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CLINICAL STUDY

# Are platelet indices promising ratios for predicting pediatric septic shock prognosis?

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**ABSTRACT**

OBJECTIVES: The aim of the present study was to determine the prognostic value of thrombocytopenia, platelet indices (MPV/PLT and PDW/PLT) in children with septic shock.

BACKGROUND: Septic shock is one of the major causes of mortality among children worldwide.

METHODS: A retrospective analysis was made of children admitted to the pediatric intensive care unit between November 2010 and December 2019. Two hundred four children were included; they were diagnosed with septic shock according to the international pediatric sepsis consensus conference criteria. The MPV/platelet ratio and PDW/platelet ratios were estimated as the MPV and PDW values divided by the platelet count on the first three days of hospitalization. The clinical outcome was 28-day mortality.

RESULTS: MPV/PLT and PDW/PLT ratios were found to be significantly higher in the non-survivors than survivor ($p \leq 0.001$). In the multivariate logistic regression analysis, higher MPV/platelet ratios at $72_h$ (OR: 7.41; 95% CI: 1.25–43.7; $p = 0.027$) and PDW/platelet ratios at $72_h$ (OR: 2.9; 95% CI: 1.13–7.50; $p = 0.027$) were significant risk factors for mortality.

CONCLUSIONS: Platelet indices are useful laboratory parameters in septic shock. MPV/PLT and PDW/PLT ratios can be promising reliable markers for 28-day mortality in children with septic shock *(Tab. 4, Fig. 1, Ref. 29)*. Text in PDF *www.elis.sk*

KEY WORDS: septic shock, mortality, platelet indices, thrombocytopenia, children.

## Introduction

Sepsis is described as systemic inflammatory response syndrome plus suspicious or proved infection, while septic shock includes cardiovascular dysfunction leading to persistent hypoperfusion and hypotension (1). Septic shock is associated with high mortality and morbidity in adults and children. Furthermore, delayed diagnosis and late treatment of septic shock has been associated with worse outcomes (2). Several various biomarkers such as white blood cells (WBC), neutrophils count, C-reactive protein (CRP) are used to early diagnose or prognosticate the reason of SIRS, sepsis or septic shock. There is no optimal indicator to discriminate septic shock (3). In case of septic shock some alterations occur in the coagulation system that are represented by thrombocytopenia prolongation of prothrombin time (PT) and activated partial thromboplastin time (aPTT) (4, 5). In several previous reports, the extent of thrombocytopenia is correlated to the mortality and improvement of thrombocyte count indicates recovery of the patient (6, 7). Septic shock increases thrombotic and inflammatory situations which may alter thrombocyte volumes (8). Platelet volume distribution width (PDW) and mean platelet volume (MPV) are platelet indices which are routinely measured, and easy to interpret, which are readily available in routine blood count (9). Recent studies suggested that thrombocytes and their indices can be utilized as inflammatory biomarkers in cancer, cardiovascular and cerebrovascular cases, and also as prognostic indicator in critical patients (10). Besides, some researchers have shown that alterations of MPV/PLT, PDW/PLT ratio are related with mortality and morbidity in patients with various illnesses (11–13). In our research, it was aimed to identify the prognostic significance of thrombocytopenia, thrombocyte indices MPV/PLT and PDW/PLT in children with septic shock.

## Material and methods

This is a retrospective, observational single-center study that was conducted in a tertiary pediatric intensive care unit (PICU). This research was reviewed and approved by Hacettepe University Ethical Committee. Patients were diagnosed with septic shock and admitted to PICU between November 2010 and December 2019. Patients with diabetes mellitus, connective tissue disease, chronic renal failure, hematologic diseases (malignancy, immune thrombocytopenic purpura) or receiving transfusion of thrombocytes

