Evaluation of management of postpneumonic empyema thoracis in children

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Background **Empyema is a well-known sequelae of pneumonia, which is increasingly being reported in children despite strict management. The appropriate management remains controversial. The aim of this study was to evaluate different management options of postpneumonic empyema in children.**

Materials and methods **A total of 330 patients were reviewed between 2002 and 2012; their ages ranged from 1.25 to 15 years, with a median age of 4.3 years. The various management procedures included thoracentesis ($n=11$), chest tube drainage ($n=229$), chest tube drainage with intrapleural fibrinolytic therapy ($n=117$), video-assisted thoracoscopic surgery (VATS) ($n=35$), and thoracotomy because of a trapped lung noted on admissions and failed procedures ($n=94$).**

Results **Variable success rates were noted as follows: tube thoracotomy (48.24%), fibrinolytic treatment (68.37%), and VATS (85.71%). Postoperative complications (11.14%) included wound infection ($n=10$), atelectasis ($n=18$), delayed expansion ($n=7$), and need for reoperation ($n=2$). Four patients died (1.21%), two of them following thoracotomy, one patient after fibrinolysis, and one patient following VATS. Patients treated with thoracotomy recovered completely.**

Conclusion **New therapeutic modalities had variable success rates in children with postpneumonic empyema. Thoracotomy is still needed as a last resort for cases unresponsive to chemical fibrinolysis and following failed thoracoscopy.** ***Ann Pediatr Surg*** **9:131–135 © 2013 Annals of Pediatric Surgery.**

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Introduction

The incidence of empyema is increasing worldwide, causing significant childhood morbidity, with an estimated 0.6% of childhood pneumonia progressing to empyema [1–5]. The aim of treatment in empyema is to sterilize the pleural cavity, reduce fever, and ensure full expansion of the lung and its return to normal function. Many treatment options are available including antibiotics alone or in combination with thoracentesis, chest-drain insertion, chest drain and fibrinolytics, and decortication through thoracotomy or video-assisted thoracoscopic surgery (VATS).

Intrapleural fibrinolytic agents (urokinase and streptokinase) have been shown to be safe in several studies and have been found to play an important role in the treatment of empyema [6,7]. Some centers use fibrinolytics and in the event of failure, patients will undergo either open decortication or VATS [8]. The treatment is not yet standardized and currently patient care is dependent on local practice and physician preference. Success rates with these treatment regimens have been highly variable, most likely related to the stage of empyema at presentation [4,5].

The aim of this study was to assess different treatment options in the management of postpneumonic pediatric empyemas.

Materials and methods

Between 2002 and 2012, 330 children (182 boys and 148 girls) were hospitalized with postpneumonic empyema in our clinic. Their ages ranged from 1.25 to 15 years, with a median age of 4.3 years. Patients were included if they were younger than 15 years of age and had radiographic evidence of empyema (pleural fluid on chest radiograph and ultrasound). Cases other than postpneumonic empyema were excluded.

Indications for drainage were a persistent fever of 38°C (100°F) or greater after more than 24 h of parenteral antibiotic treatment or respiratory distress (tachypnea and/or oxygen requirement) caused by the pleural collection.

The laboratory investigations included blood culture, hemogram, differential counts, coagulation profile, C-reactive protein, electrolytes, albumin and lactate dehydrogenase, glucose, and pH values in pleural tap. For successful drainage, imaging facilities of the chest were obtained to determine the proper chest tube insertion when pleural effusions were difficult to access and to detect loculations.

The diagnosis of empyema required one or more of the following characteristics: (a) grossly purulent pleural fluid documented by thoracentesis, (b) pleural fluid glucose level less than 50 mg/dl, (c) pleural fluid level pH below 7.00, (d) positive Gram stain, and (e) pleural fluid lactate dehydrogenase level above 1000 IU/l.

Initially, all patients were managed with wide-spectrum antibiotics (ampicillin/sulbactam) and were later tailored toward positive culture results. In acute empyemas and parapneumonic effusions, the first step in treatment was pleural aspiration plus lavage; 11 patients (4.94%) were treated in this manner. The second step was chest tube

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insertion. Patients whose conditions did not improve clinically and radiologically with thoracotomy were considered for intrapleural fibrinolytic therapy. In patients with inadequate drainage, thoracic ultrasonograms and/or computed tomography (CT) were obtained for the presence and sites of the loculations. In these patients, a second chest tube was inserted to facilitate drainage. Patients were classified into five initial treatment groups: group A: thoracentesis alone ($n = 11$); group B: chest tube drainage alone ($n = 229$); group C: fibrinolytic therapy after inadequate chest tube drainage ($n = 117$); group D: VATS following failed fibrinolytic therapy ($n = 35$); and group E: thoracotomy after lung entrapment and failed procedures ($n = 94$).

