

Evaluation of Hematological and Biochemical Parameters of Pleural Fluid in Diagnosis of Paediatric Pleural Effusion

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Abstract

Introduction: The differentiation of pleural effusion into transudative and exudative types is a key diagnostic step reflecting the underlying pathophysiology and guiding further evaluation. Transudative effusions result from systemic causes and usually require minimal pleural investigation, whereas exudative effusions arise from local pleural pathology and need detailed laboratory analysis. In children, commonly used adult-based criteria are less reliable, making accurate classification more challenging. But early recognition of exudative effusions is crucial to prevent complications.

Aims and Objective: This study aimed to evaluate the etiological profile and assess the diagnostic accuracy and statistical significance of biochemical and hematological parameters in differentiating various types of pleural effusions.

Materials and Methods: A cross-sectional observational study was conducted in the Department of Paediatrics of a tertiary care centre in Eastern India over one year (May 2018–April 2019). Children aged 1 month to 12 years with clinical and radiological evidence of pleural effusion admitted to the paediatric wards or PICU were included, while traumatic or inadequate thoracentesis samples were excluded. Ultrasound-guided diagnostic thoracentesis was performed under strict aseptic precautions and pleural fluid was analyzed for cytological, and biochemical parameters. Blood samples were simultaneously analyzed for relevant hematological and biochemical markers. Data were analyzed using Light's Criteria and statistical tests ($p < 0.05$ considered significant).

Results: Infective etiology was revealed in 91.8% of cases, with non-tuberculous parapneumonic effusion being the most frequent (73.77%), followed by Tuberculous effusion (14.75%). Other causes included Nephrotic Syndrome (6.56%), Dengue (3.28%), and Malignancy (1.6%). Using Light's Criteria, 90.16% were classified as exudates and 9.84% as transudates.

Biochemical Significance: The Pleural/Serum Protein ratio correctly identified 100% of Tuberculous and Malignant cases as exudates. Low pH (<7.2) was found in 100% of Parapneumonic and Tuberculous cases. Adenosine deaminase (ADA) >40 IU/L was highly sensitive for Tuberculosis (88.9%).

Hematological Significance: There was a highly statistically significant difference in Haemoglobin ($p < 0.0001$) and ESR ($p < 0.0003$) across groups. However, Total Leucocyte Count (TLC) did not show statistical significance ($p = 0.33$) due to high variability.

Conclusion: Infectious diseases are the primary cause of pediatric pleural effusion. While Light's Criteria, ADA, and ESR are statistically significant and reliable tools for etiological differentiation, peripheral TLC has limited diagnostic value. Low pleural fluid pH and glucose remain critical indicators for aggressive management in parapneumonic and tuberculous cases.

Keywords: Parapneumonic effusion, Light's Criteria, Thoracentesis, Children.

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Introduction

Pleural effusion is the abnormal excessive accumulation of fluid in the pleural space between visceral and parietal layer of pleura. Fluid accumulates in the pleural cavity whenever pleural fluid formation (filtration) exceeds the removal process (absorption). This disequilibrium may be the

result of disturbances in the Starling forces that regulate the filtration and absorption, or alterations in the lymphatic drainage, or both[1]. The distinction of pleural effusion into exudative and transudative types is a critical step in the diagnostic evaluation, as it reflects the underlying

pathophysiological mechanism responsible for pleural fluid accumulation and guides further etiological work-up. Transudative effusions arise due to systemic factors such as altered hydrostatic or oncotic pressures, commonly seen in conditions like congestive cardiac failure, nephrotic syndrome, and chronic liver disease, and are usually managed by treating the underlying systemic disorder with minimal need for extensive pleural investigations [2,3]. In contrast, exudative effusions result from local pleural pathology related with increased capillary permeability or impaired lymphatic drainage, as detected in infections, tuberculosis, malignancy, and inflammatory conditions [2,4]. Identification of an exudative effusion requires detailed pleural fluid analysis, including biochemical, microbiological, and cytological studies, to get the accurate etiology and initiate disease-specific therapy [5,6]. Pleural fluid was classified into transudate and exudate according to criteria developed and tested in adults and the parameters of classification are not as reliable in differentiating between transudate and exudate in children[7].