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**Tab. 1. Demographics, clinical characteristics and laboratory variables of survivors and non-survivors.**

| Variables | Survivors (n=145) | Non- survivors (n=59) | p |
|---|---|---|---|
| Age (month)* | 32(78) | 59(132) | 0.10 |
| Gender (female, n (%;) male, n (%) | 59(40.8%); 86 (59.2%) | 29 (49%); 30 (51%) | 0.25 |
| Respiratory rate (rate/min) | 45.82±11.1 | 46.37±12.7 | 0.77 |
| Heart rate (rate/min) | 147.9±24.2 | 147.1±24.4 | 0.83 |
| Systolic blood pressure (mmHg) | 70.62±8.8 | 69.78±12.53 | 0.60 |
| Diastolic blood pressure (mmHg) | 39.15±7.66 | 38.50±7.21 | 0.59 |
| Immune deficiency (n/%) | 13(10%) | 18 (33.3%) | 0.001 |
| Microbiology | | | |
| Blood culture (n/%) | 17 (13.1%) | 13 (24.1%) | 0.06 |
| Urine culture (n/%) | 7 (5.4%) | 6 (11.5%) | 0.20 |
| Duration of mechanical ventilation (day)* | 3(10) | 7(13) | 0.004 |
| Inotropic Score | 26.87 ±7.02 | 27.78 ±6.93 | 0.42 |
| $WBC_{adm}$ $\times 10^3/\mu L$ * | 12.2(9.6) | 8.5(15.8) | 0.029 |
| $Neutrophil_{adm}$ $\times 10^3/\mu L$ * | 8.1(9.1) | 5.0(7.9) | 0.005 |
| $Lymphocyte_{adm}$ $\times 103/\mu L$ * | 1.8(2.7) | 1.0(1.5) | <0.001 |
| Hgb gr/dl | 10.6±2.3 | 10.4±2.6 | 0.64 |
| $PDW_{adm}$ (%) | 17.2±0.8 | 17.4±0.9 | 0.29 |
| $PDW_{36th}$ (%) | 17.35±0.8 | 17.25±0.8 | 0.45 |
| $PDW_{72th}$ (%) | 17.54±1.03 | 17.24±1.2 | 0.08 |
| $MPV_{adm}$ fL | 10.1±1.3 | 10.4±1.2 | 0.22 |
| $MPV_{36th}$ fL | 10.16±1.18 | 10.43±1.08 | 0.12 |
| $MPV_{72th}$ fL | 10.42±1.29 | 11.12±1.12 | 0.13 |
| AST (median)(U/L)* | 62.5(93) | 66(87) | 0.38 |
| ALT (median)(U/L)* | 38(58) | 32(60) | 0.14 |
| INR * | 1.3(0.73) | 1.3(0.67) | 0.67 |
| aPTT (second)* | 32.1(12.8) | 34.2(14.3) | 0.62 |
| D-dimer (ng/dl)* | 3.9(5.7) | 2.7(4.0) | 0.10 |
| Fibrinogen (mg/dL) | 298.5±160.8 | 269.8±174.3 | 0.28 |
| PRISM 2 score* | 29.3(34.3) | 56.7(50.2) | <0.001 |
| PELOD score* | 20(10) | 30(10) | <0.001 |
| $Lactate_{adm}$ (mmol/L)* | 1.9(1.9) | 2.5(2.87) | 0.008 |
| $Albumin_{adm}$ (g/dl) | 3.3±0.72 | 2.9±0.6 | <0.001 |
| $CRP_{adm}$ mg/dl* | 1.8(3.1) | 2.67(4.9) | 0.39 |
| $CRP_{72h}$ mg/dl* | 1.1(2.4) | 3.2(7.8) | <0.001 |
| $ESR_{adm}$ (mm/h)* | 10.5(15) | 11(16) | 0.786 |
| $ESR_{72h}$ (mm/h)* | 10(16) | 20(28) | 0.001 |

*Median (IQR), PRISM 2: pediatric risk of mortality 2; PELOD: pediatric logistic organ dysfunction; Hgb: hemoglobin; WBC: white blood cell; CRP: C- reactive protein; ESR: erythrocyte sedimentation rate; MPV: mean platelet volume; PDW: platelet volume distribution width: PICU LOS; pediatric intensive care unit length of stay; aPTT: activated partial thromboplastin time; INR: international normalized ratio; AST; aspartate aminotransferase; ALT; alanine aminotransferase; SD: standard deviation; IQR: interquartile range

