Original Article

Impact of Various Platelet Indices and their Ratios in Prediction of Mortality in Septicemic Patients in Pediatric Population: A Prospective Study

B. S. Yadav[1], Rutika Bathwar[2], Akanksha Jain[3], Nehal Agarwal[4]

[1]Associate Professor, Department of Pathology, Netaji Subhash Chandra Bose Medical College, Jabalpur, India. [2]Senior Resident, Department of Pathology, Dr. Laxminarayan Pandey Government Medical College, Ratlam, India. [3]Demonstrator, Department of Pathology, Netaji Subhash Chandra Bose Medical College, Jabalpur, India. [4]Senior Resident, Department of Pathology, Netaji Subhash Chandra Bose Medical College, Jabalpur, India.

Abstract

Background: Role of platelet indices and their ratios in prediction of mortality in pediatric patients with sepsis. Settings and Design: This is a prospective study that was conducted in the Department of Pathology on 186 pediatric patients, in a tertiary heath center in central India, from September 2022 to February 2024. **Material and Methods:** Patient's sample was taken at the time of admission and analysed in pathology lab. Clinical as well as laboratory data were collected and patients were divided into two categories survivors and non –survivors. Statistical analysis used: Parametric and non-parametric data were analyzed using Mann–Whitney U test, Chi-square test, ROC analysis, and logistic regression. **Results:** Non-survivors had lower platelet counts and PCT, and higher MPV, PDW, MPV/PLT, MPV/PCT, PDW/PLT, and PDW/PCT ratios compared to survivors ($p<0.05$). MPV at the time of admission was an independent risk factor for death [odds ratio :1.418 (95% Cl: 1.059-1.243); $p=0.001$]. The MPV/PCT ratio had 'good' discriminative power for non-survivors with a cut-off value of 33.26 (AUC=0.700, Sensitivity=72%, Specificity=63.7%). **Conclusion:** Platelet indices and their ratios are simple, cost-effective markers for early identification of high-risk pediatric sepsis patients, aiding timely intervention and better resource utilization, especially in resource-limited settings.

Keywords: Sepsis; Platelet indices; ratios; Pediatric population.

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Introduction

Mortality depends on the severity of the illness at the time of hospital admission.[1] According to recent WHO status in 2020, approximately the total number of deaths under 5 years of age (U5MR) was 5 million worldwide, which is 37 deaths per 1000 live births which is even higher in developing countries like India.[2]

Major causes of pediatric mortality are prematurity, low birth weight, pneumonia, diarrhea, birth asphyxia, congenital anomalies, sepsis and infections. Sepsis is the leading cause of death in hospitalized children. In critically ill patients, hemodilution, increased platelet consumption, increased platelet destruction (immune mechanisms) & increased platelet sequestration result in thrombocytopenia. Septicemia-related platelet destruction causes increased production and release of younger and larger platelets with spherical shape and pseudopodia formation which leads to an increase in mean platelet volume (MPV) and platelet distribution width (PDW).[1] In ICU patients, an inverse correlation between the platelet count with risk of ICU stay and mortality was found.[3]

Among the platelet indices, the MPV which measures the average size of platelets, the PDW which approximates the coefficient of variation of the platelet population and plateletcrit (PCT) which is the volume that platelet occupies in the blood as a percentage are reportedly associated with platelet function.[4]

As the MPV and PDW increase and platelet count and PCT decrease in sick children, the ratio of MPV to PCT, MPV to Platelet count, PDW to PCT, PDW to platelet count could be useful markers for predicting the severity of illness and mortality. Since platelet parameters are easily calculated by counter analyzers and are relatively inexpensive, their role in the prediction of mortality is crucial for critically ill pediatric patients, particularly in developing countries.

Materials and Methods

This is a prospective study that was conducted in the Department of Pathology on 186 pediatric patients, in a tertiary heath center in central India, from September 2022 to February 2024. All children clinically presented with septicaemia admitted in PICU (Pediatric intensive care unit) between the age group of 1 month

Address for correspondence: Dr. Nehal Agarwal, Senior Resident, Department of Pathology, Netaji Subhash Chandra Bose Medical College, Jabalpur, India.
E-mail: nehal.carmel@gmail.com

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to fourteen years were included and assessed for clinical manifestations and vital parameters. Non-survivor (Group A) was taken as all the children between the ages of one month to fourteen years who died in the hospital while Survivor (Group B) were the children of similar age who survived during hospital stay.

Study Procedure: Data was collected from PICU and Medical Records Department (MRD) section of the pediatric department of this institute. The blood sample was collected immediately after admission in EDTA vial and sent to the central pathology laboratory. It was run in a fully automated hematology analyzer (SERACHEM SC60PLUS2080398, a 3-part-cell counter) for hemogram and the platelet count, MPV, PCT & PDW were noted.