Moreover, early appreciation of exudative pleural effusion is specifically important in children, as delayed diagnosis may lead to complications such as empyema, pleural fibrosis, prolonged hospital stay, and long-term restrictive lung disease[3,6]. Furthermore, accurate classification helps avoid unnecessary invasive procedures in transudative effusions and it aids rational antimicrobial use, contributing to better clinical outcomes and antimicrobial stewardship[2,5].

Thus, the differentiation between exudative and transudative pleural effusions is not merely descriptive but has substantial diagnostic, therapeutic, and prognostic impacts in paediatric practice [2,3,4,5,].

Hence, this study attempted to explore the etiology of pleural effusion in children and evaluate the hematological and biochemical indicators as tools for differentiating between effusion categories, which would help in adoption of regionally optimized diagnosis & therapeutic approach.

Material and Methods

A hospital-based cross-sectional observational study was carried out in the Department of Paediatrics of a tertiary care centre in Eastern India over a one-year period from May 2018 to April 2019. Children aged between 1 month and 12 years, admitted to the paediatric wards or the Paediatric Intensive Care Unit (PICU) with clinical suspicion of pleural effusion, were included in the study. Patients in whom thoracentesis was traumatic or yielded an insufficient quantity of pleural fluid were excluded from analysis.

Following admission, detailed clinical history was obtained and a comprehensive physical examination was performed for all enrolled patients. Radiological confirmation of pleural effusion was achieved using chest radiography in postero-anterior view, supplemented by lateral decubitus views where indicated, along with ultrasonographic examination of the chest. Ultrasound-guided diagnostic thoracentesis was undertaken in patients demonstrating a pleural fluid thickness exceeding 10 mm on lateral decubitus chest radiograph or on ultrasonography[8].

Prior to the procedure, informed written consent was obtained from the parents or legal guardians after explaining the indications, procedure, possible alternatives, and potential complications. Under strict aseptic precautions, approximately 20–50 mL of pleural fluid was slowly aspirated. The collected samples were transported to the respective laboratories within two hours of aspiration for detailed analysis of various cytological and biochemical parameters.

Automated multichannel analyzers (ERBA, XL 300) were used to assess pleural biochemical parameters, differential (polymorphonuclear vs. mononuclear leukocytes) cell counts were estimated in an automated cell counter (HORIBA, PENTRA ES 60). The plain tubes without additives were centrifuged at 3000 rpm for 15 minutes at room temperature, and the supernatant was tested for protein, LDH, glucose, and adenosine deaminase. Pleural fluid cell type, cell count were manually verified and malignant cells were examined in the pathology laboratory.

Laboratory parameter of Blood: Blood was collected after venepuncture maintaining proper asepsis and sent to laboratories for estimation of the parameters like Hemoglobin, Total and Differential Counts, Platelets count, ESR, Serum Proteins, Serum LDH (Lactate dehydrogenase).

On the basis of Lights Criteria, pleural fluid was categorized as exudative and transudative one and exudative effusion should meet at least one of the following criteria (Light's Criteria) [9,4].

- Pleural fluid protein to serum protein ratio greater than 0.5
- Pleural fluid LDH to serum LDH ratio greater than 0.6
- Pleural fluid LDH greater than two thirds of the upper limit of normal for serum LDH

Statistical Analysis Plan

The collected data were compiled and systematically tabulated using Microsoft Excel 2007 and subsequently subjected to statistical analysis using GraphPadInStat software, version 3.10. Categorical variables were analyzed using the Chi-square test.

Continuous variables with a normal distribution were compared using analysis of variance (ANOVA), while non-parametric data were evaluated using the Mann–Whitney U test or the Kruskal–Wallis test, as appropriate.

A p-value of less than 0.05 was taken to indicate statistical significance. Statistical analysis was

performed with an alpha error of 5% and a beta error of 20%, corresponding to a confidence level of 95%.

Result

A total of 61 children with pleural effusion were incorporated in the study, where parapneumonic effusion was the leading cause of pleural effusion (73.77%), followed by tuberculosis (14.75%).