**Tab. 2. Platelet variables of survivors and non-survivors.**

| Variables | Survivors (n:145) | Non-survivors (n:59) | p |
|---|---|---|---|
| $PLT_{adm}$ $\times 10^3/\mu L$* | 111.5 (155.5) | 95.5 (83.0) | <0.001 |
| $PLT_{36h}$ $\times 10^3/\mu L$* | 85.5 (94.5) | 67.0 (57.2) | <0.001 |
| $PLT_{72h}$ $\times 10^3/\mu L$* | 76.5 (100.7) | 43.5 (39.7) | <0.001 |
| $MPV_{adm}/PLT_{adm}$* | 0.090 (0.08) | 0.108 (0.10) | <0.001 |
| $MPV_{36h}/PLT_{36h}$* | 0.118 (0.09) | 0.155 (0.17) | <0.001 |
| $MPV_{72}/PLT_{72}$* | 0.136 (0.11) | 0.255 (0.21) | <0.001 |
| $PDW_{adm}/PLT_{adm}$ * | 0.1 (0.15) | 0.19 (0.22) | <0.001 |
| $PDW_{36h}/PLT_{36h}$* | 0.12 (0.17) | 0.25 (0.34) | <0.001 |
| $PDW_{72h}/PLT_{72h}$* | 0.14 (0.19) | 0.40 (0.46) | <0.001 |

*median (IQR), PLT: Platelet; MPV: mean platelet volume; PDW: platelet volume distribution width; MPV/PLT: mean platelet volume/Platelet ratio; PDW/PLT: platelet volume distribution width/Platelet ratio; IQR: interquartile range

in the first 72 hours of admission to intensive care unit were excluded. Input was obtained from patient files. Blood specimens were collected for laboratory analysis into tubes with ethylene diamine tetra acetic acid (EDTA) and automatically analyzed with ADVIA 2120, Siemens, Forchheim, Germany within maximum 60 minutes from specimen collection.

Demographic data, comorbidities, hemodynamic parameters, clinical results and laboratory data at 28 days after admission were recorded. PRISM score, PELOD score, thrombocyte number, PDW and MPV level were recorded. Septic shock was defined based on International Consensus Conference on Pediatric Sepsis (14). Additionally, MPV/platelet and PDW/platelet ratio calculated by (MPV value/platelet count) x1000, (PDW value/platelet ratio) x1000 were estimated.

SPSS Statistics 22 software (IBM, Armonk, NY, USA) was used for statistical analysis. Descriptive statistics were done for non-parametric quantitative data by median and interquartile range (IQR), and for parametric quantitative data by mean ± standard deviation, while they were done by frequency and percentage for categorical data. The demographic, laboratory and clinical data of groups were compared. Differences in continuous parameters were compared by the Mann–Whitney U test and unpaired Student t test. Chi-square test was used for evaluation of categorical variables. Spearman's correlation analysis was used to define the correlations between the $MPV_{adm}/PLT_{adm}$, $MPV_{36h}/PLT_{36h}$, $MPV_{72h}/PLT_{72h}$, $PLT_{adm}$, $PLT_{36h}$, $PLT_{72h}$, $PDW_{adm}/PLT_{adm}$, $PDW_{36h}/PLT_{36h}$, $PDW_{72h}/PLT_{72h}$ with PRISM 2 score, PELOD score, $WBC_{adm}$, $neutrophil_{adm}$, $lymphocyte_{adm}$, $CRP_{72h}$, $ESR_{72h}$, $lactate_{adm}$. Multiple logistic regression analyses were done to assess the independent risk parameters for mortality. Receiver operating characteristic (ROC) curves were used to show the predictive level of $MPV_{72h}/PLT_{72h}$, $PDW_{72h}/PLT_{72h}$, $PLT_{adm}$, $PLT_{36h}$, and $PLT_{72h}$ for mortality. P value less than 0.05 was regarded as significant.

