore Med J 2010;51(3):242-246

INTRODUCTION

Pleural space infection, or empyema, is a frequently encountered condition that is associated with significant morbidity and mortality. This condition involves three developmental stages. Stage I, the acute or exudative stage, is characterised by a thin serous fluid with minimal debris. Stage II, the fibrinopurulent stage, is characterised by a thicker fluid and thick fibrin strands. The formation of loculations makes chest tube drainage less effective. Stage III, the organising stage, is characterised by a thick fibrous peel and scar formation.[1]

Drainage with antibiotherapy has been the primary form of treatment for complicated pleural effusions. If the empyema progresses to the fibropurulent or organised stages, this option may not be sufficient. In this condition, according to the guidelines published by The American College of Chest Physicians,[2] fibrinolytics, video-assisted thoracoscopic surgery (VATS), and open thoracotomy can all be performed as acceptable approaches. Recently, since the improvement of laparoscopic techniques, thoracoscopic surgery has become more effective, and is recommended for the treatment of many thoracic diseases, including empyema, with satisfactory results.

The authors have also performed various treatment options for early stage thoracic empyema for many years in our centres. The purpose of this retrospective study was to investigate the effectiveness and outcomes of our minimally invasive surgical treatment options in early stage empyema thoracis.

METHODS

This was a retrospective review of 114 multiloculated empyema patients surgically treated from January 1995 to December 2007 at our centres. The patients'

demographics, symptoms, diagnostic studies, treatment options and complications were evaluated.

Patients who were ≥ 18 years of age and had Class 5 empyema were included in this study. Those who were aged < 18 years, unloculated and had cronic empyemas were excluded. A diagnosis of empyema was established if they met the following criteria: existence of gross pus or organisms demonstrated on Gram stain or culture, or all of the tests were positive for pH < 7.2, a glucose level of fluid < 40 mg/l, lactate dehydrogenase above 1,000 IU/ml, protein level above 3 g/ml and white blood cell (WBC) over 15,000 cells/mm^3, and if their physical, radiological and laboratory signs accompanied the relevant clinical picture.[3] The classification of empyema was re-established according to Light's criteria.[4] Class 5 empyema was defined as loculated empyema which had a demonstrated organism on Gram stain or culture, or a pH < 7.0, and/or a glucose level of pleural fluid < 40 mg/l.

After radiographic studies were conducted, the initial diagnostic thoracentesis was carried out in all patients. The treatment options were tube thoracostomy (TT) alone, TT plus fibrinolitic therapy (FT), and TT plus VATS, or VATS alone. Between 1995 and 1998, we routinely treated empyema with TT alone and then followed up with the patient. We performed TT plus FT between 1999 and 2001. Since 2001, we have been performing VATS whenever loculated empyema was detected. To date, we have performed VATS on nearly all patients with Class 5 loculated empyema, except when there is a strict contraindication for surgery, or in patients unwilling to go through the operation. In these cases, we performed open decortication in case of failure of the main treatment options, in relation to the historical clinical preference.

TT indications in our clinics were the presence of pleural fluid that was macroscopically purulent, was positive on culture for bacterial infection, and for bacteria on Gram stain, or that had a pH < 7.2 in a patient with clinical evidence of infection. TTs were carried out in the bedside position and using local anaesthesia. Large bore thoracic tubes (28–32F) were inserted into the pleural space. In case of malpositioning of the tube or inadequate drainage, a second tube was inserted. Tubes were removed when the drainage dropped below 100 mL and the pleural fluid (PF) culture was negative.

Intrapleural FT was performed with streptokinase (SK). A single dose of SK 250,000 IU in a 250 mL saline solution was administered daily through the chest tube, and the tube was clamped. After four to six hours, the tube was declamped. SK application was repeated until the drainage dropped below 100 mL and became serous in nature.

Table I. Demographics of the patients (n = 114).