Table 1: Aetiological Distribution of pleural effusion in children

Aetiology	Number of patients N=61	Percentage %	95% CI
Parapneumonic effusion (nontuberculous)	45	73.77	60.9-84.2
Tuberculosis	9	14.75	7.0-26.2
Nephroticsyndrome	4	6.56	1.8-15.9
Dengue	2	3.28	0.4-11.3
Malignancy	1	1.64	0.001- 8.8
Total	61	100.00	

Laboratory reports of pleural fluid obtained after diagnostic thoracocentesis confirmed that 55 cases (90.16%) were fulfilling the criteria (Lights criteria) for exudates and 6 samples (6/61=9.84%) were transudative in nature.

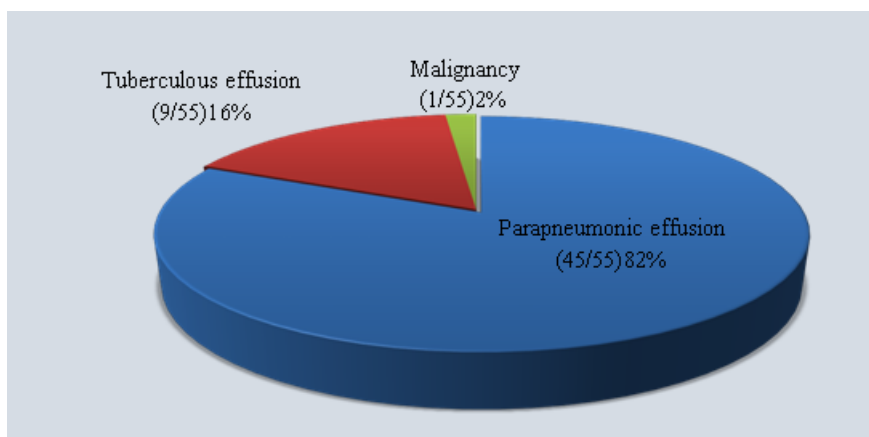


Figure 1: Distribution of Exudative pleural effusion

Among all the exudative pleural effusion, 82% (45/55) cases were due to parapneumonic effusion 16% (9/55) were due to tuberculous pleural effusion and 2% were of malignant origin.

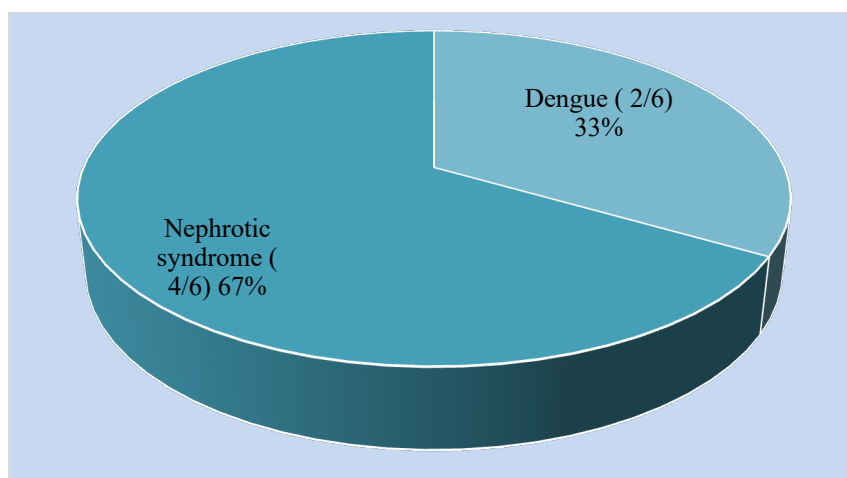


Figure 2: Distribution of Transudative Pleural Effusion

Among 6 transudative pleural effusion cases, 4 cases (67%) were due to nephrotic syndrome and 2 (33%) were due to Dengue virus infection.

Table 2: Predominant cell types* of pleural fluid of various origin

Etiology	PMN	Small Lymphocytes	Mononuclear Cells	No predominance
Parapneumonic Effusion (n=45)	42 (93.3%)	0	3 (6.7%)	0
Tuberculous Effusion (n=9)	0	9 (100%)	0	0
Nephrotic syndrome (n= 4)	0	0	2(50%)	2(50%)
Dengue (n=2)	0	0	1(50%)	1(50%)
Malignancy (n=1)	0	0	1(100%)	0

*Predominant cell types = cell type that constitutes >50% of the total leucocyte count in pleural fluid [10].

