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Clinico-Etiological Profile and Short-Term Outcome of Empyema Thoracis in Children Aged 2–12 Years: A Prospective Study from a Tertiary Care Hospital in Eastern India

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ABSTRACT

Background: Empyema thoracis remains a significant cause of morbidity among pediatric pneumonia cases, especially in developing countries. Despite advancements in diagnostic modalities and antimicrobial therapy, delayed presentation and socioeconomic factors continue to influence outcomes.

Methods: A prospective observational study was conducted over 18 months (July 2023–December 2024) at Burdwan Medical College and Hospital, including 100 children (2–12 years) with clinically and radiologically confirmed empyema thoracis. Demographic data, clinical presentation, microbiological findings, management modalities, and short-term outcomes were analyzed using SPSS v29. Statistical significance was defined as $p \leq 0.05$.

Results: Most children were aged 2–5 years (63%) and from lower socioeconomic backgrounds (42%). Fever (96%), cough (88%), and dyspnea (77%) were the predominant symptoms. Left-sided empyema was more common (52%). Pleural fluid culture was positive in 12%, most commonly isolating *Staphylococcus aureus* (41.7%) and *Streptococcus pneumoniae* (25%). Empirical antibiotics combined with intercostal chest drainage (ICD) achieved resolution in 73% of cases, while 14% required fibrinolytics. Mean hospital stay was 15.5±4.7 days for ICD-treated patients and 20.7±4.2 days for those receiving fibrinolytics. Laboratory parameters, including pleural fluid sugar, LDH, and cell count, significantly correlated with treatment intensity and outcome ($p<0.05$). Final discharge was achieved in 96% of patients.

Conclusion: Empyema thoracis predominantly affects young children from lower socioeconomic backgrounds. *S. aureus* remains the leading pathogen. Early diagnosis, prompt antibiotic therapy, and effective pleural drainage are key to favourable short-term outcomes.

Key-words: Empyema thoracis, children, *Staphylococcus aureus*, pleural drainage, fibrinolytic therapy

INTRODUCTION

Empyema thoracis refers to the accumulation of pus within the pleural space. It commonly develops as a complication of pneumonia, most often caused by *S. pneumoniae* in developed countries, whereas *S. aureus* predominates in developing regions and Asia, including post-traumatic cases [1]. Empyema accounts for approximately 5–10% of pediatric pleural diseases in India [2].

Historically, the condition was described by Hippocrates in 600 B.C., who defined empyema as the collection of pus in the pleural cavity and advocated open drainage as a treatment approach [3]. Despite centuries of clinical recognition, empyema thoracis continues to be associated with significant morbidity and mortality in children.

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Empyema arises from infection within the pleural cavity, most often following bacterial pneumonia. It may also occur secondary to thoracic trauma, surgical procedures, or esophageal perforation. The American Thoracic Society classifies empyema into three stages—exudative, fibrinopurulent, and organized—based on pathological characteristics of pleural fluid and membrane [4]. In advanced stages, the pleura becomes thickened, inflamed, and forms an abscess wall that supports pyogenic proliferation, contributing to persistent sepsis [5].

Although the overall incidence is low, approximately 0.6% of childhood pneumonia cases progress to empyema thoracis [6]. Delayed diagnosis, inappropriate antibiotic therapy, poor drug penetration into the pleural space, resistant organisms, malnutrition, and low socioeconomic status are major contributors to adverse outcomes. Common clinical presentations include fever, pleuritic chest pain, cough, dyspnea, and occasionally abdominal pain or vomiting due to diaphragmatic irritation. Physical findings typically reveal diminished breath sounds and dull percussion notes.

Radiological confirmation is essential. While chest X-ray helps identify pleural collections, thoracic ultrasonography is more sensitive in determining the volume and nature of the effusion, without radiation exposure. Computed tomography (CT) is reserved for atypical or complicated cases, including suspected malignancy [7].

