ORIGINAL ARTICLE

Platelet Indices as Predictive Marker of Prognosis in Critically Ill Children Admitted to Pediatric Intensive Care Unit: An Observational Study

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Abstract

Introduction: Platelets play a key role in hemostasis and inflammatory processes. Routinely available platelet indices, platelet count, mean platelet volume, platelet distribution width, and plateletcrit may serve as useful prognostic markers in critically ill children. This study aimed to evaluate their role using routine complete blood count tests.

Methods: A one-year prospective observational study was conducted in the Pediatric Intensive Care Unit of a tertiary hospital in Nepal from May 2023 to April 2024. Ethical approval was sought from the Institutional Review Committee (Ref: PMP2305161725). A convenience sampling technique was used. Platelet indices were compared with mortality, need for mechanical ventilation, inotropes, and hospital stay, using Receiver Operating Characteristic analysis to identify predictive cut-off values. Data were managed using Epidemiologic Information, Microsoft Excel, and Easy R.

Results: Marked differences in platelet indices were noted across clinical outcomes. Survivors had significantly higher platelet count (270.75 ± 136.06) and plateletcrit (0.37 ± 0.15) than non-survivors (130.25 ± 86.72 and 0.21 ± 0.12, respectively; $p < 0.001$). Patients requiring inotropes had lower platelet count (184.32 ± 114.57) and plateletcrit (0.27 ± 0.16), but higher Mean platelet volume, platelet distribution width, and platelet distribution width-to-platelet count ratio ($p < 0.001$). Similarly, those requiring invasive mechanical ventilation had lower platelet count (195.01 ± 125.30) and plateletcrit (0.29 ± 0.16), but higher mean platelet volume and platelet distribution width-to-platelet count ratio ($p < 0.001$). Platelet count had the highest sensitivity (90.30%) for predicting mortality, while platelet distribution width had the highest specificity (86.7%). The platelet distribution width-to-platelet count ratio showed good sensitivity (77.40%) and specificity (79.20%) at a cutoff of 0.09.

Conclusions: Platelet indices are valuable prognostic markers for critically ill children. However, further research with larger sample sizes, multicenter designs, and serial monitoring of platelet indices is needed to validate these findings.

Keywords: *inotropes; mortality, pediatric intensive care unit; platelet indices.*

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Introduction

The Pediatric Intensive Care Unit (PICU) is a specialized unit in the hospital that plays a vital role in managing critically ill children who require rapid assessment and timely intervention.[1] Despite advances made in pediatric critical care, many children admitted to the PICU remain at a high risk of mortality. Scoring systems like PRISM (Pediatric Risk of Mortality) and PIM (Pediatric Index of Mortality) predict PICU mortality, but they rely on multiple physiological variables and laboratory indices.[2] Thus, there arises a need for a simpler and readily available biomarker.

Platelet plays a crucial role in coagulation, thrombosis, inflammation, and vascular integrity.[3–6] Common platelet indices include platelet count (PC), mean platelet volume (MPV), platelet distribution width (PDW), plateletcrit (PCT), and PDW/PC ratio.[7–9] Studies suggest these indices are important prognostic markers in critically ill patients.[2, 10–19]

This study aimed to evaluate platelet indices from routine Complete Blood Count (CBC) tests as prognostic markers for mortality and critical interventions in critically ill Nepalese children admitted to PICU.

Methods

This was a prospective observational study carried out over a period of one year, from May 2023 to April 2024, in the Pediatric Intensive Care Unit at Patan Academy of Health Sciences, Patan Hospital. Ethical approval was sought from IRC-PAHS before commencing the study (Ref: PMP2305161725). Informed written consent from parents and informed assent were taken from children aged 7 to 14 years before enrolling in the study. The sample size was calculated based on a reference study, which was done in India, using the following formula.[11,20]

$n = (Z^2 \times p \times q)/ e^2$

Where n is the sample size, (Z = 1.96), p is the sensitivity (77.10%) or specificity (77.50%) from the reference study, and e (margin of error) is taken as 0.05. The sample size was calculated as 271. Children aged 1 month to 14 years admitted to PICU within the study period were included, except those with known platelet disorders, requiring immediate surgery, lacking a CBC test within 24 hours of PICU admission, or leaving against medical advice.

Special identification and demographic data were taken from the hospital record at the PICU. Platelet indices value, from the CBC test done at admission, were taken from the laboratory from the Sysmex XN-550 analyser. Platelet indices were not routinely reported but regularly estimated as a part of CBC in our laboratory. So, there was no extra burden of cost to the patient and their families. The need for inotropes, invasive mechanical ventilator and length of hospital stay were documented. Patients were followed up till discharge, and outcomes were recorded as survivors or non-survivors. A structured proforma was used for data collection.