Neutrophilic predominance in pleural fluid was noted in 93.3% of Parapneumonic Effusion, whereas predominance of small lymphocyte was observed in all cases of tuberculous effusion. Malignant cells in pleural fluid was detected in a single case.

Table 3: Biochemical Analysis of pleural fluid

Etiology	Pleural fluid protein / Serum Protein		Pleural fluid LDH / Serum LDH		Pleural fluid LDH (IU/L)		Glucose (mg/dl)		ADA (IU/L)		pH	
	<0.5	>0.5	<0.6	>0.6	<200	>200	<60	>60	<40	>40	<7.2	>7.2
Parapneumonic effusion (n=45)	3	42	2	43	2	43	42	3	42	3	45	0
Tuberculous Effusion (n=9)	0	9	1	8	1	8	8	1	1	8	9	0
Nephrotic syndrome (n=4)	4	0	4	0	4	0	0	4	4	0	0	4
Dengue (n=2)	2	0	2	0	2	0	1	1	2	0	0	2
Malignancy (n=1)	0	1	0	1	0	1	1	0	0	1	1	0
Total	9	52	9	52	9	52	52	9	49	12	55	6

Table 3 presents a biochemical analysis of pleural fluid across different etiologies. The statistical and clinical significance of this data is rooted in Light's Criteria, which is the gold standard for differentiating between exudative and transudative effusions.

Pleural fluid protein / Serum Protein ratio (>0.5): This ratio was >0.5 in 85.2% of all patients (52/61). It correctly identified 100% of Tuberculous and Malignant cases and 93.3% of Parapneumonic cases as exudates. Conversely, all Nephrotic Syndrome

cases (4/4) had a ratio <0.5, confirming their transudative nature. Pleural fluid LDH / Serum LDH ratio (>0.6) and Absolute LDH (>200 IU/L): These markers showed high concordance with the protein ratio. For Parapneumonic Effusion, 43 out of 45 cases (95.5%) met both LDH criteria. Glucose (<60 mg/dl): Low glucose was present in 93.3% of Parapneumonic cases (42/45) and 88.9% of Tuberculous cases (8/9). Adenosine Deaminase (ADA): 8 out of 9 (88.9%) Tuberculous cases had an ADA >40 IU/L. pH (<7.2): 100% of Parapneumonic (45/45) and Tuberculous (9/9) cases had a pH <7.2.

Table 4: Comparison of Haemoglobin, Total Leucocyte count and ESR in various types of pleural effusions

Etiological Diagnosis (no. of cases)	Mean	SD	P value
Haemoglobin (gm/dl)			
Parapneumonic Effusion (n=45)	10.9	1.6	p value is < 0.0002 One way ANNOVA with Tukey Multiple Comparisons post test
Tuberculous Effusion (n=9)	8.7	0.53	
Nephrotic syndrome (n= 4)	9.4	0.31	
Dengue (n=2)	8.95	0.77	
ESR (mm/1st Hr)			
Parapneumonic Effusion (n=45)	35.4	17.06	p value is < 0.0003 Kruskal-Wallis Test with Dunn's Multiple Comparisons post test
Tuberculous Effusion (n=9)	71.0	8.3	
Nephrotic syndrome (n= 4)	30	4.8	
Dengue (n=2)	31.5	0.7	
Total Leucocyte Count /cumm			
Parapneumonic Effusion (n=45)	11135.1	4807.2	p value =0.33 Kruskal-Wallis Test
Tuberculous Effusion (n=9)	8122.2	573.9	
Nephrotic syndrome (n= 4)	8075	464.6	
Dengue (n=2)	8000	141.2	

The analysis reveals a highly statistically significant difference in hemoglobin levels between the groups ($p < 0.0001$). Patients with Parapneumonic Effusion showed the highest mean haemoglobin while those with Tuberculous Effusion had the lowest.