Management primarily involves broad-spectrum intravenous antibiotics targeting common pathogens. In cases with significant pleural collection or respiratory compromise, intercostal chest drainage is indicated, preferably under ultrasound guidance with adequate analgesia in children. Intrapleural fibrinolytics facilitate drainage in thick or loculated empyema [8]. Surgical intervention becomes necessary in cases refractory to antibiotics, drainage, or fibrinolytics [7]. The fundamental goal of treatment is complete sterilization and evacuation of the pleural cavity, most effectively achieved through early drainage via a closed underwater seal system combined with appropriate antimicrobial therapy [6,8].

Empyema in resource-limited settings remains a challenge due to late presentation, antimicrobial resistance, and nutritional deficiencies, all contributing to prolonged hospitalization and increased morbidity [2].

MATERIALS AND METHODS

Research Design- This prospective observational study was conducted at the Department of Pediatrics, Burdwan Medical College and Hospital, from June 2023 to December 2024, with institutional ethics committee approval. Written informed consent was obtained from the parents or guardians of all participants. A total of 100 children aged 2–12 years with clinical suspicion of empyema thoracis were enrolled based on the inclusion and exclusion criteria. Each child was followed from admission for a minimum period of 14 days, and short-term outcomes were recorded.

Methodology- Children between 2 and 12 years of age who presented with clinical features suggestive of empyema thoracis, supported by radiological evidence and confirmed by the aspiration of purulent pleural fluid, were included in the study. Relevant clinical history, including symptoms, past illness, contact exposure, and treatment history, was obtained, followed by detailed general and systemic examination. The diagnosis of empyema thoracis was established based on clinical features, radiological evidence of pleural effusion on chest radiograph or ultrasonography, and confirmation by aspiration of purulent pleural fluid. Pleural aspiration was performed under aseptic precautions, with ultrasound guidance when required. After appropriate positioning and local anesthesia, pleural pus was aspirated using a suitable needle at the 7th–9th intercostal space in the posterior axillary line as per ultrasound guidance. and the sample was collected in sterile vials. Vital signs were monitored during and after the procedure. All patients underwent hematological, biochemical, microbiological, and radiological evaluation, including hemoglobin, total leukocyte count, C-reactive protein, blood culture, and pleural fluid analysis for cell count, cell type, Gram stain, Ziehl–Neelsen stain, ADA, LDH, CBNAAT, and culture. Empirical intravenous antibiotics were initiated as per departmental protocol and subsequently modified based on culture sensitivity and clinical response. In cases with negative cultures or inadequate improvement, second-line agents such as meropenem and vancomycin were administered. Total duration of antibiotic therapy ranged from 2–4 weeks, with step-down to oral therapy based on clinical recovery. Closed intercostal chest tube drainage was performed under aseptic techniques, usually in the 4th or

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5th intercostal space in the mid-axillary line, connected to a water-seal drainage system. Daily assessment of drainage volume, air leak, and respiratory swing was documented. Fibrinolytics were instilled in loculated empyema, and surgical referral was sought in non-responsive cases. The chest tube was removed when drainage was <20 mL/day for two consecutive days with clinical improvement. Discharge criteria included afebrile status for at least seven days, removal of the chest tube, absence of respiratory distress, and adequate oral intake. All data were recorded in a structured proforma and subjected to statistical analysis.

Inclusion criteria

- Children aged 2 to 12 years
- Admitted to the Pediatric department, Burdwan Medical College, during the study period
- Clinical and/or radiological evidence of empyema thoracis, confirmed by the presence of pus in the pleural cavity
- Patients whose parents gave consent for participation in the study

Exclusion criteria

- Post Traumatic Empyema Thoracis
- Post-surgical Empyema thoracis
- Patients below 2 years of age
- Patients more than 12 years of age
- Patients whose parents refused to participate in the study/ refused to give consent

Statistical Analysis- Data were checked for accuracy and completeness, tabulated in Microsoft Excel, and analyzed using SPSS (Statistical Package for the Social Sciences) software version 29.0.2.0(20). Continuous variables were expressed as mean±standard deviation (SD), and categorical variables as frequencies and percentages. The independent t-test, one-way ANOVA, and chi-square test were applied for comparisons. A p-value≤0.05 was considered statistically significant.

