RESEARCH PAPER

Serum Procalcitonin and Ferritin as Predictive Markers of Severity of Bacterial Infection in Pediatric Patients with Lower Respiratory Tract Infections

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ABSTRACT

Background: Lower respiratory tract infections (LRTIs), mainly community acquired pneumonia (CAP), are a main etiology of hospitalization and death in children under five years, with bacterial and viral pathogens being prevalent causes, with biomarkers like procalcitonin and serum ferritin serving as valuable predictors of disease severity and outcomes.

Objective: To assess the prognostic and diagnostic value of serum procalcitonin and ferritin in pediatric cases had LRTIs and evaluate their role as predictors of disease severity and correlation with clinical outcomes.

Methods: This cross-sectional research has been performed on 100 children admitted to Pediatric department and pediatric intensive care unit (PICU) at October 6 University hospital due to chest infection, during the period from January 2025 to December 2025.

Results: Procalcitonin and serum ferritin were significantly higher in severe cases, positive cultures, and PICU admissions. ROC analysis showed procalcitonin had the highest predictive value for bacterial infections (AUC 0.980) at cutoff value of 2.6 nanogram per milliliters with sensitivity = 95% and specificity = 93.7%, followed by ferritin/procalcitonin ratio (AUC=0.958) with a cutoff value of 190, sensitivity = 89.6% and specificity= 92%. Serum ferritin showed (AUC=0.872) with a cutoff value of 175 with sensitivity = 95% and specificity= 71%, while CRP was not significant.

Procalcitonin showed high prediction for PICU admission (AUC 0.972), and mortality (AUC 0.885). Ferritin and ferritin/procalcitonin ratio also showed good predictive performance.

Conclusion: Procalcitonin and serum ferritin were higher, while ferritin/procalcitonin ratio was lower in severe cases, positive blood cultures, PICU admission, mechanical ventilated patients and in non-survivors. Procalcitonin is a good predictor for bacterial infection, PICU admission, and mortality, followed by ferritin/procalcitonin ratio and serum ferritin.

Keywords: Pediatric, Lower respiratory tract infections, Procalcitonin, Ferritin, Bacterial infection.

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INTRODUCTION

Lower respiratory tract infections (LRTIs) are infections that affect the respiratory tract under the larynx. The global frequency of LRT Approximately 12,197.8 new infections per 100,000 children were detected among those below five years of age. LRTIs are the primary reason for hospitalizations among the pediatric population1.

Community-acquired pneumonia (CAP) is a main etiology of a hospital stay and death, especially in individuals under five years of age. CAP was identified as an infectious illness resulting from viral invasions or bacterial infections. Bacterial pathogens include Haemophilus influenza, Streptococcus pneumonia, Staphylococcus aureus, as well as Streptococcus pyogenes, together with respiratory viruses like a respiratory syncytial virus, are prevalent etiological agents of CAP in children2. Despite the great occurrence and severe results related to a CAP, identifying causal agents is difficult. The overlap of CAP symptoms with other respiratory conditions complicates accurate diagnosis depending on clinical symptoms and signs. Consequently, it is essential to enhance existing diagnostic strategies to address the threats triggered by CAP in children3.

Several research have recommended that bacterial pneumonia can't be differentiated from non-bacterial pneumonia on the basis of chest radiography (CXR); and except for serum C-reactive protein (CRP) concentrations, routine hematological tests have less practical value4.

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Procalcitonin (PCT) is an indicator of systemic inflammation that is steadily elevated in bacterial infections in comparison with viral infections5. Five Increased serum ferritin is frequently related to inflammatory illnesses and cancers, underscoring the significance of it as a vital clinical indicator6. The evaluation of serum ferritin's predictive potential for severity and death has shown promising results, with ferritin demonstrating slightly greater predictive value for death than for severity7.

This research aims to estimate the prognostic and diagnostic value of serum PCT and ferritin in pediatric cases with lower respiratory tract infections and assess their role as predictors of illness severity and clinical results.