The ESR values showed significant variation across the groups ($p < 0.0003$). There is a stark contrast between Tuberculous Effusion and the other groups, such as Nephrotic Syndrome and Dengue.

In contrast to the other parameters, the Total Leucocyte Count did not reach statistical significance ($p = 0.33$). While the mean TLC was highest in the Parapneumonic group and lower in the Dengue group the high Standard Deviation (SD) indicates significant variability within the groups.

Discussion

In the present study, parapneumonic effusion emerged as the predominant etiology of pleural effusion in children, accounting for 73.77% (45 out of 61) cases. Tuberculous pleural effusion constituted the second most common cause, observed in 14.75% (9/61) of patients. Pleural effusion secondary to nephrotic syndrome was identified in 6.56% of cases, while dengue-associated pleural effusion was noted in 3.28%. Malignancy was an infrequent finding, with only a single case of pleural effusion attributable to non-Hodgkin lymphoma.

These observations are in close agreement with the findings reported by Das I *et al* [11] from Kolkata, where empyema was documented as the leading cause (52%), followed by tuberculous pleural effusion (26%) among paediatric patients. The regional burden of tuberculosis is likely to influence the proportion of tuberculous pleural effusions observed in different studies. Similar trends have been reported by Saliya MP *et al* from Gujarat [12], Lingayat AM *et al* from Maharashtra [13], and Alkrinawi S *et al* from Canada [14], all of whom identified parapneumonic effusion as the most common etiology of pleural effusion in children.

Additionally, studies conducted in Kolkata [11] and Gujarat [12] reported dengue fever as a contributory factor for pleural effusion in 8% and 5.88% of cases, respectively. Although uncommon, malignancy has also been recognized as an etiological factor for pleural effusion in children in various studies from India and other countries [11,12,14]. [Table 1]

Among all the pleural effusion cases, 90.16 % (55/61) were exudative and 9.84% (6/61) were transudative in nature. This result of the present study corroborates the finding of Das I *et al* [11] in Kolkata and Saliya M *et al* in Gujarat [12] whereas Kargar Maher *et al* [15] reported exudate in 56.38% and transudate in 43.61% of pleural effusion in children.

Among all the exudative pleural effusion, 82% (45/55) cases were due to parapneumonic effusion other than tuberculosis, 16% (9/55) were due to tuberculous pleural effusion and 2% were of malignant origin. Almost similar distribution of exudative pleural effusion was seen in study by Saliya M *et al* [12] (82.35%), and Das I *et al* [11] [Fig 1]. Among transudative pleural effusion cases, 67% cases were due to nephrotic syndrome and 33% were due to Dengue virus infection. No significant pleural effusion of cardiac origin was observed in the current study. [Fig 2]

In parapneumonic effusion neutrophilic predominance in pleural fluid was observed in 93.3% cases and small lymphocytes were seen in 100% of cases of tuberculous pleural effusion. A significant correlation of pleural fluid neutrophil count (p value 0.001) and lymphocyte count (p value 0.002) with etiology was found in the study by Das I *et al* [11]. Data from a single-center, 15-year investigation at University Children's Hospital Zurich also revealed a predominance of polymorphonuclear cells within parapneumonic effusions [16]. But Lymphocytic predominance was reported in a study by Jha R *et al* [17]. This discordance may be due to prevalence of tuberculosis in that region [Table 2].

Pleural fluid protein / serum protein ratio was >0.5 in (52/61) 85.2% of all patients. It was 100% in tuberculous effusion and malignancy and (42/45) 93.3% in parapneumonic effusion whereas, it was <0.5 in all dengue and nephrotic syndrome patients. Therefore, this parameter appeared as a highly sensitive indicator of pleural inflammation. Result of this study corroborates the study by Saliya M *et al* [11] where pleural fluid protein / serum protein ratio was >0.5 in 88.23% of all patients, and 100% in tubercular effusion and empyema and 92.3% in parapneumonic effusion., it was <0.5 in dengue and an undiagnosed patient.