Demographic	Value
Mean age ± SD (range) (years)	50 ± 17 (18–89)
Male/Female	77/31
Symptoms	
Fever	91
Dyspnoea	80
Cough	67
Weakness	65
Chest pain	63
Aetiology	
Pneumonia	90
Tuberculosis	16
Pneumothorax	3
Trauma	3
Iatrogenic	2
Comorbid diseases	
COPD	8
DM type 2	6
CHI	2
Lung cancer	1
Bacteriology	
Pseudomonas Aeroginosa	24
Streptococcus Pneumoniae	20
Staphylococcus Aereus	4
Gram stain	
No staining	43
Gram negative	23
Gram positive	20

COPD: chronic obstructive lung disease; DM: diabetes mellitus; CHI: congestive heart insufficiency

VATS for empyema was performed as soon as possible after TT. VATS deloculation and debridement were performed with two or three port entries under general anaesthesia. A single large bore chest tube was inserted at the end of VATS.

Open decortication (OD) was not included in the study, as we considered the necessity of open decortication as a treatment failure for noninvasive treatment options in this study. The main criteria for open decortication were inadequate drainage, defined as the presence on a chest radiograph of > 50% of the original amount of pleural fluid, inadequate reexpansion of the lung, defined as the presence on a chest radiograph of > 30% of the hemithorax, and persistent sepsis, defined as the presence of persistent fever (> 38.0°C) and elevated peripheral WBC count (> 11,000/mm^3).

Illness days before intervention was described as the period between the beginning of the initial symptoms and TT application. Antibiotherapy days before intervention was described as the period between the beginning of antibiotherapy and the main application. Drainage after intervention refers to the drainage period between the main treatment option and chest tube removal. Hospital stay refers to the period between TT application and

Table II. Comparison of the treatment options.

Parameter	TT (n = 47)	SK (n = 23)	VATS (n = 44)	p-value
Mean age ± SD (range) (years)	50 ± 19 (18–88)	55 ± 16 (26–89)	49 ± 15 (18–89)	0.407
Gender (male/female)	31/16	17/6	26/18	0.494
Gram stain (Gram −/+)	7/20	6/7	10/21	0.452
Illness day before intervention	7 ± 3 (4–14)	5 ± 1 (2–8)	4 ± 1 (2–8)	0.001*
Antibiotherapy day before intervention	8 ± 4 (2–21)	7 ± 4 (1–19)	6 ± 2 (2–14)	0.065
Drainage day after intervention	11 ± 4 (5–23)	9 ± 3 (5–20)	2 ± 1 (1–3)	0.001*
Hospital stay (days)	13 ± 4 (5–25)	11 ± 3 (6–23)	3 ± 1 (1–5)	0.001*
Total complication count	23	9	2	<0.001*
Pleural decortication requirement	17	0	0	<0.001*
Perioperative mortality	2	0	0	NA

Multiple comparison: Illness day before intervention: TT vs. SK, p = 0.003*; TT vs. VATS, p = 0.013*; SK vs. VATS, p = 0.625
Drainage day after intervention: TT vs. SK, p = 0.231; TT vs. VATS, p < 0.001*; SK vs. VATS, p < 0.001*
Hospital stay: TT vs. SK, p = 0.209; TT vs. VATS, p < 0.001*; SK vs. VATS, P < 0.001*
* denotes statistical significance.
SD: standard deviation; TT: tube thoracostomy; SK: streptokinase; VATS: video-assisted thoracoscopic surgery

patient discharge. Perioperative mortality rate was defined as the percentage of patients who died of causes related or unrelated to the disease, or operation within 30 days of surgery.

The data was expressed as mean ± standard deviation. The categoric variables were expressed by the count and percentage. One way ANOVA was used to compare the continuous variables. Tamhane's T^2 test was used for post hoc comparisons, while the chi-square test was used to compare the categorical variables. A p-value of < 0.05 was considered to be significant.