PATIENTS AND METHODS

This observational, cross-sectional research has been performed on 100 children admitted to Pediatric department inpatients and PICU at 6 October university hospital due to chest infection, during the period from January 2025 to December 2025.

Inclusion criteria: Patients aged 2 months to **5** years, both male and female participants, patients with moderate to severe respiratory distress according to PRESS score system and patients with LRTI, involving pneumonia, and bronchiolitis.

Exclusion criteria: Patients with congenital heart diseases, patients with immunodeficiency syndrome or with autoimmune diseases, patients with pre-existing chronic respiratory conditions, like bronchopulmonary dysplasia, or cystic fibrosis and patients with recent trauma, or conditions affecting coagulation, such as disseminated intravascular coagulation (DIC) unrelated to LRTI.

Sample size

Sample Size has been determined as regards the following equation:

N= Z*Z*P*Q/E*e

Where Z=1.96, P= Prevalence, Q=1-P, E=0.05, based on previous study. Accordingly, the least sample size is 95 cases.

Ethical considerations

The research design obtained has been permitted by the local ethics committee, Faculty of Medicine, October 6 University, Egypt, (Ethical Code: SCCREIRB-MEDICIN6OCT-PU-001-121224-018) and following clarifying the value of the research and procedures that would be commenced, an informed written consent has been gained from the guardian of every participant prior to being involved in the research.

Methods:

All children have been subjected to the following: medical and demographic history taking, general and systematic examination, laboratory investigations and chest X-ray.

The investigations done included complete blood count, C-Reactive Protein (CRP), arterial blood gases (ABGs) and blood culture, serum concentration of PCT quantified with an automated sandwich immunoassay utilizing TRACE technology. The PCT-sensitive KRYPTOR assay has a detection limit of 0.02 nanograms per milliliter, and a functional assay sensitivity of 0.06 nanograms per milliliter. Serum ferritin has been assessed utilizing chemiluminescent immunoassay on AxSYM (Abbott Laboratories, Chicago, IL, united state of America).

Pediatric Respiratory Severity Score (PRESS) was recorded for the included pediatric patients at the time of hospital admission.

Score Component	**Operational Definition**		**Scoring**
Respiratory rate	Respiratory rate at rest, on room air*		0 or 1
Wheezing	High-pitch expiratory sound heard via auscultation		0 or 1
Accessory muscle use	Any visible utilization of accessory muscles		0 or 1
SpO_2	Oxygen saturation under ninety-five percent on room air		0 or 1
Feeding difficulties	Refusing feedings		0 or 1
	Sum of 5 components		
PRESS score	0-1: mild 2-3: moderate 4-5: severe		0-5
Criteria of tachypnea*	Month	Respiratory rate	
	<12	>60	1
	=12, <36	>40	1
	≤36, <156	>30	1
	≥156	>20	1

*** Respiratory rate assessed regarding American Heart Association guideline.**
PRESS, Pediatric Respiratory Severity Score (Thokngaen, & karoonboonyanan 2019)[8].

Statistical Analysis

Information has been revised, coded, and entered into the Statistical Package for Social Sciences (IBM SPSS Statistics for Windows, Version 25.0; IBM Corp., Armonk, NY, United States of America). Data have been summarized and analyzed according to their type, and normality of distribution has been evaluated utilizing the Shapiro–Wilk test. Descriptive statistics have been represented as mean ± SD for parametric quantitative information and median with range for non-parametric quantitative data, while qualitative information has been represented as frequency and percentage. For inferential analysis, Student's t-test has been applied to compare the means of two independent groups with normally distributed information, while one-way analysis of variance (ANOVA) has been applied for comparisons among more than two groups. For non-parametric information, the Mann–Whitney U test and Kruskal–Wallis test was utilized. The test Fisher's exact and

Chi-square test were done to examine the association among qualitative parameters, while correlation analysis was performed to estimate relation among quantitative parameters. Receiver operating characteristic (ROC) curve analysis has been done to evaluate diagnostic performance, and the optimal cutoff point was determined according to the area under the curve (AUC), which was interpreted as excellent (0.9–1.0), good (0.8–<0.9), fair (0.7–<0.8), poor (0.6–<0.7), and failed (0.5–<0.6). All p-values were two-tailed, and a p-value under 0.05 has been deemed statistically significant at a 95% confidence interval.