Pleural fluid LDH /Serum LDH ratio was >0.6 in (52/61) 85.2% of all patients. It was 95.55% in parapneumonic effusion and 88.89% in tuberculous pleural effusion and it was <0.6 in all dengue and nephrotic syndrome patients. Result of the present study was a reflection of the study by Saliya M *et al* [12]. Pleural fluid LDH value >200 IU/L represented as a significant marker for cellular turnover. 95.55 % cases of parapneumonic effusion met the threshold, providing a statistically robust confirmation of infection.

Pleural fluid glucose <60 mg/dl was seen in (52/61) 85.2% of all patients. It was <60 mg/dl in (42/45) 93.3% of parapneumonic effusion, (8/9) 88.89% of tuberculous pleural effusion and 100% of malignant pleural effusion. It highlights the metabolic activities of bacteria in pleural spaces [18].

Pleural fluid ADA > 40 IU/L was seen in (12/61)

19.67% of all patients. It was > 40 IU/L in (8/9) 88.89% of tuberculous pleural effusion. ADA was the most reliable marker of the tubercular pleural effusion. Only (3/45) 6.67% of parapneumonic effusion had ADA value > 40 IU/L. No dengue or nephrotic syndrome patients had raised ADA of >40IU/L.

In the child with malignant pleural effusion ADA of >40IU/L was detected. In high burden setting, an ADA >40 IU/L and lymphocytic predominance in pleural fluid, often considered as sufficient evidence to start anti-tubercular medication immediately, significantly reducing diagnostic delay.[19]

Pleural fluid pH <7.2 was detected in (55/61) 90.16% of all patients. pH <7.2 was observed in all patients of parapneumonic, tuberculous and malignant pleural effusion. On the other hand, all dengue and nephrotic syndrome patients had pleural fluid pH >7.2. Low pH is a critical marker for complicated pleural effusion, typically demands urgent drainage [20,21]. [Table 3].

The present study suggests that the type of effusion is a strong predictor of anemia severity, with tuberculous cases being significantly more anemic than parapneumonic cases. Mean Hb in this study was 10.9gm/L, which was a bit higher than that of the study done by Jha R *et al* in Madhya Pradesh [17] (8.6gm/L).

This study also highlights that a markedly elevated ESR is a significant clinical marker for Tuberculous Effusion. This suggests that ESR remains a valuable, though non-specific, inflammatory marker for differentiating tuberculosis from non-inflammatory causes like nephrotic syndrome in the context of pleural effusion), TLC alone cannot reliably differentiate between these four specific causes of pleural effusion. [Table 4].

Conclusion

Exudative pleural effusion was more common than transudative variety in the study population. All the parapneumonic, tuberculous effusion, malignant pleural effusion fulfilled Light's criteria to be considered as exudative in nature. Nephrotic syndrome and Dengue virus infection presented as transudative effusion. Pleural fluid leucocyte count was significantly higher in parapneumonic effusion. Neutrophilic predominance in pleural fluid was noted in Parapneumonic effusion, whereas predominance of small lymphocytes was observed in tuberculous effusion. Pleural fluid protein / serum protein ratio >0.5, Pleural fluid LDH /Serum LDH ratio >0.6, Pleural fluid LDH value >200 IU/L were helpful to categorise the exudative and transudative effusion. The statistical significance ($p < 0.0001$) across all biochemical markers emphasizes the critical role of pleural fluid analysis for detection of aetiology of pediatric pleural effusion. Specifically,

ADA serves as a robust marker for tuberculosis, while LDH and protein levels effectively differentiate between parapneumonic exudates and systemic transudates like nephrotic syndrome. Overall, precise etiological evaluation of pleural effusion in children is indispensable for rational therapy and improved long-term respiratory outcomes.

