Original Article

Surgical management of stage III pediatric empyema thoracis

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ABSTRACT

Aim and Objective: This study aims to report 100 pediatric patients of empyema thoracis treated by open decortication, highlighting the presentation, delay in referral, operative findings, the response to surgical intervention, and follow-up. **Materials and Methods:** All the children who underwent open decortication for stage III empyema thoracis during the study period January 2015–December 2016 were included. Preoperative workup included hemogram, serum protein, chest radiographs, and contrast-enhanced computed tomographic (CECT) scan of the chest. **Results:** One hundred (65 males, 35 females) (age 2 months–13 years, mean 4.5 years) were operated during a 2-year period. Among them, 90% patients were referred 3 weeks after the onset of disease. Intercostal chest drainage (ICD) had been inserted in (95) 95% cases. Thickened pleura, multiloculated pus, and lung involvement were invariably seen on CECT scan. Bronchopleural fistula was present in five patients. Decortication and removal of necrotic tissue were performed in all the patients. Mean duration of postoperative ICD was 4 days. Follow-up ranged from 1 month to 2 years (mean 12 months). There was no mortality. Five patients had proven tuberculosis. Only 10% presented within the early period of the disease. **Conclusion:** The duration of the disease had a direct relationship with the thickness of the pleura and injury to the underlying lung. Delayed referral causes irreversible changes in the lung prolonging recovery. Meticulous open surgical debridement gives gratifying results. The status of the lung at the end of surgery is a major prognostic factor.

KEY WORDS: Contrast-enhanced computed tomographic chest scan, decortication, empyema thoracis, pediatric

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INTRODUCTION

Empyema thoracis is a common disease. Children often present with persistent fever associated with cough, respiratory distress, and occasionally chest pain. Most cases follow a bout of pneumonia which may have been particularly virulent in a child with poor nutritional status or immunity. The American Thoracic Society has described 3 stages of empyema, namely exudative, fibrinopurulent, and organized, more or less based on the characteristics of the contents of the pleural cavity. Empyema thoracis is seen all over the world with an apparent increase in its incidence in the West.[1,2] In addition, the overall percentage of empyema as a proportion of pneumonia increased from 0.27% to 0.70% ($P < 0.05$).[2] In our own experience, over the past few years, there appears to be an increasing awareness among pediatrician colleagues over the requirement and benefits of decortication, which has led to a higher referral rate. We present our data from a tertiary care center, highlighting the presentation, delay in referral, response to surgical intervention, and follow-up.

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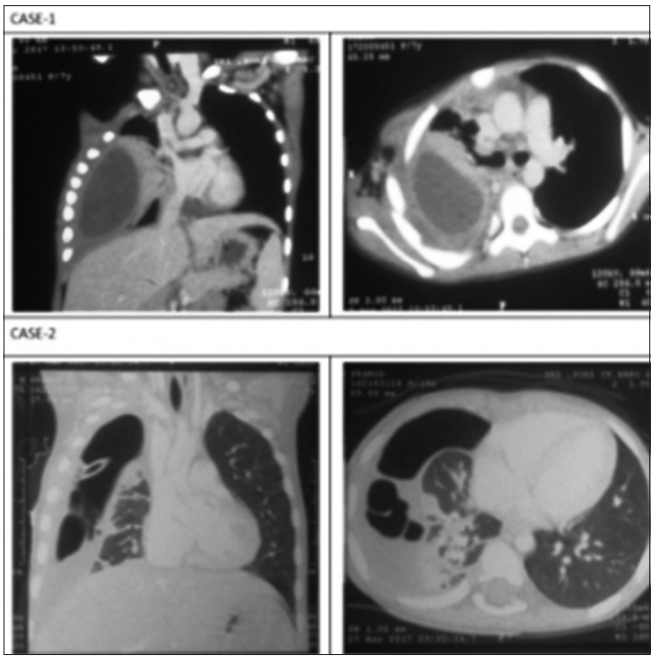