Statistical Analysis: Data was collected and entered using MS Excel and tables were generated through IBM software SPSS version 27.0. Statistical analysis was done using Mann-Whitney U Test (non-parametric test) and the Chi-square test for quantitative and qualitative variables respectively. A p-value <0.05 was considered statistically significant. ROC (Receiver Operating Characteristics) curve analysis was used to identify the best threshold value for the measured variables and the variables ratios studied. Multiple logistic regression was applied to identify independent predictors of mortality. All ratios were transformed into a logarithmic scale for analysis.

Results

A total of 186 patients (87 males and 99 females) were studied. Out of these, 93 patients (50%) were non-survivors, and another 93 patients (50%) were survivors (controls). All the patients in our study were septicemic, diagnosed either septicemia (70.4%) or pneumonia (29.6%). Pneumonia and septicemia have similar lab findings so we have analysed pneumonia and septicemia data combinedly.

There was an equal distribution of survivors and non-survivors.

The statistical analysis in platelet indices between survivors and non-survivors was done using Mann-Whitney U Test and was expressed in Median and IQR2-3 (Inter Quartile range). Data with statistical significance (p< 0.05) was considered a predictive marker for mortality in pediatric patients.

As shown in [Table 3], significant differences were observed in platelet indices (platelets, MPV, PDW, PCT) and their ratios (MPV/PLT, MPV/PCT, PDW/PLT and PDW/PCT) between non-survivors and survivors. Non-survivors had lower median platelet counts, PCT and higher MPV, PDW, MPV/PLT, MPV/PCT, PDW/PLT, and PDW/PCT ratios compared to survivors. These differences were statistically significant (p<0.05), indicating that these indices can be used as potential markers for predicting mortality. Except PLT/LYMPHO ratio, that is not statistically significant.

[Table 4] shows - Multivariate analysis for platelet indices and their ratios was applied to determine the independent risk factor for death in children with sepsis. The MPV value at the time of admission was statistically significant [as its odds ratio was 1.418 (95% Cl: 1.059-1.243) with p=0.001] and it was observed that per unit increase of MPV at the time of admission increases the risk of death by 1.418 times.

A discriminative power of laboratory parameters between survivors and non-survivors were evaluated using ROC analysis and area under the ROC curve (AUC). The parameters with AUC ≥0.7 with statistical significance (p< 0.05) were considered to have good discriminative precision. The best diagnostic cut-off was selected with values corresponding to maximum sensitivity and specificity.

ROC analysis [Table 5 and Figure 1] shows only the MPV/PCT ratio have 'good' discriminative power for non-survivors with a cut-off value of 33.26 (AUC=0.700, Sensitivity=72%, Specificity=63.7%) and can be used for classifying survivors and non-survivors with statistical significance. While MPV, platelets, PDW, PCT, PDW/PLT, PDW/PCT, MPV/PLT and PLT/LYMPHO showed 'Poor' discriminative power for mortality.

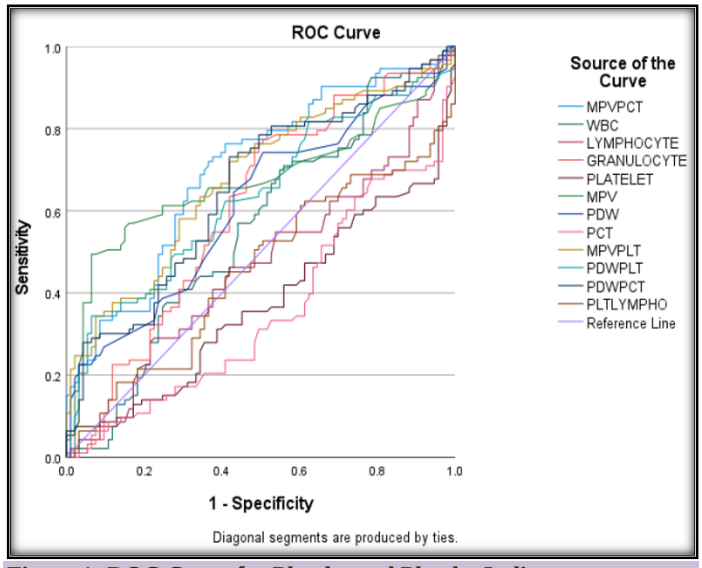

Figure 1: ROC Curve for Platelet and Platelet Indices.