Multiloculation was detected radiologically. The main multiloculation criteria were as follows: viscous pleural fluid with septations consisting of fibrin clusters detected by ultrasonography, no improvement in the chest radiograph view after chest tube insertion, viscous and less empyema fluid drainage than expected relative to films, and continued fluid aspiration with thoracentesis after thoracotomy. Streptokinase, 250 000 U in 100 ml of 0.9% saline solution, instead of urokinase, was instilled daily into the chest tube and the tube was clamped for 4 h. Mobilization of the patient was encouraged. The drain was then unclamped and placed on a negative suction pressure of 10–20 cm of H_2O until the next instillation. This treatment was continued daily for 3–7 days until resolution was achieved by chest radiograms or computed chest tomography. Patients were also observed for signs of anaphylaxis, respiratory decompensation, chest pain, and bleeding.

In patients without clinical and radiological improvement, or no increase in pleural fluid drainage, or in whom an allergic reaction developed, fibrinolytic treatment was discontinued. Failure was defined as persistent fever of more than 38°C for 4 days after intervention, associated with persistence of fluid on pleural ultrasound scan.

After instillation, those who failed fibrinolytic treatment received VATS or decortication. VATS was performed through three ports and under general anesthesia. The free fluid was evacuated and loculations were drained, the fibrinous adhesions were separated, and the pleural debris removed from the pleural lining using endoscopic grasping forceps or by extensive irrigation and suction. After the procedure, one or two chest drains were placed in port holes on negative suction pressure of 10–20 cm of H_2O to facilitate further drainage.

In all patients, the chest drains were removed when there was minimal drainage (40–60 ml/24 h) and the patients were discharged home if they remained afebrile for 48 h after drain removal. Patients whose conditions did not improve clinically with thoracotomy, fibrinolysis, or VATS were considered for open decortication. All decortications were performed through muscle-sparing thoracotomy. Therefore, the fibrinous peel on the surface of the visceral and parietal pleura was removed carefully with success.

Statistical analysis

Median values were calculated for discrete variables. All categorical variables were presented as number of patients and percentages. The median of five groups was analyzed using the Kruskal–Wallis test, followed by the post-hoc Mann–Whitney corrected Bonferroni test. Two-sided P values were considered statistically significant at a P value of 0.05 or less. Statistical analyses were carried out using the statistical packages for SPSS 15.0 for Windows (SPSS Inc., Chicago, Illinois, USA).

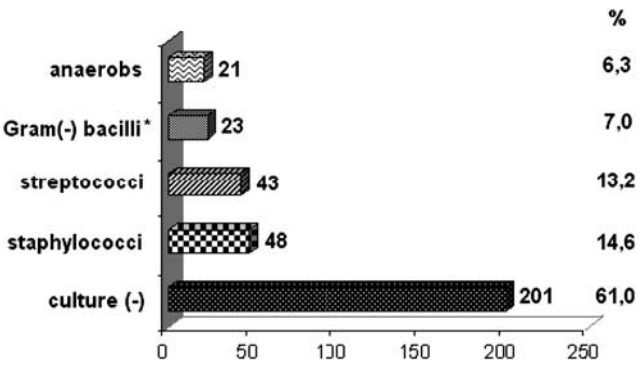
Results

Pleural fluid culture results are shown in Fig. 1. Microbiologic studies of pleural aspiration fluid showed that *Staphylococcus aureus* was the most common pathogen in 48 (14.6%) patients. Polymicrobial results were 1.78%. The blood culture was positive in 12 (3.6%) cases in addition to bacterial growth in pleural fluid culture. No agent was isolated from the cultures of 61.0% of patients.

Eleven patients (4.94%) were treated with repeated thoracentesis and appropriate intravenous antibiotics (group A). Closed-tube thoracotomy was performed in 229 patients (group B), and 109 (47.59%) of them were treated successfully in this way. Bronchopleural fistula was seen in three patients. Two patients died because of accompanying pneumonia and one underwent thoracotomy. In the remaining 117 patients with chest drain (group C), streptokinase was used as fibrinolytic therapy. Death followed an allergic reaction and pleural hemorrhage in one patient. One patient developed bronchopleural fistula. Fibrinolysis was successful in 80 (68.37%) patients. VATS was performed in the remaining 35 cases (group D). VATS failed in five (14.28%) cases and one patient died in this group. Group E included 94 patients (90 cases of lung entrapment on the admission CT and four patients of failed procedures). This group underwent thoracotomy for decortication.

All patients of group C showed an increase in chest tube drainage within 24 h following instillation of a fibrinolytic agent, with volume of drainage considerably greater than that instilled. Most of the improved drainage was within 48 h. The coagulation parameters of all our patients remained within normal limits before and after fibrinolytic therapy. Overall, a response rate was obtained in 80 patients with fibrinolytics. Treatment was ineffective in 35 of 117 patients who underwent streptokinase instillation; they were

Fig. 1



Microbiological results of patients.