Figure 1: Contrast-enhanced computed tomographic chest images

MATERIALS AND METHODS

All consecutive patients during the period from January 2015 to December 2016, who underwent decortication, were analyzed. Patients were investigated with complete hemogram, serum proteins, chest radiographs, and a contrast-enhanced computed tomographic (CECT) scan [Figure 1] of the chest before surgery. Both clinical symptoms and presence of debris/pus as well as degree of lung entrapment on CECT scan were taken into account. The postoperative care included care of the chest drain [Figure 1]. Chest radiographs were taken on day 1 postoperative, when the drain output was nil and after removal of the tube to rule out pneumothorax/collection. It was also done when there was no drainage, but the patient was symptomatic. Patients were started on incentive spirometry as early as possible along with nursing in an upright position [Figure 2]. Adequate pain relief and antibiotics were given intravenously till good oral intake resumed. The antibiotics were changed depending on the culture report of the pus/debris sent at the time of surgery. Patients were followed up at 3 months and 1 year or more frequently in the presence of symptoms.

Surgical technique

Surgery was done with a standard posterolateral thoracotomy through the 4th or 5th intercostal space. The thick parietal pleura appearing in the incision site was excised and all pus and debris in the pleural cavity were removed [Figure 3]. The visceral pleura was meticulously removed. The lung was allowed to expand, closing all air leaks detected with the help of manual ventilation. Necrotic lung tissue was removed and bronchopleural fistulas (BPFs) were closed. Chest tube drains were placed, and the thoracotomy wound closed after giving an intercostal block.

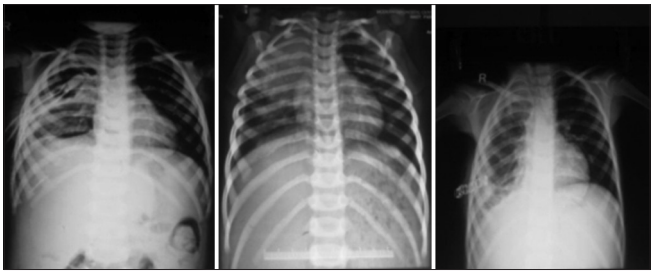

Figure 2: Follow-up chest X-ray

Table 1: Pre operative and post operative data of the patients

Variable	Number of patients and %
Sex (%)	
Male	65 (65)
Female	35 (35)
Side of the thorax of empyema (%)	
Right side	55 (55)
Left side	40 (40)
Bilateral	05 (05)
Presentation (%)	
Before 3 weeks	10 (10)
After 3 weeks	90 (90)
Previous intercostal drainage	95 (95)
Postoperative BPFs	10 (10)
Preoperative culture (%)	
Sterile	75 (75)
Positive	25 (25)
Previously inserted ICD in lung parenchyma	10 (10)
Complete expansion after decortication	70 (70)
Histopathologically proved tuberculosis	05 (05)
Average operative time	90 min
Average postoperative surgical stay	5 days
Postoperative complication (%)	
Occasional fever and cough	10 (10)
Wound infection	05 (05)
Mortality	00 (00)

ICD: Intercostal chest drainage, Bronchopleural fistula

RESULTS

One hundred patients were treated. There were 35 girls (male:female = 1.85:1). Age ranged from 2 months to 13 years in boys and from 7 months to 11 years in girls. There were 55% right-sided, 40% left-sided, and 5% bilateral effusions. Decortication was performed on the right side in sixty patients, on the left in 40. There was a peak incidence during summers and rainy season (45%) compared to the rest of the year [Table 1].

Of the 100 patients, only 10% presented to us before 3 weeks of onset of illness. Ninety patients (90%) were referred after 3 weeks of the start of symptoms [Table 1]. It can be observed that 90% of the cases were delayed referrals. As a consequence of delay, they had a higher incidence of lung necrosis.

History of fever and cough was the most common feature. Respiratory distress often appeared to be the triggering

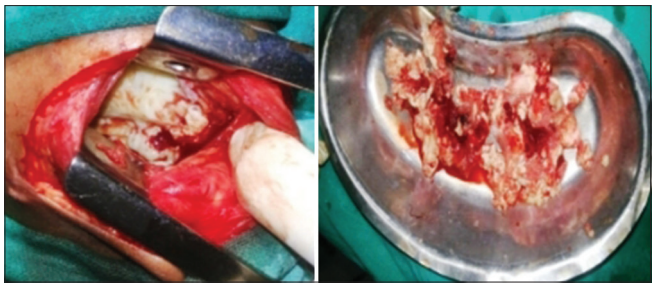

Figure 3: Operative photo

factor for referral. Serum albumin ranged from 1.8 to 3 g% with an average of 2.2 g%. Pallor was common with mean hemoglobin (Hb) 8.9 g% (6.5–10.9 g%). In majority of the patients, erythrocyte sedimentation rate, total leukocyte counts, and pleural lactate dehydrogenases (LDH) were raised.