Ethical Clearance- Approval for the study was obtained from the Institutional Ethics Committee (Ref No: BMC/IEC/179 dated 17th July 2023), Burdwan Medical College and Hospital. Burdwan, India.

RESULTS

Table 1 provides an overview of the demographic, clinical, laboratory, microbiological, and outcome characteristics of children diagnosed with empyema thoracis. It outlines the age distribution and sex ratio of the cohort, along with the most common presenting symptoms. The table also highlights the pattern of pleural involvement and summarizes pleural fluid culture results, identifying the predominant pathogen. Management strategies—including intercostal drainage, fibrinolytic therapy, and surgical intervention—are presented, along with the average duration of hospital stay. Table 1 concludes with overall short-term outcomes, showing a high recovery rate and minimal requirement for surgical referral.

Table 1: Key demographic, clinical, laboratory, microbiological, and outcome findings among children with empyema thoracis (n=100)

Parameters	Findings
Mean Age	5.42±2.65 years
Male: Female	1.32:1
Fever/Cough/Dyspnea	96%/ 88%/ 77%
Side (Right/Left/Bilateral)	52%/ 45%/ 3%
Pleural fluid culture positivity (leading pathogen)	12% (*S. aureus* 41.7%)
ICD only/ ICD+Fibrinolytics/ Surgery	73%/ 14%/ 3%
Mean hospital stays	15.5± 4.7 days
Recovery Rate	96%

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Table 2 presents the laboratory parameters and pleural fluid characteristics of the study population, including hematological indices, inflammatory markers, serum biochemistry, pleural fluid cytology and biochemical findings, and microbiological results from Gram stain, Ziehl–Neelsen stain, CBNAAT, and pleural fluid culture.

Table 2: Hematological and Pleural Fluid profile in children with empyema thoracis

Prameters	**Values**
Hemoglobin	9.18±0.87 g/dl
Total leukocyte count	14,465±2,955.2cells/mm^3
C-reactive protein	72.93±41.1 mg/L
Serum Albumin	3.17±0.36 g/dl
Pleural fluid cell count	11,947±3,786.94 cells/mm^3
Pleural fluid protein	8.31± 3.9 g/dl
Pleural fluid sugar	38.28±10.34 mg/dl
Pleural fluid ADA	20.98±7.05 U/L
Pleural fluid LDH	1,382.52±677.46 U/L
Polymorphonuclear predominance	89%
Gram stain/ZN stain/CBNAAT	All negative (0%)
Pleural fluid culture positivity	12%
-*Staphylococcus aureus*	41.7% (of positives)
-*Streptococcus pneumoniae*	25% (of positives)
-*Pseudomonas* sp.	25% (of positives)
-*Klebsiella pneumoniae*	8.3% (of positives)

Table 3 shows the association between pleural fluid culture positivity and final short-term outcome (n=100), among culture-negative patients (n=88), 85 (97.6%) were discharged, 1 (1.1%) left against medical advice, and 2 (2.3%) were referred. Among culture-positive patients (n=12), 11 (91.7%) were discharged and 1 (8.3%) was referred. Overall, there was no statistically significant association between pleural fluid culture status and final short-term outcome (Pearson chi-square, p=0.48).

Table 3: Association between pleural fluid culture positivity and final short-term outcome (n = 100)

Pleural fluid culture	**Discharged (n, %)**	**LAMA (n, %)**	**Referred (n, %)**	**Total (n, %)**
Negative (n = 88)	85 (97.6)	1 (1.1)	2 (2.3)	88 (100)
Positive (n = 12)	11 (91.7)	0 (0)	1 (8.3)	12 (100)
Total	96 (96)	1 (1)	3 (3)	100 (100)

Distribution of demographic and clinical characteristics among 100 children with empyema thoracis. The figure illustrates the age and sex distribution of the study population along with the frequency of major presenting symptoms such as fever, cough, dyspnea, chest pain, and abdominal pain, highlighting the predominance of the 2–5-year age group and the higher incidence in males (Fig. 1).