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Reference

1. Efrati O, Barak A. Pleural effusions in the pediatric population. *Pediatr Rev.* 2002 Dec; 23(12):417-26. PMID:12456894 DOI:10.1542/pir.23-12-417.
2. Light RW. Pleural effusions. *Med Clin North Am.* 2011;95(6):1055–1070.
3. Kliegman RM, St Geme JW, Blum NJ, et al., editors. *Nelson Textbook of Pediatrics.* 21st ed. Elsevier; Chapter: Pleural Effusion and Empyema.
4. Light RW, Macgregor MI, Luchsinger PC, Ball WC Jr. Pleural effusions: the diagnostic separation of transudates and exudates. *Ann Intern Med.* 1972;77(4):507–513.
5. Heffner JE, Brown LK, Barbieri CA. Diagnostic value of tests that discriminate between exudative and transudative pleural effusions. *Chest.* 1997;111(4):970–980.
6. Rahman NM, Maskell NA, Davies CWH, et al. The relationship between pleural fluid findings and clinical outcome in pleural infection. *Chest.* 2006;130(4):1149–1156.
7. Septimus J E. Pleural effusion and empyema. In: Mandell, Douglas and Bennett's *Principle and Practice of Infectious Diseases*, Vol.1, 6th edn. Eds. Bennet JE, Dolin R, Bleser JM. Philadelphia PA. Elsevier Saunders. 2015; pp 847-854.
8. Sahn SA, Light RW. The sun never set on a parapneumonic effusion. *Chest.* 1989; 95:945-47.
9. Light RW. Pleural effusion. *N Engl J Med.* 2002; 346:1971-1977.
10. Light RW, Yener S, Erozan Y S, Ball WC. Cells in Pleural Fluid Their Value in Differential Diagnosis. *Arch Intern Med.* 1973. 132 :854-860 Downloaded From: <http://archinte.jamanetwork.com/> by a University of California - San Diego User on 06/10/2015.
11. Das I, Misra S, Jana P K, Sinha M K. A study of etiology, clinical profile and outcome of pleural effusion in children in a tertiary care hospital in eastern india. *Paripex -Indian Journal of Research.* 2017; 6(4) :62-65.
12. Saliya MP, Joshi GS. Profile of children with pleural effusion in an urban tertiary care hospital. *International Journal of Contemporary*

- Pediatrics. 2017; 4:1857-60. DOI: <http://dx.doi.org/10.18203/2349-3291.ijcp20173799>.
13. Lingayat A.M., Wankhade P.R. Study of clinical profile, etiological bacterial agents and outcome in pediatric patients of empyema. *Indian Journal of Basic and Applied Medical Research*. 2015; 4(2): 502-509.
 14. Alkrinawi S, Chernick V. Pleural fluid in hospitalized pediatric patients. *Clin Pediatr (Phila)*. 1996;35(1):5-9. PMID:8825844DOI:10.1177/000992289603500102.
 15. Kargar Maher MH, Farshi M R, Bilan N, Jalilzadeh-Binazar M, Teimouri-Dereshki A, Abdini B. Evaluation and Outcomes of Pediatric Pleural Effusions in Over 10 Years in Northwest, Iran. *International Journal of Pediatrics*. 2014; 2(3-2): Serial No. 8: (Supplement 4):41-46.
 16. Sauteur PM, Burkhard A, Moehrlen U, Relly C, Kellenberger C, Ruoss K, et al. Pleural tap-guided antimicrobial treatment for pneumonia with parapneumonic effusion or pleural empyema in children: A single-center cohort study. *J Clin Med*. 2019;8(5):698. <https://doi.org/10.3390/jcm8050698>.
 17. Jha R, Bharani, A., Chaube D. Clinico-epidemiological profile and outcome of pleural effusion of infective etiology in children from central India. *Asian Journal of Medical Sciences*. 2022; 13(6): 134–138. Retrieved from <https://www.nepjol.info/index.php/AJMS/article/view/42808>.
 18. Light RW. *Pleural diseases*. 6th ed. Philadelphia: Lippincott Williams & Wilkins; 2013.
 19. Valdés L, Alvarez D, San José E, et al. Tuberculous pleurisy: a study of 254 patients. *Arch Intern Med*. 1998;158(18):2017–2021.
 20. Light RW. Parapneumonic effusions and empyema. *Proc Am Thorac Soc*. 2006 Jan 15; 3(1):75-80.
 21. Davies HE, Davies RJ, Gleeson FV; BTS Pleural Disease Guideline Group. Management of pleural infection in adults: British Thoracic Society Pleural Disease Guideline 2010. *Thorax*. 2010 Aug;65 Suppl 2:ii41-53.