Statistical analysis was performed using Kolmogorov-Smirnov tests for normality and unpaired t-tests for mean comparisons. Receiver Operating Characteristic (ROC) curves were used to determine optimal cut-off values, with sensitivity, specificity, positive predictive value, and negative predictive value calculated accordingly. Correlation coefficients were analyzed between platelet indices and hospital stay duration, with significance set at $p < 0.05$. Data were managed using EPI-INFO, Microsoft Excel, and Easy R, stored securely on a password-protected computer.

Results

During this one-year study period, 371 children were admitted to the PICU. Out of 371 cases, 271 cases fulfilled the inclusion criteria. 100 cases were excluded from the study in which 41 were excluded because they were admitted for postoperative and post-procedure monitoring, 19 were excluded because of known case of platelet disorder including haematological malignancy, 18 were excluded because they left against medical advice, 10 were excluded because for not having CBC test within 24 hours of admission and 12 were excluded because of less than 1 month of age. Of the 271 patients enrolled in this study, 31 (11.40%) did not survive, 69 (25.50%) required invasive mechanical ventilation, and 49 (18%) required inotropes. The average length of hospital stay was 11.30 days, with a minimum of 1 day and a maximum of 40 days. The average length of hospital stay was longer in those who survived (11.60 days in survivor and 9 days in non survivors), and those who needed invasive mechanical ventilation (12 days in those who required invasive mechanical ventilation, 11.10 days in those who did not require) and inotropes (11.60 days in those who needed inotropes, 9.70 days in those who did not).

This study found a statistically significant difference in mean platelet indices between survivors and non-survivors (P<0.001) (Table 1). Survivors had significantly higher mean platelet counts and plateletcrit (270.75 ± 136.06 for platelet count and 0.37 ± 0.15 for plateletcrit) compared to non-survivors (130.25 ± 86.72 for platelet count and 0.21 ± 0.12 for plateletcrit), while mean MPV, PDW, and PDW/PC were significantly lower in survivors than in non-survivors.

Table 1: Platelet indices in relation to outcome

Platelet indices	Survivors (n=240) (Mean ± 2SD)	Non-Survivors (n=31) (Mean ± 2SD	p value
PC (thousand/ul)	270.75±136.06	130.25±86.72	<0.001
PCT (%)	0.37±0.15	0.21±0.12	<0.001
MPV (fL)	8.55±1.21	9.85±1.42	<0.001
PDW (%)	13.51±4.09	16.47±4.31	<0.001
PDW/PC	0.08±0.11	0.25±0.26	<0.001

Similarly, there was a statistically significant difference in mean platelet indices between patients who required inotropes and those who did not (P<0.001) (Table 2). Patients requiring inotropes had significantly lower mean platelet counts and plateletcrit, while their mean MPV, PDW, and PDW/PC were significantly higher than those of patients who did not require inotropes.

Table 2: Platelet indices in relation to need of inotropes

Platelet indices	Need for inotropes Yes(n=49) (Mean ±2SD)	Need for inotropes No (n=222) (Mean ± 2SD)	p value
PC (thousand/ul)	184.32±114.57	270.21±138.93	<0.001
PCT (%)	0.27±16	0.37±0.15	<0.001
MPV (fL)	9.48±1.44	8.53±1.21	<0.001
PDW (%)	15.27±4.55	13.53±4.09	0.009
PDW/PC	0.18±0.23	0.08±0.12	<0.001

A similar trend was observed in patients requiring invasive mechanical ventilation (P<0.001) (Table 3). Their mean platelet count and plateletcrit were significantly lower than those of patients who did not require ventilation, while mean MPV and PDW/PC were significantly higher. However, there was no statistically significant difference in mean PDW between ventilated and non-ventilated patients (P = 0.189).

Table 3: Platelet indices in relation to the need for invasive mechanical ventilation

Platelet indices	Need for an invasive mechanical ventilator Yes(N=69) (Mean ± 2SD)	Need for an invasive mechanical ventilator No (N=202) (Mean ± 2SD)	p value
PC (thousand/ul)	195.01±125.30	275.06±137.40	<0.001
PCT (%)	0.29±0.16	0.38±0.15	<0.001
MPV (fL)	9.22±1.41	8.52±1.22	<0.001
PDW (%)	14.42±4.54	13.65±4.1	0.189
PDW/PC	0.16±0.23	0.08±0.1	<0.001

The area under the curve (AUC) for platelet count in predicting mortality was found to be 0.80 (95% CI, 0.734–0.872), indicating that low platelet count can be a reliable predictor of mortality. The optimal cutoff for platelet counts to predict mortality was determined to be 222.5 thousand/µL, with a sensitivity of 90.30%, specificity of 61.30%, positive predictive value (PPV) of 23.10%, and negative predictive value (NPV) of 98% (Table 4). Similarly, the AUC for other platelet indices, along with their optimal cutoff values, sensitivity, specificity, PPV, and NPV for predicting mortality, are presented in Table 4.