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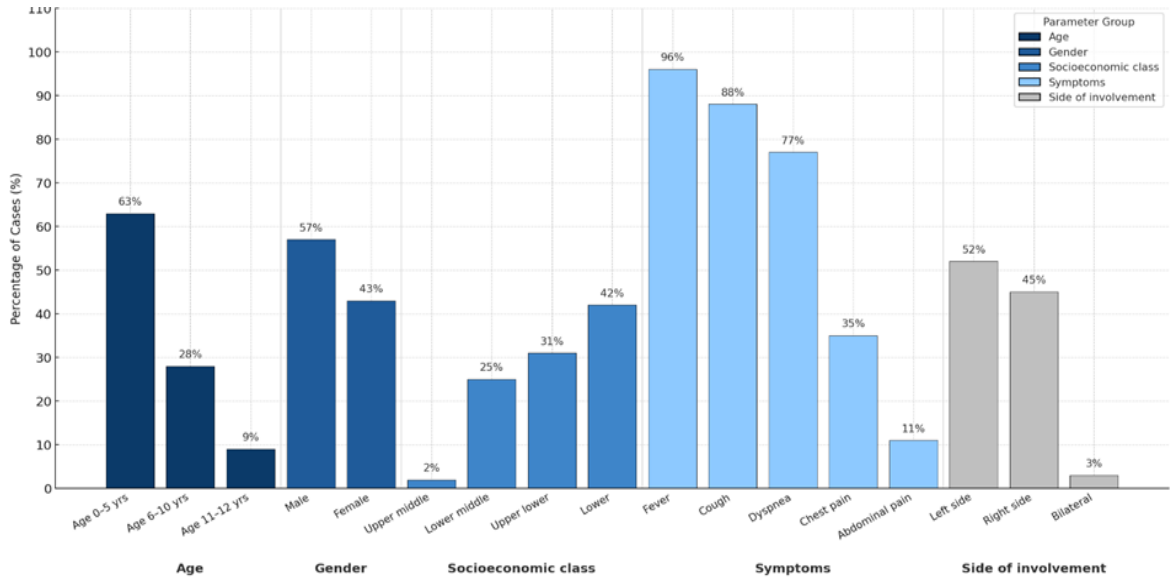

Fig. 1: Demographic characteristics and clinical features of the study population

Relationship between therapeutic interventions and 14-day discharge outcomes in pediatric empyema thoracis. The figure compares treatment modalities—including antibiotics alone, antibiotics with intercostal chest drainage (ICD), and ICD with fibrinolytic therapy—in relation to pleural fluid culture positivity and hospital stay duration, showing delayed recovery among culture-positive cases and those requiring fibrinolytics (Fig. 2).