RESULTS

This research comprised 42% females and 58% males; age of cases ranges from 2 months - 4. years, 8 months, their mean age was 1.5±1.1 years. Twenty-eight percent of children had history of previous hospital admission (Table 1).

Table 2: Sociodemographic data in the examined group

		Study group	
		Number=100	**%**
Age (years)	**Mean ± SD**	1.5±1.1	
	Range	2 months - 4 years, 8months	
Sex	**Female**	42	42.0%
	Male	58	58.0%
History of previous hospital admission	**No**	72	72.0%
	Yes	28	28.0%
PRESS score	**Mild (0-1)**	13	13%
	Moderate (2-3)	42	42%
	Severe (4-5)	45	45%
Blood culture	**No growth**	40	40.0%
	Strept pneumonia	35	35%
	Staph aureus	15	15%
	Klebsiella pneumoniae	10	10%
Oxygen support	**Nasal oxygen**	72	72%
	HFNC	8	8%
	MV	20	20%
Place of admission	**Inpatient**	64	64%
	PICU	36	36%
Outcome	**Recovered**	87	87.0%
	Died	13	13%

HFNC: high frequency nasal cannula, PICU: pediatric intensive care unit, MV: mechanical ventilation

PCT was significantly higher in cases had positive blood culture, cases with lobar consolidation and those with pleural effusion. Procalcitonin showed a median value of 6.6 ng/mL in patients who needed mechanical ventilation (MV) compared to high flow nasal cannula (HFNC), median 3.3 ng/mL (p under 0.01). A statistically significant variance has been noted among non-survivors and cases who recovered (p below 0.001) as demonstrated in Table **2**.

Table 2: Procalcitonin level regarding to patients' clinical data and outcome

		Procalcitonin (ng/mL)		Test	P value
		Median	Range		
Blood culture	**No growth**	0.6	0.1-3.8	W=42.3	<0.001*
	Strept pneumonia	3.7	1.7-8.5		
	Staph. Aureus	7.2	5.7-8.7		
	Klebseilla pneumonia	7.2	2.7-17.1		
Chest-X ray	**bilateral patchy consolidations**	0.7	0.3-17.1	W=8.4	0.038*
	Lobar consolidation	2.1	0.4-7.7		
	Localized consolidation	0.5	0.1-3.8		
	Pleural effusion, Bilateral consolidation	1.5	0.2-8.7		
Oxygen support	**Nasal oxygen**	0.6	0.1-5.7	W=43.6	<0.001*
	HFNC	3.3	1.6-8.7		
	MV	6.6	2.7-17.1		
Place of admission	**PICU**	2.7	0.6-17.1	U=7.8	<0.001*
	Ward	0.5	0.1-5.7		
Outcome	**Died**	4.3	1.5-17.1	U=4.4	<0.001*
	Recovered	0.6	0.1-8.7		

W: Kruskal Wallis test, U: Mann-Whitney U-test, *: Significant.