There was variable amount of pus, air, and debris between the thickened parietal and visceral pleura. In majority of them, multiloculations were present with encasement of the entire lung with collapse consolidation. Intercostal chest drain had been inserted before referral in 95% patients (95%). The drain had been kept for a period with a mean of 3 weeks.

While 75% preoperative pus cultures were sterile, 25% were positive and mostly grew *Staphylococcus* and *Pseudomonas*. Before referral, nearly, all the patients had been administered multiple antibiotics. Five patients in the series were proven to have tuberculosis on histopathological examination of pleural/lung biopsy. There was evidence of BPF in ten patients, with leakage of large amount of air in the chest drain. The previously inserted intercostal drain was seen within the lung parenchyma in ten patients.

Complete expansion of the entire lung after decortication was seen in 70% cases. These patients had a faster time to recovery and removal of chest drain. Chest drains placed at the time of surgery could be removed within 3–7 days in the majority of patients. In the presence of cavitary necrosis, patients who underwent segmentectomy or lobectomy had faster recovery than those who underwent only debridement.

Follow-up ranged from 1 months to 2 years (mean = 1 year). No procedure-related or delayed deaths were seen. Weight gain was seen in nearly all patients, 3 months after surgery. Ten patients complained of occasional fever and cough. Five patients had wound infection. The average surgical time was 90 min (range 60–120 min). All patients underwent chest roentgenography, ultrasound, and chest computed tomography (CT). The average postoperative stay was 5 days (range 4–10 days).

DISCUSSION

Empyema, an accumulation of infected fluid within the thoracic cavity, is commonly secondary to postinfectious pneumonia. Empyema thoracis is a life-threatening emergency. It still remains a significant health problem in developing countries due to low socioeconomic status, malnutrition, and delay in diagnosis of pneumonia, delayed referral to higher center. In our study, we also found delayed referral. Determination of the stage of the empyema has been reported to be crucial in choosing an appropriate therapeutic option. Duration of symptoms has been suggested as one of the means of estimating the stage of the empyema. Empyema cases were seen more often in malnourished children similar to other studies conducted in developing countries.[3,4] Apart from the fluid, organized fibrinous deposits appear early in the disease-preventing complete drainage of fluid as well as penetration of antibiotics. An inflammatory peel of variable thickness soon forms preventing complete lung expansion. This leads to a variable clinical course creating a lot of confusion about the exact method of management. The disease becomes chronic, and delayed referral to the surgeons by the community physicians is common world over. Patients have usually been seen by local physicians in the presence of fever and cough and put on several courses of broad-spectrum antibiotics. They tend to come to a tertiary center with the onset of respiratory distress.

Furthermore, the availability of nonoperative alternatives frequently results in delayed surgical consultation, and ultimately, increased patient morbidity and mortality.[5] We found an increased incidence between May and August every year. A study from Taiwan also showed that the incidence of both pneumonia and empyema was highest each spring.[6] Another study from Canada showed that while admissions occurred throughout the year, they peaked between November and April.[7] In our study, there was increased numbers of cases in the summer and rainy seasons.

Chronic empyema was defined in accordance with the American Thoracic Society staging system, where stage III empyema corresponds to chronic empyema or the organizing stage. Fibroblasts migrate into the pleural cavity and produce an inelastic membrane, entrapping the lung and rendering it essentially functionless. This diagnosis was corroborated by illness durations of more than 15 days before definitive treatment as well as supportive imaging findings, such as constriction of the chest cavity.

Pleural effusion and empyema are known complications of bacterial pneumonia. Effusion occurs in at least 40% of bacterial pneumonias, with up to 60% of effusions resulting in the formation of empyema in all age groups. It occurs when bacteria invade and propagate in the normally sterile pleural space.