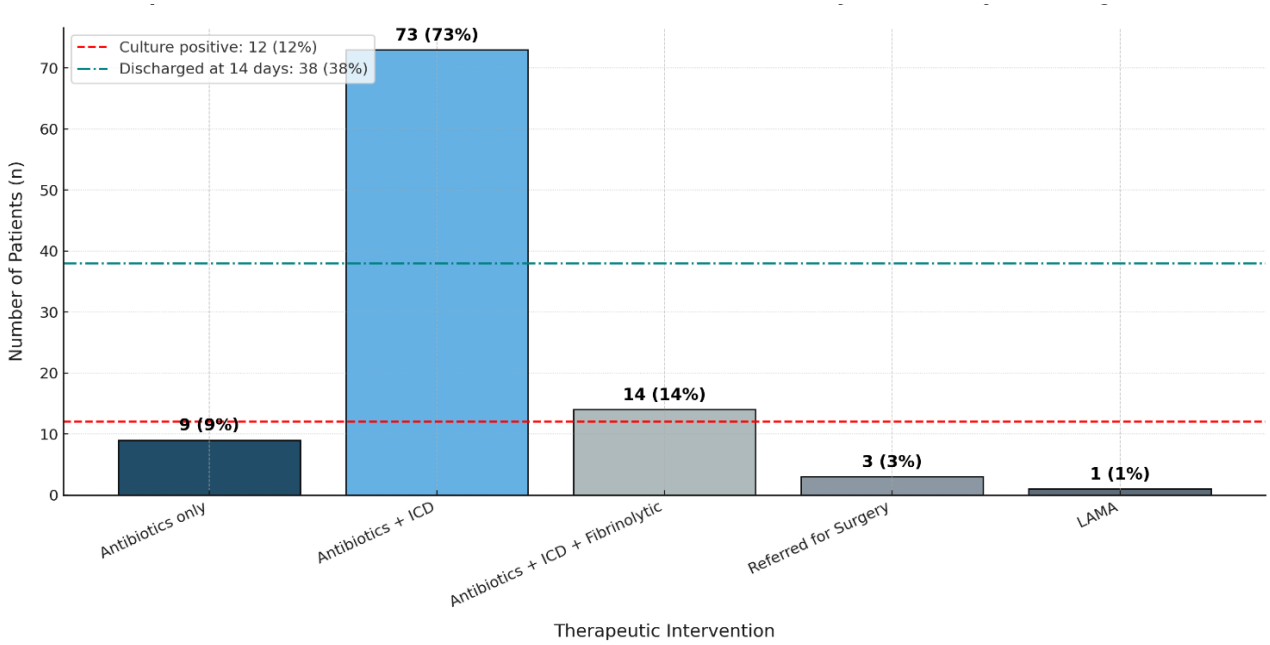

Fig. 2: Therapeutic interventions in relation to pleural fluid culture positivity and 14-day discharge outcomes in pediatric empyema (n=100).

DISCUSSION

Empyema thoracis continues to pose a significant clinical challenge in pediatric populations, especially in developing countries where delayed diagnosis, malnutrition, and limited access to healthcare persist. In the present study, the majority of affected children were aged 2–5 years; this finding is consistent with previous studies that report higher susceptibility during early childhood due to immature immunity and increased pneumonia incidence in this age group [2,9]. The male predominance observed in our study aligns with earlier findings by Toppo *et al.* [5] and Laishram *et al.* [3], indicating a consistent gender trend in lower respiratory tract infections among pediatric patients.

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The predominance of cases among children from lower socioeconomic strata underscores the influence of poverty, overcrowding, and poor nutrition, as observed by Singh *et al*. [10]. Fever, cough, and dyspnea were the most prevalent symptoms, reflecting the typical clinical course described in pediatric empyema literature and guidelines such as the BTS [8] and Nelson Textbook of Pediatrics [1]. comparable to findings by Toppo *et al.* [5], left-sided involvement was slightly more common.

Consistent with studies by Pan *et al*. [9] and Sadani *et al*. [11], the laboratory findings revealed anemia, leukocytosis, and elevated CRP levels, which are markers of systemic inflammation. Pleural fluid analysis demonstrated exudative characteristics with high protein, low glucose, and elevated LDH, confirming bacterial etiology. Although pleural fluid and blood culture positivity were relatively low (12% and 14%), *S. aureus* remained the predominant organism, reinforcing earlier studies identifying it as the leading cause of pediatric empyema in developing regions [5, 9, 12]. Negative CBNAAT and ADA values, along with the absence of ZN positivity, suggested a non-tubercular etiology in this cohort.

Comparable to outcomes reported by Sharma *et al*. [16] and Satpathy *et al*. [17], most children (73%) required intercostal chest drainage in addition to antibiotics, while a smaller proportion (14%) required fibrinolytics, reflecting the stepwise escalation of management advocated in current guidelines [13-15]. Surgical referral was necessary in only 3% of cases, indicating the effectiveness of conservative management. Most patients (96%) achieved full recovery.