Table 1 Baseline characteristics and results of the groups

Groups	A	B	C	D	E	Kruskal–Wallis test P^a	Post-hoc Mann–Whitney corrected Bonferroni test (groupi–groupj) P^b
N	11	229	117	35	94		
Age (years) (range)				4.3 (1.25–15)			
Sex (male/female)	6/5	126/103	59/58	18/17	49/45		
Symptom history (days)	9.5	13.0	15.0	16.0	16.5	<0.001	A–B; A–C; A–D; A–E; B–C; B–D; B–E; <0.001
Postintervention hospital stay (days)	9.0	10.0	11.0	10.0	10.5	0.039	A–B; A–C; A–D; A–E; <0.05
Success (%)	4.94	47.59	68.37	85.71	100.00	<0.001	A–B; A–C; A–D; A–E; B–C; B–D; B–E; C–D; C–E; D–E; <0.001
Morbidity (*n*)	1	9	11	9	7		
Mortality (*n*)	–	2	1	1	–		

[a]Kruskal–Wallis test was used to analyze the median of five groups (A, B, C, D, and E).
[b]Post-hoc Mann–Whitney corrected Bonferroni test was used to analyze paired groups that were found to be significant by the Kruskal–Wallis test.

then considered for further surgery and underwent thoracotomy or VATS.

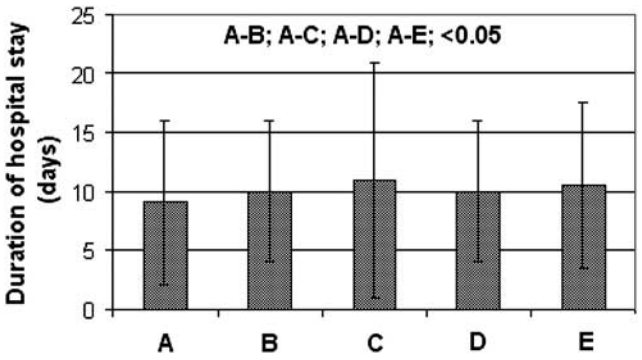
Diagnostic thoracentesis was negative or minimal in 90 patients. After initial thoracentesis and thoracotomy, these patients underwent thoracotomy for decortication because of trapped lung on chest CT. In addition to decortication, pulmonary resections were performed in five patients. We performed lobectomy in two, wedge resection in one, and segmentectomy in two patients. All patients recovered completely in the thoracotomy group (Table 1).

Postoperative complications (11.14%) included incisional infection in 10 patients, atelectasis in 18 patients, delayed expansion in seven patients, and reoperation after hemorrhage in two patients. In cases with wound infection, complete resolution was achieved with antibiotics tailored to culture results and repeated dressings. Atelectasis was treated with respiratory exercise and nasotracheal aspiration; no bronchoscopy was needed. Indication for reoperation in a 7-year-old child was the oozing of 300 ml/day through the chest tube. Intercostal artery ligation was performed in this case.

Patients were regularly seen at the polyclinic at 10, 30, and 90 days after discharge. Four patients died because of sepsis, heart failure, pneumonia, or pleural hemorrhage (1.21%). These four patients presented with congestive heart failure and pneumonia at the time of admittance. In one patient with fibrinopurulent phase empyema, intrapleural streptokinase treatment was discontinued because of hemorrhagic drainage. In the thoracotomy group, all patients recovered completely and no deaths occurred.

The baseline characteristics and results are summarized in Table 1. All data were analyzed according to the intention-to-treat principle. The median of five groups was analyzed using the Kruskal–Wallis test, followed by the post-hoc Mann–Whitney corrected Bonferroni test. According to the results of the test, symptom history (days), postintervention hospital stay (days), and success rate were found to be significantly different ($P \leq 0.05$). Patients successfully treated within group A had a shorter duration of median hospital stay of 9 days (range 5–12).

Fig. 2



Length of hospital stay of various groups.

Patients with VATS, group D, had a shorter postintervention hospital stay of 10.0 days (range 5–11) compared with children who received fibrinolytic therapy, group C (11.0 days; range 7–17). The median hospital stay after open surgery, group E, was 10.5 days (range 6–13) (Fig. 2).

Discussion

Pleural effusion that may develop during the course of nonspecific bacterial pneumonia can progress to empyema for several reasons including malnutrition, immunodeficiency, irregular antibiotic treatment, delay in diagnosis of pneumonia, contamination during thoracentesis, the tendency for antibiotic treatment in the acute phase in pediatric clinics, and disappearance of the signs and symptoms of pneumonia [1].