Staphylococcus aureus is the most common cause in the developing world, while the *Streptococcus pneumoniae* in the developed world.[8,9] The reported rates of identifying an infectious cause from pleural fluid vary between 8% and 76%, respectively. Pleural fluid is sterile due to widespread

early use of antibiotics. Other causes are *Streptococcus pyogenes*, *Haemophilus influenza*, *Mycobacterium* species, and *Escherichia coli*. In our study, *S. aureus* was the most common organism and most of the cultures were sterile.

Most patients had received one or more courses of antibiotics. Of these, only five patients were proven to have tuberculosis on histopathological specimen of pleural/lung biopsy. There was evidence of BPF in ten patients, with leakage of large amount of air in the chest drain.

Serum albumin averaged 2.2 g%. This may be secondary to the disease process or the disease itself may have manifested in a child with poor nutritional status. Pallor at presentation was common with preoperative Hb averaging 8.9 g% in our series. We usually transfuse whole blood preoperatively when the Hb is below 8–9 g%. Our study has shown that most cases of empyema are secondary to pneumonia.

Delayed referral increases morbidity by not only increasing parenchymal involvement but also causing a state of malnutrition. Since we are in a tertiary referral unit, patients invariably present at a late stage of the disease. Only 10% patients in our series gave a history of <3 weeks. Even in this group, thin pleura was seen at thoracotomy only in few patients. In most cases, the pleura had become a hard, leathery peel densely adherent to the underlying lung. However, we advise surgery only based on the clinical features (persistent high-grade fever, cough, respiratory distress, irritability, and poor appetite) along with corroboration by CECT scan and not on the duration of the disease.[10]

Empyema usually presents with persistent high-grade fever, cough, tachypnea/dyspnea, irritability, and chest deformity. Malnourishment and wasting are associated. Rarely, the empyema may be bilateral. A plain X-ray chest may show opacity, loculated air, pleural peel, and scoliosis. Loculated pus and pulmonary entrapment are not easily made out. Ramnath *et al*. devised an ultrasound-based grading system subdividing patients into low grade or high grade categorized by presence or absence of septations, fronds (like a leaf with many divisions), and loculi. Those with higher grade uniformly did better on surgical intervention with lesser hospital stay.

Lung necrosis may be associated in any of the scenarios. It may be secondary to incorrect placement of the chest tube, or more often, it is due to the severity of the disease process and may involve a part of a lobe, the entire lobe, or rarely the entire lung. In 10% cases, tube was placed in the lung parenchyma in our study.

Computed tomographic scan with contrast enhancement should be performed with lung and mediastinal windows to reveal the exact extent and nature of the disease. Very few authors have realized the importance of CECT chest while deciding for surgery.[11] The majority of studies that we reviewed were based on a chest radiograph and not a CT scan leading to incorrect judgment of the stage of the disease as well as delay in surgical intervention with consequent increased morbidity.[12]

A chest radiograph provides only two-dimensional information. It may only show opacity occupying a certain area of the hemithorax, which may be secondary to consolidated parenchyma, pleural peel, or a lung abscess. On the other hand, the ability of CECT to show the thorax in various sections and planes helps to reveal precise information about the location, density, and volume of the fluid along with the thickness of the pleural peel and the status of the underlying lung with its degree of entrapment. Loculations may be single or multiple, may contain pus, air, or both. A common clinical problem encountered is that the chest tube has stopped draining although the patient is still symptomatic. This may be secondary to the tube missing the pocket of loculated air or pus altogether or due to the consistency of the debris.

The most important investigation is a recent CECT scan of the chest. This and the clinical status of the child are the cornerstones for reaching the correct decision on surgical management.

Surgeons themselves are reluctant to operate partly due to inexperience and also because of the fear of "postoperative morbidity" mentioned in pediatric literature. However, our data show that it is a condition which if approached by the correct surgical technique gives excellent results with minimal morbidity.