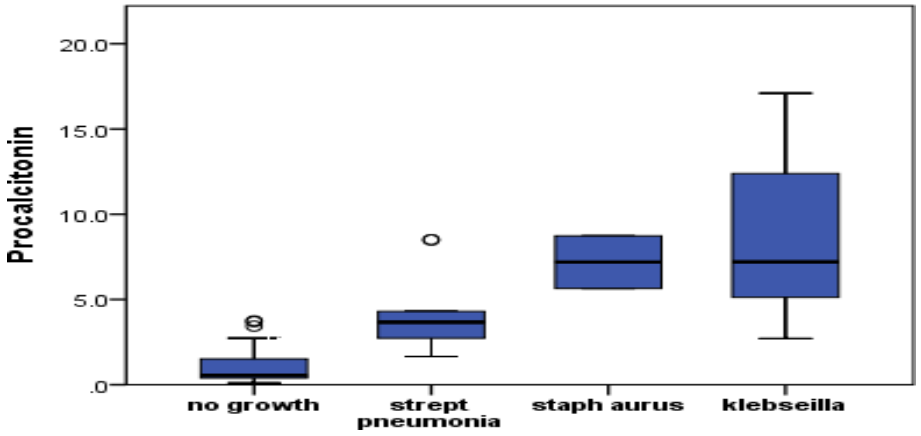

Figure 1: Procalcitonin level as regarding to blood culture results

Table 3: Procalcitonin levels Regarding Press Score Severity

PRESS Score Severity	Number of Cases (N=100)	Procalcitonin (Mean ± SD)	Median	Range (Min-Max)
Mild (0-1)	13	0.295 ± 0.096	0.33	0.11-0.37
Moderate (2-3)	42	0.600 ± 0.338	0.50	0.24-1.55
Severe (4-5)	45	3.833 ± 3.670	2.71	0.61-17.10

Table 4: Serum ferritin regarding patients' clinical data and outcome

		Serum ferritin (ng/mL)		Test	P value
		Median	Range		
Blood culture	**No growth**	165.0	51.0-460.0	W=25.8	<0.001*
	Klebsiella pneumonia	361.5	175.0-650.0		
	Staph aureus	301.0	274.0-328.0		
	Strept pneumonia	290.0	190.0-365.0		
Chest X ray	**bilateral patchy consolidations**	180.5	51.0-650.0	W=2.1	0.46
	Lobar consolidation	228.0	65.0-370.0		
	Localized consolidation	165.0	68.0-460.0		
	Pleural effusion, Bilateral consolidation	187.0	129.0-328.0		
Oxygen support	**Nasal oxygen**	165.0	51.0-370.0	W=31.4	<0.001*
	HFNC	339.5	260.0-412.0		
	MV	361.5	175.0-650.0		
PICU	**PICU**	307.5	140.0-650.0	U=6.9	<0.001*
	Ward	155.0	51.0-277.0		
Outcome	**Death**	277.0	154.0-650.0	U=3.6	<0.001*
	Recovered	171.0	51.0-412.0		

*: Significant.

As regards culture results, serum ferritin was significantly higher in cases with positive blood culture (p below 0.01), patients who needed PICU admission and MV (p below 0.01). A statistically significant variance has been noticed with elevated ferritin level in non-surviving patients in comparison with survivors (277 and 171 ng/mL, respectively).

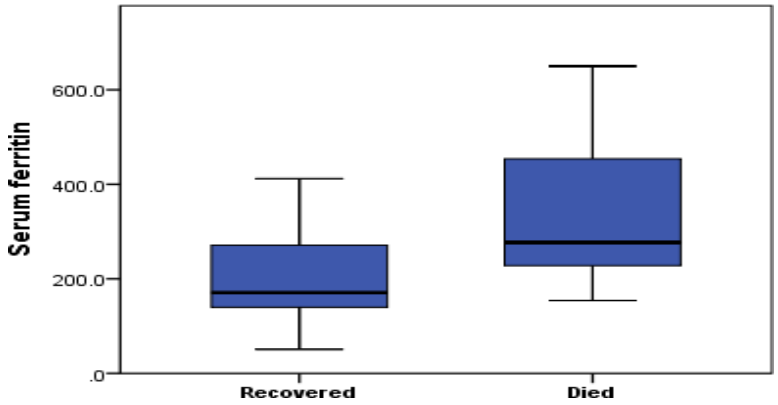

Figure2 : Serum ferritin regarding patient outcome

Ferritin/procalcitonin ratio was statistically lower in patients with positive blood culture, cases with lobar consolidation or pleural effusion, patients who needed PICU admission, HFNC and MV, and in patients who didn't survive (p under 0.01).