## Results

Two hundred thirty-six septic shock children were admitted to PICU during the period of the study. 32 patients who had diabetes mellitus, connective tissue disease, chronic renal failure, hematologic disease and platelet transfusion were excluded based on predetermined study protocol and 204 patients were included.

There were 131 male (64 %) and 73 female (36 %) cases. Patients' median age was 62.9 months (±63.7 SD). 59 patients (29 %) died during the study period. There was no difference between survivor and non-survivor group with regard to gender, age, vital signs and microbiological data (Tab. 1). Patients with immunodeficiency had a higher mortality rate (33.3 % vs 10 %; p=0.001). Non-survivor group had longer mechanical ventilation support day (11.19±14.67 vs 10.3±23.46; p=0.004) but hospitalization day was longer in survivor group (44.27±49.70 vs 11.19±14.67; p=0.31). PRISM, PELOD score, $CRP_{72h}$ and $ESR_{72h}$ values were significantly higher in non-survivor patients than those who survived (p=0.001). Lactate was higher in non-survivor group (3.7541+3.32942 vs 2.9185+2.92071; p=0.008), in contrast to albumin that was lower in non-survivor group (2.8943+0.61223 vs 3.3019+0.71811; p ≤0.001). Although there was no significant difference between these two groups at 36 and 72 hours, the admission white blood cell count (WBC) and neutrophil count were significantly greater in the survivors. Coagulation parameters (PT, aPTT, D-dimer, and fibrinogen), liver function tests, platelet indices (MPV, PDW, difference of MPV levels at admission and at 72nd hour and 36th hour ($\Delta MPV72_{h\text{-}adm}$, $\Delta MPV36_{h\text{-}adm}$) are shown in Table 1. Isolated PDW/platelet and MPV/platelet ratios were compared within each group during the first 72 hours after admission. Non-survivors exhibited a significantly higher MPV/platelet, PDW/platelet ratio than survivors at admission, after 36 and 72 hours, and thrombocyte numbers were significantly lower in the non-survivor group in all values (p ≤ 0.001) (Tab. 2). Length of hospitalization day, $albumin_{adm,}$ platelet count variables, $PDW_{72h}/PLT_{72h}$, $MPV_{72h}/PLT_{72h}$ were evaluated by multivariate logistic regression model. As a conclusion, $PLT_{adm}$ (OR 0.99), $PLT_{36h}$ (OR 0.98), $PLT_{72h}$ (OR 0.97), $PDW_{72h}/PLT_{72h}$ (OR 2.9) and $MPV_{72h}/PLT_{72h}$ (OR 7.41) ratio had a significant impact on mortality (Tab. 3). Correlation analysis was performed between $MPV_{72h}/PLT_{72h}$, $PDW_{72h}/PLT_{72h}$, platelet counts, $WBC_{adm}$, $CRP_{72h}$, $ESR_{72h}$, $lymphocyte_{adm}$, $albumin_{adm}$ $neutrophil_{adm}$ and $lactate_{adm}$ levels with PRISM 2 and PELOD scores. $Lactate_{adm}$, $CRP_{72h}$, PRISM 2 and PELOD scores were positively correlated with $PDW_{72h}/PLT_{72h}$. $WBC_{adm}$, $albumin_{adm}$, $lymphocyte_{adm}$, $neutrophil_{adm}$ were negatively correlated with $PDW_{72h}/PLT_{72h}$. $Lactate_{adm}$, $CRP_{72h}$, PRISM 2 and PELOD scores were positively correlated with $MPV_{72h}/PLT_{72h}$ and negatively correlated with platelet counts. $WBC_{adm}$, $albumin_{adm}$ $lymphocyte_{adm}$ and $neutrophil_{adm}$ were positively correlated with platelet counts and negatively correlated with $MPV_{72h}/PLT_{72h}$. All these correlations were statistically significant (p ≤ 0.001) (Tab. 4). To predict 28-day mortality receiver operating characteristic (ROC) analysis was applied and the outcomes displayed that the areas under the ROC curve for $PDW_{72h}/PLT_{72h}$, $MPV_{72h}/PLT_{72h}$, $PLT_{adm}$, $PLT_{36h}$, and $PLT_{72h}$ were 0.83, 0.81, 0.71, 0.79 and 0.834, respectively. The cut-off values for $PDW_{72h}/PLT_{72h}$, $MPV_{72h}/PLT_{72h}$, $PLT_{adm}$, $PLT_{36h}$, $PLT_{72h}$ were 0.20 (sensitivity 90.7 %, specificity 36.9 %), 0.093 (sensitivity 88.9 %, specificity 38.5 %), 101.5x10³/μL (sensitivity 70.8 %, specificity 44.4 %), 86.5 x10³/μL (sensitivity 70 %, specificity 31.5 %), 58.5 x10³/μL (sensitivity 80 %, specificity 37 %), respectively (Fig. 1).