Table 4: Platelet indices with their AUC, Optimal cutoff, sensitivity, specificity, PPV and NPV

Platelet indices	AUC	Optimal cutoff	Sensitivity	Specificity	PPV	NPV
PC (thousand/ul)	0.80 (95% CI, 0.734-0.872)	222.5	90.30	61.30	23.10	98
PCT (%)	0.80 (95% CI, 0.732-0.880)	0.30	80.60	67.90	24.50	96.40
MPV (fL)	0.75 (95% CI, 0.658-0.842)	9.30	64.50	73.30	22.50	94
PDW (%)	0.69 (95% CI,0.589-0.802)	18.15	48.40	86.70	31.90	92.90
PDW/PC	0.82 (95% CI,0.759-0.897)	0.09	77.40	79.20	31.60	96.40

Among the platelet indices, platelet count (PC) exhibited the highest sensitivity (90.30%) for predicting mortality, while PDW demonstrated the highest specificity (86.70%). The PDW/PC ratio also showed good sensitivity (77.40%) and specificity (79.20%) at a cutoff value of 0.09. While all platelet indices exhibit a negative predictive value (NPV) exceeding 90% at their optimal cutoff values, their positive predictive values (PPV) remain notably low (Table 4, Figure 1-5).

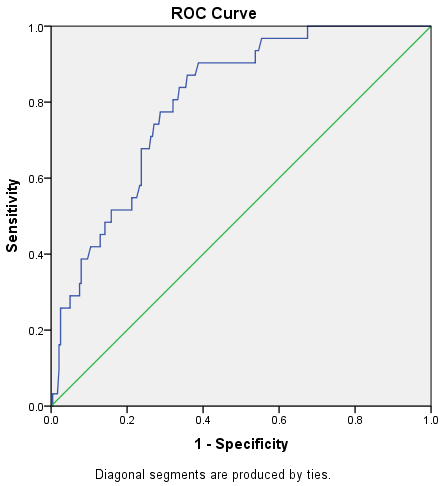

Figure 1: ROC curve for Platelet counts and Mortality

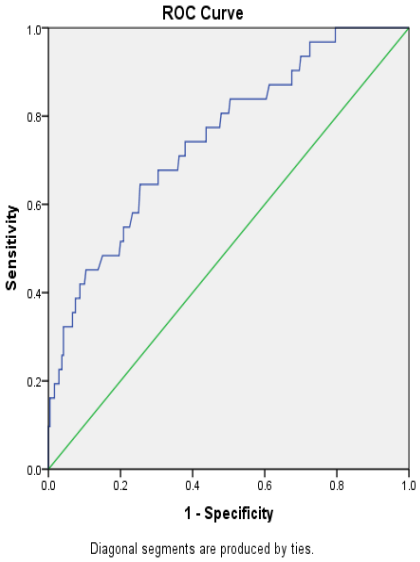

Figure 3: ROC curve for MPV and Mortality

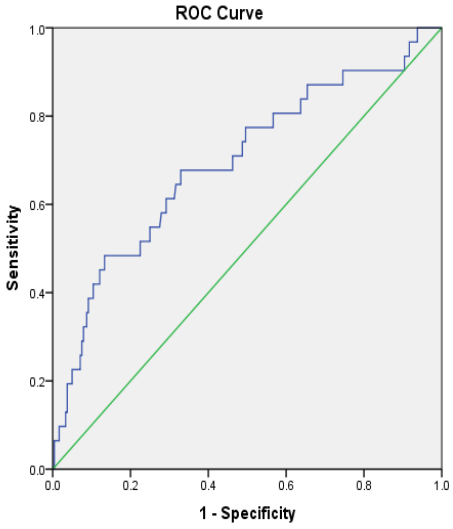

Figure 4: ROC of PDW with Mortality

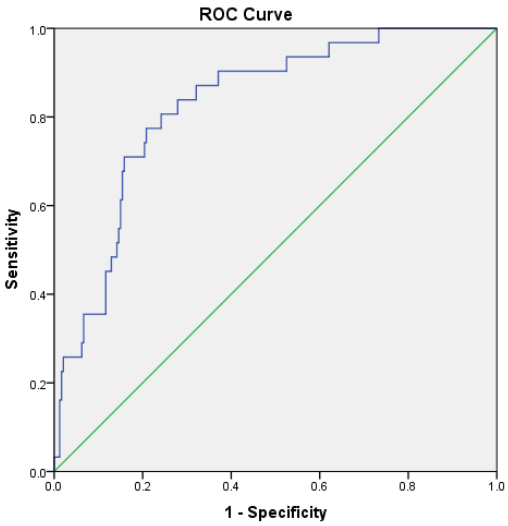

Figure 5: ROC of PDW/PC with Mortality

Table 5: Correlation between platelet indices and length of hospital stay

Platelet indices	Correlation coefficient (r)	p value
PC (thousand/ul)	0.117	0.054
PCT (%)	-0.002	0.977
MPV (fL)	-0.118	0.052
PDW (%)	0.001	0.990
PDW/PC	-0.01	0.87