The best cutoff value for procalcitonin on the ROC curve analysis to predict bacterial infections was 2.6 ng/mL with area under the curve (AUC=0.980), sensitivity of 95% and specificity of 93.7 % followed by ferritin/procalcitonin ratio (AUC=0.958) with a cutoff value of 190 with sensitivity = 89.6% and specificity= 92%. Serum ferritin showed (AUC=0.872), while CRP was not significant (AUC=0.568) as demonstrated in Table 5, Figure 3.

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Table 5: ROC curve analysis for prediction of bacterial infection utilizing acute phase reactants

	AUC	95% CI		Cut-off value	Sensitivity	Specificity	P value
Serum ferritin (ng/mL)	0.872	0.800	0.943	>175	94.7%	71.4%	<0.001*
Procalcitonin (ng/mL)	0.980	0.956	1	>2.6	94.9%	93.7%	<0.001*
CRP (mg/L)	0.568	0.432	0.704				0.359
Ferritin/Procal (FPR)	0.958	0.892	0.997	<190	89.6%	91.7%	<0.001*

AUC: Area Under Curve *: Significant.

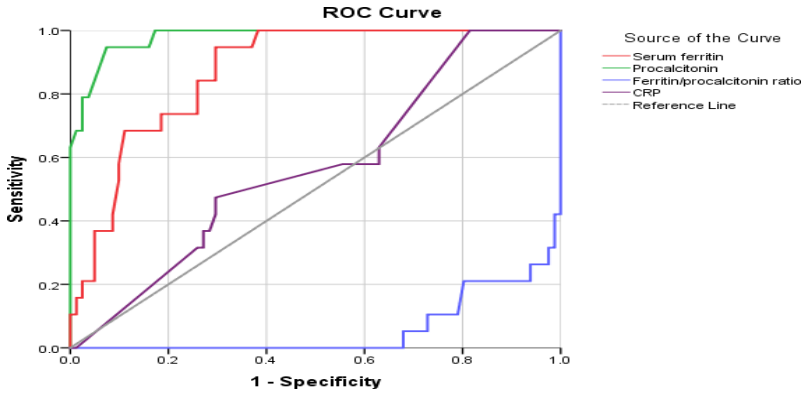

Figure 3: ROC curve to predict bacterial infection using acute phase reactants.

Table 6: Performance of acute phase reactant to predict PICU admission

	AUC	95% CI		Cut-off value	Sensitivity	Specificity	P value
Serum ferritin(ng/mL)	0.918	0.863	0.974	>181	88.9%	84.5%	<0.001*
Procalcitonin (ng/mL)	0.972	0.941	1	>1.5	94.4%	93.7%	<0.001*
CRP (mg/L)	0.622	0.511	0.732	>37	66.7%	50%	0.044*
Ferritin/procal (FPR)	0.894	0.799	0.921	<217	87.4	79.5	<0.001*

CRP: C Reactive Protein *: Significant.

ROC analysis done to assess acute phase reactant's ability to predict PICU admission in the studied group; procalcitonin showed highest AUC 0.972, with sensitivity = 95% and specificity = 93.7% at cutoff value >1.5 ng/mL, followed by serum ferritin (AUC=0.918), ferritin/procalcitonin ratio (FPR) (AUC=0.894) and CRP (AUC=0.622), (Table 6, Figure 4).