Determination of the empyema has been reported to be crucial in choosing an appropriate therapeutic option [9]. The duration of hospital treatment of patients with empyema is longer in those with parapneumonic effusion. If untreated, empyema progresses to a fibrinopurulent nature in a short time, leading to more fibrin accumulation in the pleural area. Aspiration may fail to treat empyema unless the pleural fluid is free flowing. Obtaining pleural effusion by thoracentesis may sometimes be difficult even using a large needle. Chest tube

drainage becomes the mainstay treatment when the effusion continues to increase.

The total hospital stay reached 26 days for some patients who finally underwent decortication. Hospital duration of our patients was longer than those reported in the literature. This may be related to the need for longer preparation and observation as well as the relatively high mean number of multiloculated chronic cases [10].

This retrospective study aimed to show whether there is significant clinical difference in the duration of hospital stay after intervention among chest tube drainage alone, intrapleural fibrinolysis over chest tubes, and VATS for the treatment of empyema in children. Although there have been many case series comparing surgical interventions with fibrinolytics, the aim of instillation of fibrinolytics into the pleural cavity is to lyse the fibrinous strands and clear lymphatic pores, thus improving drainage [11–13]. Because of the reported low success rate of tube thoracotomy for loculated empyema, alternative approaches have been developed. Several reports have documented successful drainage of multiloculated empyema using streptokinase and urokinase administrated through a single chest tube [14–16]. In multiloculated cases, fibrinolytic instillation had a success rate of 68.37%, whereas this rate was 100% with open thoracotomy for decortication.

The use of VATS for the primary treatment of empyema in children has been gaining popularity over the past decade. Proponents of VATS suggest that it has a potential advantage over open surgery of limiting the morbidity to skin, muscles, nerves, and supporting structures that occur after a large surgical incision entailing pain, infection, limitation of movement, and cosmetic scarring [17–20]. Furthermore, VATS may reduce cytokine responses compared with conventional surgery [21]. The major limitation of VATS is the absence of skilled operators; poor results have been reported in some centers and surgical expertise to perform pediatric VATS is limited to some centers [22,23]. It was reported that a group of patients in the fibrinopurulent phase were treated with VATS and compared with patients treated by formal thoracotomy [24]; patients with VATS in that series had the same success rate as open thoracotomy but offered substantial advantages over thoracotomy in terms of resolution of the disease, hospital stay, and cosmesis [24].

We started treating with VATS and have achieved positive outcomes in 85.71% of 35 cases. We specifically found that VATS is an encouraging treatment option in cases of the fibrinopurulent phase. Our study was not designed as an equivalence study as we based our hypothesis on previously reported results and expected patients were randomly selected for VATS treatment to shorten their hospital stay.

In evaluating the most effective management approach, we identified our primary outcome measure as the length of hospital stay following intervention, rather than as the total hospital stay. The treatment groups in the study were well matched for baseline characteristics. We found a difference in length of hospital stay following intervention among the groups.

Some authors suggested that if on inspecting the pleural cavity and trial of thoracoscopic decortication, the surgeon deemed VATS to be inappropriate (thick peel preventing lung expansion), the procedure was converted into a minithoracotomy. This was deemed to be a failure of VATS [25]. There are no therapeutic or recovery advantages between VATS and fibrinolysis for the treatment of empyema; however, VATS resulted in significantly higher cost. Fibrinolysis should be used as initial therapy in children with empyema even though there is less risk of clinical worsening [26].

Early decortication had beneficial effects on pulmonary perfusion [27]. Fibrinolytic use should be considered in potential decortication candidates in an effort to avoid surgery with attendant morbidity [28]. However, surgical morbidity is low and the mortality rate is very rare. In contrast, surgery resulted in a low mean empyema and complete resolution in 100% of patients. In contrast to studies that favor intrapleural fibrinolytic therapy, in an experimental animal model, streptokinase and urokinase were not found to be effective for liquefaction of thick pleural exudates [29].

Chest tube drainage is a safe, effective primary treatment of postpneumonic pediatric empyema, especially in exudative and purulent stages. In cases where chest tube drainage is insufficient, thoracotomy with decortication can be used successfully, with low morbidity and mortality rates [30].

The presence of a thick rind and trapped lungs is an indication for surgery and decortications [3,31–33]. The inability to evacuate fibrinous debris through chest tube is also an indication for decortication. Decortication should be performed as soon as possible if drainage is not effective. It may be used as an initial treatment instead of wasting time by performing thoracotomy. When the patient's status is suitable for surgery, we choose this approach because of the decrease in mortality and morbidity, reduction of hospital stay, and discharge of the patient with uneventful recovery.

Conclusion

Fibrinolytic therapy is not an alternative to surgery, especially in loculated empyemas in children. However, it should be tried in all cases of fibrinopurulent phase empyema not responding to closed chest tube drainage. This treatment increases the success of less invasive treatment. We prefer open thoracotomy or VATS for complete lung decortication, in fibrinopurulent cases, following the escalation process.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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