In our study, the correlation between the platelet indices and duration of hospital stay is not established. There was a very weak positive correlation between platelet count and PDW with duration of hospital stay. There was a very weak negative correlation between PCT, MPV, PDW/PC and duration of hospital stay. However, none of these correlations were statistically significant (Table 5).

Discussion

This study explored the potential of platelet indices as prognostic markers in critically ill children admitted to the PICU. Traditionally used in diagnosing hematological disorders, platelet indices are increasingly being recognized for their association with illness severity and patient outcomes. This is because growing evidence indicates that platelet indices also reflect inflammatory activation, endothelial dysfunction, and coagulopathy.[15] Consistent with multiple previous studies conducted in similar settings, our findings support the growing recognition of platelet-derived parameters as a potential prognostic tool in critical illness in patients admitted to PICU.

Our study demonstrated that the mean platelet count was significantly higher among survivors than non-survivors. This finding is consistent with research by Mohamed Fawzi et al., Dr. Pramod V.U. et al., and Sheng Zhang et al., reinforcing the role of platelet indices in predicting patient outcomes.[10,12,13] Additionally, the mean values of PCT, MPV, PDW, and PDW/PC were significantly different between survivors and non-survivors, in agreement with multiple studies. However, Mohamed Fawzi et al. reported no significant difference in MPV and PDW, likely due to differences in sample size and exclusion criteria.[10]

We also examined the association between platelet indices and the need for inotropic support and invasive mechanical ventilation. Patients requiring inotropes had significantly lower platelet counts than those who did not, a trend consistent with findings by Aygün et al.[21] Similarly, platelet counts were lower in patients requiring invasive mechanical ventilation, supporting previous research that associates lower platelet counts with increased disease severity.

The study determined an optimal platelet count cutoff of 222.5 thousand/μL for predicting mortality, with a sensitivity of 90.30%, specificity of 61.30%, and an AUC-ROC of 0.80. Comparisons with Purbiya et al., Dr. Pramod V.U. et al., and Sheng Zhang et al. revealed differences in cutoff values, possibly due to variations in sample size, mortality rates, and exclusion criteria.[11-13] Although cutoff values reported in the literature vary widely, the overall trend consistently links lower platelet counts and altered platelet indices with higher mortality risk. Similarly, cutoff values for MPV, PDW, and PDW/PC were comparable with those reported by Purbiya et al., though sensitivity and specificity varied when compared to studies by Dr. Pramod V.U. et al. and Sheng Zhang et al.[12,13] Such variations further highlight the need for multicenter studies to establish standardized reference thresholds.

Despite a high negative predictive value for mortality prediction (>90%), the positive predictive value of platelet indices remained low, consistent with findings by Dr. Pramod V.U. et al.[12] Among platelet indices, platelet count exhibited the highest sensitivity (90.30%) for mortality prediction, while PDW demonstrated the highest specificity (86.70%). Additionally, a PDW/PC ratio >0.09 was identified as an independent predictor of mortality, with 77.40% sensitivity and 79.20% specificity, corroborating findings by Purbiya et al.[11]

In our study, platelet count and PDW exhibited a weak positive correlation, whereas PCT, MPV, and PDW/PC showed a weak negative correlation. However, this correlation was not statistically significant. This contrasts with Samuel et al., who reported different correlation trends, likely due to differences in patient severity and survival rates.[22] Further focused studies are needed to better understand the relationship between platelet indices and hospital stay, particularly in critically ill pediatric populations.

This was a single-centre study conducted over a short duration with a relatively small sample size. The samples between survivors and non-survivors were not balanced, resulting in a large disparity in their ratio, which may have influenced the final results. Children who were critically ill and admitted to the PICU but later left against medical advice had to be excluded from our study. This exclusion is a limitation, as these critically ill children with abnormal platelet parameters may have impacted the final results. Another limitation is that we did not evaluate the trend of platelet indices over time or after treatment.

Conclusions

Platelet indices are simple, accessible, and cost-effective parameters in our setting, potentially serving as valuable prognostic indicators for mortality and for predicting the need for invasive mechanical ventilator and/or inotropes in critically ill children. However, further research with larger sample sizes, multicenter designs, and serial monitoring of platelet indices is needed to validate these findings.

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