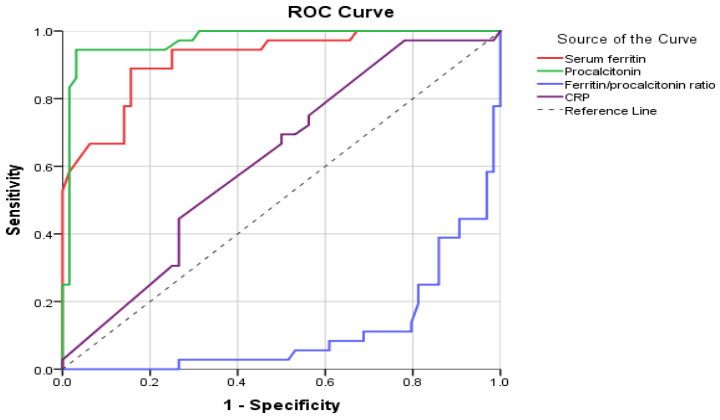

Figure 4: ROC curve of acute phase reactant to predict PICU admission

ROC analysis done to predict mortality using acute phase reactants in patients; procalcitonin showed highest AUC 0.885, at cutoff value was 2.5 nanograms per milliliters, with sensitivity = 84.6% and specificity = 80.7 %, followed by ferritin/procalcitonin (FPR) (AUC= 0.880) at cutoff value 218, with sensitivity = 84% and specificity = 80%, then serum ferritin (AUC=0.789) at cutoff value of 209, sensitivity = 84.6% as shown in table 7 and figure 5 .

Table 7: ROC curve analysis for prediction of mortality utilizing acute phase reactants

	AUC	95% CI		Cut-off value	Sensitivity	Specificity	P value
Serum ferritin(ng/mL)	0.789	0.651	0.927	>209	84.6%	67.3%	<0.001*
Procalcitonin (ng/mL)	0.885	0.811	0.959	>2.5	84.6%	80.7%	<0.001*
CRP (mg/L)	0.697	0.569	0.826	>61	53.8%	72.3%	0.022*
Ferritin/PCT (FPR)	0.880	0.798	0.956	<218	84.2%	79.1%	<0.001*

*: Significant.

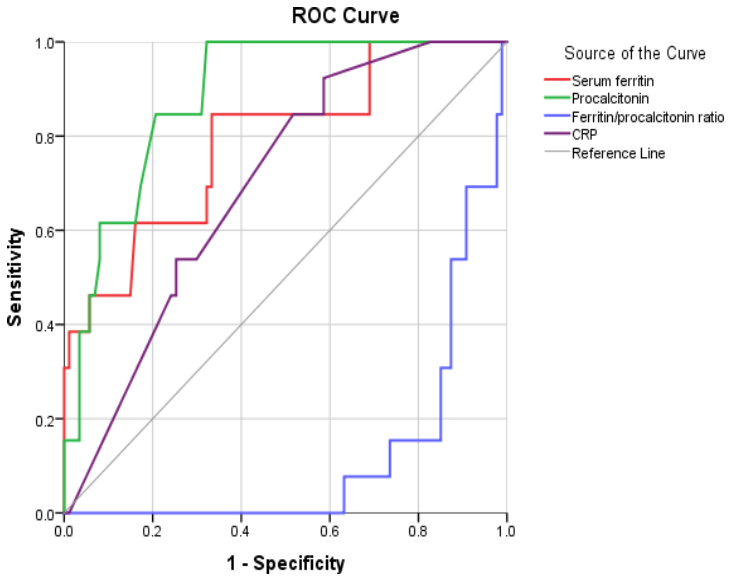

Figure 5**: ROC curve to predict mortality using acute phase reactants**

There was statistically significant positive correlation among PCT, and PRESS score, absolute neutrophilic count (ANC), and duration of hospital stay. Also, there was statistically significant positive correlation among ferritin, and PRESS score, absolute neutrophilic count (ANC), and duration of hospital stay.