In this study, the duration of hospital stay varied according to the treatment modality. Patients managed with antibiotics alone had a mean stay of 10.0±1.732 days, while those receiving antibiotics + ICD had an average stay of 15.52±4.747 days. Patients treated with antibiotics + ICD + fibrinolytic therapy had a mean stay of 20.71±4.196 days. Those requiring surgical intervention and subsequently referred had a hospital stay of 20.71±4.196 days before referral. One LAMA patient stayed for 17 days**.**

These findings are comparable to Dass *et al*. [6], who reported mean hospital stays of 14.87±8.58 days for ICD alone, 18.27±7.84 days for ICD with fibrinolytics, and 21.73±10.49 days for patients needing surgery. The relatively longer stays in our setting likely reflect the preference for conservative management, resource limitations, and delayed acceptance of early referral for surgical intervention.

Statistical analyses revealed significant correlations between laboratory parameters (pleural fluid glucose, LDH, cell count, CRP, and leukocyte count) and treatment requirements, supporting their role in assessing severity and guiding intervention. Prolonged hospitalization was observed in culture-positive cases, emphasizing the clinical burden of resistant infections.

The study findings reinforce the importance of timely diagnosis, pleural fluid analysis, and early drainage in reducing complications. However, limitations include a single-center design, reduced microbiological yield due to pre-treatment antibiotics, and a lack of long-term follow-up. Future multicentric research incorporating biomarkers, advanced imaging, and surgical approaches such as VATS would enhance understanding of prognostic indicators and optimize therapeutic strategies.

Furthermore, the broader implications of this study highlight the urgent need for capacity building at peripheral health centers, enabling earlier recognition of pleural infections and timely referral. Public health initiatives aimed at improving nutritional status, vaccination against pneumococcal disease, and caregiver education may substantially reduce the incidence and severity of empyema thoracis. Additionally, the role of serial monitoring of inflammatory markers such as CRP and leukocyte counts warrants emphasis, as their downward trend often correlates with clinical recovery and can guide step-down from invasive interventions. Advanced biomarkers like procalcitonin or pleural elastase, though not routinely available in resource-limited settings, may offer prognostic value in differentiating complicated effusions in future clinical protocols. Moreover, the integration of pneumococcal and Hib vaccination programs across national immunization schedules could contribute significantly to reducing the incidence of parapneumonic effusions and their progression to empyema.

Future studies should focus on establishing standardized staging-based treatment algorithms, incorporating fibrinolytics and minimally invasive approaches such as VATS where feasible. Establishing multicenter registries would enable better surveillance of microbial patterns and antibiotic resistance, refining empirical therapy

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protocols. Strengthening referral pathways and capacity building of paediatric units, especially at secondary care hospitals, remains crucial to improving timely diagnosis and management of empyema thoracis.

CONCLUSIONS

Pediatric empyema thoracis remains a major clinical concern in resource-limited settings, particularly among children from lower socioeconomic backgrounds. S. aureus continues to be the predominant causative organism. Pleural fluid culture results did not significantly influence the final clinical outcomes. Culture sensitivity alone may be inadequate for identifying the pathogen, as a high proportion of cultures remained sterile. Conservative management with ICD and appropriate antibiotic therapy was effective in most cases; however, a subset of patients required surgical intervention for faster recovery. These findings highlight the need for larger, multicentric studies to validate and generalize these observations. Early diagnosis, prompt initiation of appropriate antibiotics, and timely chest drainage remain the cornerstone of effective management. Intrapleural fibrinolytics provide a safe, minimally invasive option for non-responders, reducing the need for surgery. Strengthening primary care services, standardising referral pathways, and addressing socioeconomic barriers are vital to improving outcomes. Enhanced pneumonia control measures and greater community awareness may further reduce disease incidence and delays in presentation.

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