Table 1: Baseline characteristics of study subjects (N = 186)

Characteristics	Percentage (%)
Gender	
Male	46.7% (87)
Female	53.3% (99)
Etiology	
Septicemia	70.4%
Pneumonia	29.6%
Outcome	
Survivor	93 (50%)
Non - survivor	93 (50%)

Table 2: Distribution of cases by age and outcome

Demographic Indices	Survivors	Non - Survivors	Total
1 month-5 year	81 (51.6%)	76 (48.4%)	157 (84.41%)
5-12 years	05 (25%)	15 (75%)	20 (10.75%)
12-14 years	07 (77.7%)	02 (22.2%)	09 (04.84%)
Total	93	93	186 (100%)

Pearson Chi-square = 6, p-value = 0.199(not significant)

Table 3: Table showing platelet, mpv, pdw, pct, and their ratios in picu patients according to their outcome

Variables	(Non-survivors) Median / (IQR 2-3) N= 93	(Survivors) Median / (IQR 2-3) N=93	P-Value
WBC (x103/µl)	10.58 (6.76- 14.17)	9.11 (5.91- 13.62)	0.203
Lymphocytes (x103/µl)	3.54 (1.35- 5.5)	3.7 (2.64- 5.28)	0.438
Granulocytes (x103/µl)	6.28 (4.01- 9.91)	3.99 (1.98- 8.33)	0.012
Platelets (x103/µl)	241 (87 – 418)	334 (217- 469)	0.003
MPV (fl)	11 (8- 13.4)	8.5 (7.8 – 9.5)	<0.001
PDW (%)	16.5 (15.7- 17.4)	15.9 (15.4 – 16.7)	0.008
PCT (%)	0.247 (0.076- 0.321)	0.31 (0.183 – 0.366)	0.001
MPV/PLT	0.039(0.026- 0.139)	0.025 (0.016- 0.047)	<0.001
PDW/PLT	0.06 (0.038- 0.190)	0.004(0.032- 0.080)	0.002
PDW/PCT	65.99 (51.84- 220)	50 (38.37- 86.33)	<0.001
PDW/Lymphocytes	80 (25.56- 136.15)	77.56 (37.53- 163)	0.271
MPV/PCT	44.86 (30.73- 119.4)	29.23(21.02- 44.69)	<0.001

Table 4: Multivariate analysis of platelet indices and their ratios

Variable	Odds Ratio (OR)	95% Confidence Interval (CI) Lower bound	Upper bound	P-Value
Platelet Count	1.002	.999	1.004	.287
MPV	1.418	1.059	1.243	0.001
PDW	.974	.883	1.074	0.591
PCT	.346	.012	9.903	0.535
MPV/PLT	46.958	.001	4126947.446	0.508
MPV/PCT	.997	.989	1.004	0.388
PDW/PLT	3.685	.005	2831.017	0.700
PDW/PCT	1.002	.998	1.006	0.301
PLT/LYMPHO	1.000	.999	1.001	0.875

Table 5: ROC curve analysis for platelet indices for predicting mortality in septicemia in PICU.

Platelet Index	Optimal cutoff	AUC (Area Under the Curve)	Sensitivity (%)	Specificity (%)
Platelet Count (x 103/*µl)*	146.50	0.375	60.2 %	23.7 %
MPV (fL)	8.25	0.672	72 %	41.9 %
PDW (%)	15.85	0.613	74.2 %	49.5 %
PCT (%)	0.1840	0.358	63.4 %	25.8 %
MPV/PLT	0.0287	0.679	72 %	58.1 %
MPV/PCT	33.26	0.700	72 %	63.7 %
PDW/PLT	0.0405	0.634	73.1 %	49.1 %
PDW/PCT	52.87	0.652	73.1 %	55.9 %
PDW/LYMPHO	64.24	0.453	61.3%	39.8 %

Discussion

Pediatric mortality is defined as death occurring in individuals under 14 years of age, represents a significant global public health challenge. In this study, out of 186 children admitted to PICU between one month to fourteen years of age, 93 were non-survivors and 93 were survivors. This near-equal distribution highlights the severity of the conditions being studied and the importance of identifying predictive markers for mortality. The majority of participants 157 (84.41%) were in the age group of 1 month to ≤ 5 years which indicates a higher prevalence of different health conditions among younger children admitted in PICU in the study, aligning with the global trend where younger children have higher morbidity and mortality rates due to infections and other health complications. The WHO 2020 report (U5MR 32.63/1000 live births and the infant mortality rate was 27/1000 live births) and data from the NFHS-5 from 2019 to 2021 (U5MR 49.2/1000 and Infant mortality rate 41.3/1000 live birth) also showed higher mortality rates in younger children (<5 years) and the critical nature of healthcare needs in this age group.[2,5].