In a study from Taiwan, the radiographic manifestations associated with severity of disease included bilateral involvement, thickness of empyema >3 cm mantle by chest CT scan in lying position, multiple loculated effusions, extent of empyema >1/3 hemithorax, and presence of air-fluid level in CT scans.[13] Hoff *et al*. in 1989 gave an empyema severity score to ascertain patients who may progress to a more severe disease based on the pleural fluid characteristics, chest radiography findings, and type of infection. Although the pleural fluid investigations (fluid with pH <7.2, glucose <40 mg/dL, LDH >1000 IU/dL, protein >2.5 g/dL, WBC >500/μL, and specific gravity >1.018) are good markers, this score singularly suffers from basing the severity on a chest radiograph alone and not a CT scan.

The definitive results of the surgical procedure were assessed using the scheme proposed by Melloni *et al*.[14] which takes into account elimination of symptoms, normalization of the white blood cell count, removal of pleural drains, return to preillness physical activities, and roentgenography.

In our experience, patients do not get referred to the surgeon at an early stage making thoracoscopic debridement extremely difficult. Due to delayed stage,

bleeding secondary to the inflammation is common, making endoscopic visibility poor and consequent conversion to open procedure. A study conducted in Switzerland had similar observations.[15] This has to be kept in mind that the primary aim is not only to remove pus but also to facilitate complete expansion of the lung by removing the visceral pleural peel. This may not be always achievable by thoracoscopic approach due to the thickness of the peel.[16] The pleural collection is often solid debris unlikely to come out through a catheter. The role of VATS in stage III empyema is however very much debatable.[17]

In theory, patients with loculations and septations should respond to fibrinolytic agents, thereby reducing the hospital stay instead of being treated only with chest tube drainage. However, solid evidence for the role of agents such as urokinase and streptokinase is lacking. There are also concerns regarding fibrinolytic therapy including bleeding and development of bronchopleural fistula.

Majority of the patients attending the tertiary care centers like ours are in this stage of the disease with massive debris, loculations, or thick leathery peel encasing the lung, and open surgical decortication becomes mandatory. The gold standard for surgical treatment at this stage remains thoracotomy and decortication.

Goal of surgery

(1) Thorough pleural debridement; (2) release of encased lung parenchyma by carefully removing the thick plural peel from the entire lung surface and making the lung expand; (3) meticulous closure of all major air leaks; and (4) excision of necrotic lung tissue, which may be required in nonresponsive necrotizing pneumonias, fungal pneumonias, and parenchymal abscesses.

Only standard open thoracotomy can attain all the above-described 4 surgical goals in comparison to thoracoscopic procedures and the mini thoracotomy described by Raffensperger.[18] In addition, lung expansion can be easily assessed before closure. In Hoff *et al*.'s study, in 18 of the 51 patients of empyema who underwent decortication, no deaths or morbidity were associated. No complications were observed in other studies as well.[18] Scoliosis resolved after completion of treatment in all four patients in whom it was noted in the Montreal's study. We also had no mortality in our study.

In addition, lactic dehydrogenase was consistently elevated in our study. Soriano *et al*.[19] established a direct relationship between higher levels of lactic dehydrogenase and a longer disease duration.

It is generally accepted that pleural empyema should be treated early to avoid complications, extensive operations, and lengthy hospital stays.[19,20] Unfortunately, there are some patients for whom early treatment is not possible and in whom chronic empyema will develop, mainly due to delayed diagnosis or delayed referral. At this stage, the standard treatment is open thoracotomy and decortication. In our study, open thoracotomy and decortication were found to be an excellent surgical procedure with low morbidity and mortality.

CONCLUSION

Empyema thoracis following parapneumonic effusions is a progressive disease and is associated with a lot of morbidity unless treated adequately and on time. If the period is more than 7 days, then an additional CECT chest should be performed which exactly quantifies the disease and the patient was treated as per stage and progress of disease process. Chest X-ray is only suitable for monitoring of lung expansion, and relying solely on it delays decision-making as it is unable to reveal the disease severity and predict the need for surgical intervention. CECT chest is necessary for complete evaluation of a child with suspected empyema, especially for surgical decision-making. Early surgery reduces morbidity and hospital stay. Decortication in empyema is safe, effective, and well tolerated by children.

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Conflicts of interest

There are no conflicts of interest.

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