RESULTS

A total of 114 Class 5 empyema patients were surgically treated with TT (n = 44), SK (n = 23) or VATS (n = 47). The mean age was 50 ± 16 (range 18–89) years, and the male to female ratio was 80:34. The demographics of the patients are provided in Table II. Fever and dyspnoea were the most frequently encountered symptoms, and pneumonia was the most frequent aetiological source. 50% (43 out of 86) of PF performed Gram stains revealed bacterial isolation. A bacteriologic diagnosis could be made in 48 of the 114 patients (42%) with PF culture. Tuberculosis empyemas was diagnosed with PF tuberculosis culture. The patients' demographics are provided in Table I.

A total of 84 patients underwent initial TT after diagnosis. In total, 52 chest tubes were introduced among the patients in the TT group and 27 in the SK group. The mean SK application was 5.4 ± 2.4 (range 2–11) days. In the VATS group, 17 patients underwent initial TT to improve their septic condition before VATS, and 30 underwent VATS decortication directly. In total, 17 patients underwent open decortication due to treatment failure. All these patients were in the TT group, and were treated prior to the utilisation of VATS in our centres. No patient required open decortication in the SK and VATS groups.

In the TT group, the mean illness time was significantly longer than that of the SK and VATS groups. The mean antibiotherapy time before intervention was 7.3 ± 3.8 (range 1–21) days for all patients. There was no statistical difference in antibiotherapy time among the groups ($p = 0.065$). However, in the VATS treatment group, the drainage day after intervention and hospital stay were significantly shorter than in the TT and SK groups ($p < 0.001$ in both). The TT group had a higher complication rate and more OD requirements than the SK and VATS groups ($p < 0.001$ in both). The comparative evaluation of our treatment options is shown in Table II.

The success rates for TT, SK and VATS were 66%, 95% and 100%, respectively. The most frequent complication was pleural space (Table III). Two cases of perioperative mortality occurred. One patient died due to sepsis on the 18th day, and the other died because of bronchopleural fistula on the 27th day of hospital stay. 17 patients required OD in the TT group. One patient had pleural haemorrhaging after the second SK instillation, after which SK application was stopped. Out of the 114 patients, 100 were followed up after a mean of 26.1 (range 2–86) months. Two patients in the TT group had recurrent empyema on the sixth and eighth day after chest tube removal. They were treated with OD uneventfully.

DISCUSSION

This study has shown that VATS deloculation and debridement involves less drainage time, hospitalisation time and morbidity than using TT alone or with FT, in

the treatment of early stage multiloculated empyema.

Between 1995 and 1998, we performed TT alone and followed up with the empyema patients. It was observed that the success rate was low, and that a high rate of open decortication was required among patients with loculated empyema. We then performed SK in patients with loculated empyema immediately after TT. This increased our success rates, and open decortication was no longer required in patients with loculated empyema between 1999 and 2001. On the other hand, our drainage time and hospital stay remained as long as that observed with TT alone. Since 2001, we have routinely performed VATS decortication when a diagnosis of loculation results in empyema. An initial chest tube before VATS decortication has been introduced in order to improve the general condition of the patient when required. So far, after VATS decortication applications, our success rate has been 100%, and the hospital stay has been significantly shortened in Class 5 empyema patients.

According to Light's classification,[4] antibiotic treatment is sufficient for Class 1 and Class 2 empyema, whereas pleural drainage in addition to antibiotic treatment is recommended for Class 3 and above. We had also routinely conducted TT in patients with Class 5 empyema thoracis in our clinics in the past. Currently, VATS evacuation, deloculation and debridement under general anaesthesia is preferred. We have also performed TT in multiloculated empyema in order to stabilise risky patients, such as in septic conditions and/or in cases with the existence of bronchopleural fistula.

Out of the 114 patients, 47 were treated with TT alone, and the success rate was 66%. High failure rates (up to 87%) with conservative treatment have been reported, especially in patients with multiloculated empyema.[5-7] Mandal et al reported a 37% failure rate for TT in his series of 179 patients, where the mortality rate was 11% in the same group, and 26% of the patients had to undergo a second intervention. The overall mortality was 6.7%.[8] Our morbidity and mortality rates for TT alone were 49% and 0.4%, respectively. Eight (18%) patients required a second tube insertion, and 34% of the patients required OD.