In our study, significant differences in platelet indices were observed between non-survivors and survivors. Non-survivors had lower platelet counts and PCT values; higher MPV values and PDW when compared to survivors. The differences are statistically significant (p =< 0.001). Elevated MPV and PDW indicate increased platelet activation and consumption, which is common in severe infections and inflammatory conditions.

These findings are supported by studies done by Z. Sayed et al. (2020) which also reported that non-survivors had lower platelet

counts and lower PCT value and higher MPV values when compared to survivors.[7] Study done by Sriram et al. (2018) in children with sepsis also reported lower platelet levels and PCT values and higher MPV values and PDW values in non-survivors in comparison to survivors.[6]

On the contrary finding by Nagwan et al., (2024) reported no platelet indices were useful for the diagnosis of sepsis but they may be useful for predicting mortality among critically ill children in PICU. On comparing platelet counts and their indices between non-survivors and survivors, only differences in platelet counts and MPV were found statistically significant. Non-survivors had lower Median/IQ2-3 of platelet counts [202.5/(130.5-330.3)] and higher Median/ IQR2-3 of MPV level [8.2/(7.7-9.9)] when compared to survivors. Limitation of this study was its small sample size (n=133) and a heterogeneous group of disorders associated with risk of mortality.[8]

In this study, statistically significant difference (p =< 0.001) in the ratios of platelet indices (MPV/PLT, MPV/PCT, PDW/PLT, and PDW/PCT) between non-survivors and survivors were found. Non-survivors had higher ratio of MPV/PLT, MPV/PCT, PDW/PLT, PDW/PCT in comparison to survivors. These findings suggest that these ratios could serve as additional predictive markers for mortality in pediatric patients.

A study done by Rani et al. (2021) reported that non-survivors had a higher Mean ± SD ratio of MPV/PLT, MPV/PCT and PDW/PLT when compared to survivors.[9] Studies done by Z. Sayed et al. (2020),[7] also show similar results. The MPV/PLT ratio has been shown to correlate with the severity of systemic inflammation and the extent of platelet activation, making it a valuable marker for predicting outcomes in sepsis and other critical conditions in paediatric patients.[10]

RECEIVER OPERATING CURVE (ROC Curve) Analysis

In our study, the ROC curve analysis demonstrated that the MPV/PCT (AUC = 0.700, cut off value : 33.26) ratio had 'good' discriminative power for non-survival highlighting their potential utility in clinical settings to discriminate non-survivors from survivors and guide interventions. While MPV, platelets, PDW, PCT, PDW/PLT, PDW/PCT, PLT/LYMPHO showed 'Poor' discriminative power for mortality. [Table 5]

In the study done by Z. Sayed et al. (2020) [7], ROC curve analysis for platelet count and their indices to predict death in children with severe sepsis revealed platelet count, PCT, MPV/PLT, MPV/PCT, PDW/PCT had 'excellent' discriminative power.

The discriminative power of these indices underscores their potential for early identification of high-risk patients with sepsis, allowing for timely and targeted interventions that can significantly improve survival rates and reduce morbidity in PICU.

Also, multivariate analysis was applied which shows that per unit increase of MPV at the time of admission increases the risk of death by 1.418 times. Z. Sayed et al. (2020),[7] found that the decrease in PCT was statistically significant (p=0.02) with an odd ratio 0.101 (95% Cl: 0.1-0.15) and associated risk factors for death in children.[8]

These findings explain the role of platelets and their indices for the early detection of high-risk children with sepsis and severe infections. Our findings reinforce the critical need for enhanced clinical protocols and interventions targeted at these high-risk conditions in young children.

Conclusion

This study revealed a balanced gender distribution with a predominance of younger children between 1 month to ≤ 5 years (84.41%). Sepsis was the most common diagnosis. Significant differences in platelet indices (platelet count, MPV, PDW, and PCT) between non-survivors and survivors highlight their potential as prognostic markers. Higher MPV/PLT, MPV/PCT, PDW/PLT, and PDW/PCT ratios were associated with non-survivors. The ROC curve analysis identified MPV/PCT ratios as having good discriminative power in predicting mortality, with AUC values of 0.700. These ratios showed good discriminative power for non-survival, highlighting their potential use in clinical settings. Multivariate analysis shows that an increase in MPV increases the risk of mortality by 1.418 times. These results suggest that incorporating platelet indices and their ratios into routine clinical assessments could enhance the early identification of high-risk pediatric patients and allow for timely interventions to improve survival rates.

Limitations:

Single-Center Study: The study was conducted at a single-centre, which may limit the validity of the findings. Institutional practices, patient demographics, and local epidemiology could influence the results, making it difficult to apply these findings universally.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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