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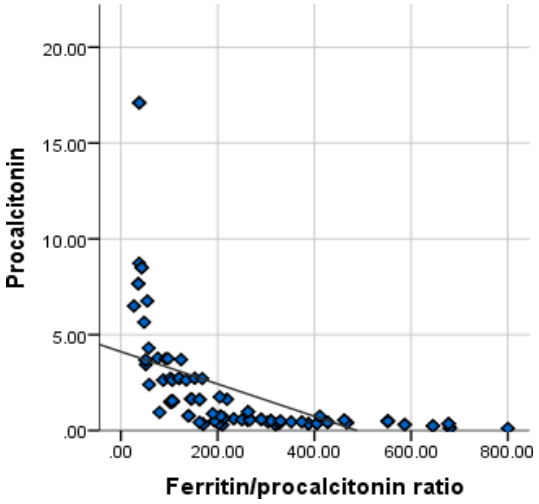

Figure 6: Correlation between ferritin /procalcitonin ratio and procalcitonin level.

DISCUSSION

CAP is the main reason of death and hospital stay globally, especially among those below five years of age2. It is essential to enhance existing diagnostic strategies to address the risks of community acquired pneumonia in children3.PCT serves as an indicator for systemic inflammation, exhibiting consistently elevated levels in bacterial infections in comparison with viral infections5.

Our patients' mean age was 1.5±1.1 years, admitted to pediatric inpatient and PICU due to LRTIs. Our results were in agreement with Mirkarimi et al (2020)9. Jain et al., (2015) & Neuman et al., (2011) who stated that the greatest proportion in infants under two years (forty-five to forty-six percent) in children admitted with LRTIs, and Sukarno et al, (2023) who found that children below five years accounted for sixty to seventy-five percent of pediatric pneumonia10-11-12.

In the present study, males were predominantly admitted to the hospital for LRTI, that was comparable of other researches performed by Greenbaum et al (2014); Zhong et al.(2019)13-14. This gender bias can be because of the etiology that male children are brought early to the hospital for management in comparison with females because of comparatively more preference for male children in our country & other developing countries15.

In the present research, procalcitonin was statistically higher in patients with positive blood culture, and with pleural effusion, patients who needed PICU admission, HFNC and MV, and in patients who didn't survive. This is in agreement with investigation done by Meher et al (2025) 16. PCT is produced in response to bacterial Lipopolysaccharide (LPS) or other endotoxins and to inflammatory indicators such as interleukin-6, interleukin -β, interleukin -2, TNF-α. Some studies recommend that specific organs as neuroendocrine cells in the lungs, pituitary, splanchnic area, intestine, liver or hypothalamus are the source of PCT in sepsis 17.

There was statistically significant positive correlation among PCT, and PRESS score, absolute neutrophilic count (ANC), and duration of hospital stay. Similarly, Zulkifli et al.,(2025) noticed a significant correlation among procalcitonin concentrations and the degree of pneumonia in children18. Sartori et al., (2021) found that median procalcitonin in the very severe group was 5.06 (interquartile range [IQR] 0.90–16.83), 0.38 (IQR 0.11–2.11) in the severe group, 0.29 (IQR 0.09–1.90) in the moderate group, and 0.21 (IQR 0.12–1.2) in the mild group19. PCT is a commonly utilized serum biomarker that is intricately associated with bacterial composition and the degree of illness. It is particularly relevant to bacterial infections, as it is diminished by INF9 expressed in response to viral infection20.

In the current study, serum ferritin was statistically greater in cases with positive blood culture, cases needed HFNC and MV, in patients needed PICU admission and in patients who did not survive. A statistically significant positive correlation has been found among serum ferritin and PRESS score, ANC, and duration of hospitalization.

Our results were in line with Hasan et al (2026)who detected that CRP and serum ferritin concentrations were significantly greater in pneumonia cases in comparison with controls (p below 0.001) and illustrated a progressive rise from mild to severe cases (p below 0.001). Both biomarkers illustrates significant positive associations with white blood cell count, and length of hospitalization21.