Our results also highlight the importance of the interval between the onset of symptoms or pleural effusion and intervention on the success of the treatment of empyema. In the TT group, the period of illness days before intervention was longer than that in the SK and VATS groups. This condition may worsen the success rate of TT treatment as compared to the other groups.

Many reports have shown that intrapleural FT provides significant benefits in reducing the requirement for surgical intervention, and increases the success rate as compared to performing TT alone.[9-11] Success rates of 35%–87% have been reported, even in patients with frank empyema.[11,12] Fibrinolysis is an independent factor for a better outcome.[11] In contrast, Maskell et al reported in a large randomised study that SK instillation did not improve mortality, the rate of surgery or the length of hospital stay in patients with empyema.[13] Our study confirmed that SK instillation is beneficial in reducing the requirement of OD, and increases the success ratio. In our series, FT had to be interrupted in one patient because of haemorrhagic drainage during the second dose, and no patient underwent OD. Our success ratio was 95%. This relatively higher ratio may be due to the time allowed for the re-expansion of the patients' lungs before OD was attempted. Although seven patients had obvious pleural space at the time of drainage removal, all had complete re-expansion at the first to third month follow-up.

With the advent of VATS, several authors have reported encouraging results for the management of fibrinopurulent Stage II empyema.[14-16] VATS is less invasive than OD and is better accepted by both the referring physician and patient. However, VATS has obvious limitations for the treatment of Stage III disease. Its success rate ranges from 68%–93%.[17] The success rate of VATS is higher in patients with a history shorter than four weeks; however, the requirement of decortication increases in patients with a history of over five weeks.[17] Our success rate was 100%, which was relatively higher than that reported in the literature. This can be explained by the fact that our patients were all early stage multiloculated (Class 5) empyema patients.

In patients undergoing a VATS approach to empyema, the conversion thoracotomy rate ranges from 5%–59%.[17,18] The conversion thoracotomy rate is influenced by the aetiology of empyema. In patients with clinical Stage II empyema, the rate has been reported as 55% in postpneumonic, 32% in postraumatic

Table III. Complications after the treatment options.

Complications	TT	SK	VATS
Air space	17	7	1
Air leak > 5 days	3	0	0
Atelectasis	2	0	1
Bleeding	0	1	0
Air-fluid level	0	1	1
Wound infection	1	0	0
Total	23	9	3

TT: tube thoracostomy; SK: streptokinase; VATS: video-assisted thoracoscopic surgery

and 29% in postoperative empyemas.[18] The reported postoperative complication, recurrent empyema and 30-day postoperative mortality rates were 9%, 2.4% and 4%, respectively.[18] Our complication, conversion thoracotomy and mortality rates were 0.7%, 0.0% and 0.0%, respectively.

Open surgery is still a method that achieves excellent results in advanced pleural empyema. Although its indications are now limited by its invasive nature, OD by thoracotomy must be the procedure of choice for the treatment of pleural empyema when VATS is not sufficient. Light has advocated that if a sizeable empyema cavity remains after seven days of chest tube drainage, consideration should be given to performing an OD.[4] However, our experience has shown that, particularly in patients with concomitant pneumonic consolidation, lung expansion is not as good as in a healthy lung, even in the absence of pleural thickening. In these patients, waiting and a follow-up period after chest tube removal may be better than early OD in achieving re-expansion of the lung. In 13 of our 25 patients with a pleural cavity, the lungs fully expanded one to two months after the drain removal.

In conclusion, in patients with early stage empyema, VATS deloculation and debridement is superior to TT alone and FT in reducing the drainage time and hospital stay. It has a rather high success rate without significant morbidity. Therefore, it may be recommended as a first-line therapy for early stage multiloculated empyemas.

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