In the same way, Meher et al (2025), observed that ferritin levels were significantly greater in children with pneumonia who died in comparison with children who survived ($p < 0.05$)19.

Serum ferritin has demonstrated effectiveness in assessing illness degree, indicated by a high area under the receiver

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operating characteristic curve, demonstrating its possibility as a prognostic marker for illness degree22.

Moreover, serum ferritin concentrations were recognized as predictors for results in hospitalized cases, including the need for ICU hospitalization and MV. Evaluations of serum ferritin's predictive ability for degree of illness and death have produced promising results, with ferritin demonstrating slightly higher a predictive value for death than for severity7.

Ferritin/procalcitonin ratio was statistically lower in patients with positive blood culture, patients in patients who needed HFNC, MV, and PICU admission, and in patients who didn't survive ($p<0.01$). This could be explained by higher procalcitonin levels in patients with bacterial infections esp. klebsiella pneumoniae and staph. aureus infection compared to blood cultures with negative growth probably due to viral infections or atypical organisms, thereby driving the overall F/P ratio downwards, figure 6. Furthermore, decreasing F/P ratio associated with critical illness suggest that patients requiring PICU admission and mechanical ventilation likely suffered from overwhelming bacterial sepsis or secondary superinfection. The massive bacterial load in severe cases rapidly increase procalcitonin levels, making the decreased F/P ratio a reflection of severe bacterial burden and a strong predictor of poor prognosis.

The ratio of ferritin to procalcitonin (F/P) ratio was first assessed by Jankousky et al (2020), in cases had COVID 19. He stated that F/P reflects greater viral activity and host response with Coronavirus Disease 2019pneumonia, whereas bacterial pneumonia would be related to less cytolysis (reduced ferritin) and more inflammation (elevated procalcitonin), thus a reduced F/P ratio23. On the same side with Soliman et al (2025), illustrated that in patients with pneumonia, the median FPR concentrations were lower in dead cases in comparison with survivors24.

In the current research, ROC analysis was done to assess the capability of acute phase reactant to expect bacterial infection in studied cases; PCT had a high accuracy prediction in bacterial infection in children with LRTI, followed by ferritin/procalcitonin ratio, serum ferritin, and CRP.

Our results also agreed with Lippi and Sanchis-Gomar,(2017), who observed that PCT concentrations are typically increased in bacterial infections, with higher serum PCT concentrations correlating with an increased possibility of septic shock and mortality. PCT wasn't raised or only slightly raised in viral illnesses25.

Ferritin serves as a biomarker for infection and inflammation in the identification of bacterial and viral infections; nevertheless, concentrations of ferritin are typically not elevated in acute extracellular bacterial sepsis. Significantly high serum ferritin levels have been stated only in a numerous viral infections26. Regarding mortality; our results agree with Chen et al (2023), who observed that the PCT concentrations in non-survivors were greater in comparison with those in survivors. The AUC value of Procalcitonin in this interval was 0.81, demonstrating the discriminative power of the biomarker27.

The ease of measuring the laboratory tests performed in this study is one of our study's strengths. All institutions, even those in developing countries, can afford and use these standards. Our study has potential limitations, first, single centered research with a small sample size. Second, PCT and serum ferritin were done only at admission, Serial measurements are recommended in the future studies for a better insight into their prognostic value in children with LRTIs.

CONCLUSION

Procalcitonin is a potent predictor for severity, PICU admission, and transience in children with LRTI. Ferritin also is a good predictor for severity in cases with LTRI. FPR, a simple analysis, may be utilized to expect illness degree and outcome. With the ratio direction, patients with bacterial infection and poor prognosis may be recognized previous as they will have reduced ratios. Hence, it might be utilized as alarming sign of high-risk death cases as FPR is inversely correlated to bacterial infection severity.

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DECLARATION OF CONFLICTS OF INTERESTS

Author declares that they have no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE

Not applicable

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