**Tab. 3. Multivariate Logistic Regression Analysis for the Prediction of 28-day Mortality.**

| Variables | Odd Ratio | 95% Confidence Interval | p |
|---|---|---|---|
| $PLT_{adm}$ | 0.99 | 0.989–0.998 | 0.004 |
| $PLT_{36h}$ | 0.98 | 0.97–0.99 | 0.001 |
| $PLT_{72h}$ | 0.97 | 0.96–0.98 | <0.001 |
| $PDW_{72h}/PLT_{72h}$ | 2.9 | 1.13–7.50 | 0.027 |
| $MPV_{72h}/PLT_{72h}$ | 7.41 | 1.25–43.7 | 0.027 |

PLT: Platelet; MPV/PLT: mean platelet volume/Platelet ratio; PDW/PLT: platelet volume distribution width/Platelet ratio

**Tab. 4. Correlation between $PDW_{72h}/PLT_{72h}$, $MPV72h/PLT_{72h}$, Platelet Counts and Other Variables.**

| | $PDW_{72h}/PLT_{72h}$ | | $MPV_{72h}/PLT_{72h}$ | | $PLT_{adm}$ | | $PLT_{36h}$ | | $PLT_{72h}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | r | p | r | p | r | p | r | p | r | p |
| PRISM 2 | 0.219 | 0.003 | 0.312 | <0.01 | –0.16 | 0.03 | –0.195 | 0.008 | –0.229 | 0.002 |
| PELOD | 0.315 | <0.01 | 0.203 | 0.06 | –0.138 | 0.062 | –0.261 | <0.01 | –0.317 | <0.01 |
| $WBC_{adm}$ | –0.339 | <0.01 | –0.325 | <0.01 | 0.302 | <0.01 | 0.311 | <0.01 | 0.342 | <0.01 |
| $Albumin_{adm}$ | –0.385 | <0.01 | –0.388 | <0.01 | 0.36 | <0.01 | 0.35 | <0.01 | 0.31 | <0.01 |
| $Lactate_{adm}$ | 0.277 | <0.01 | 0.23 | <0.01 | –0.155 | 0.036 | –0.222 | <0.01 | –0.279 | <0.01 |
| $CRP_{72h}$ | 0.376 | <0.01 | 0.3641 | <0.01 | –0.368 | <0.01 | –0.386 | <0.01 | –0.376 | <0.01 |
| $ESR_{72h}$ | 0.065 | 0.378 | 0.056 | 0.449 | –0.073 | 0.32 | –0.082 | 0.27 | –0.061 | 0.413 |
| $Lymphocyte_{adm}$ | –0.439 | <0.01 | –0.428 | <0.01 | 0.421 | <0.01 | 0.464 | <0.01 | 0.442 | <0.01 |
| $Neutrophil_{adm}$ | –0.365 | <0.01 | –0.355 | <0.01 | 0.294 | <0.01 | 0.314 | <.01 | 0.369 | <0.01 |

PRISM 2: pediatric risk of mortality 2; PELOD: pediatric logistic organ dysfunction; WBC: white blood cell; CRP: C-reactive protein; ESR: erythrocyte sedimentation rate; PLT: Platelet; MPV/PLT: mean platelet volume/Platelet ratio; PDW/PLT: platelet volume distribution width/Platelet ratio

## Discussion

The present study is a retrospective clinical study that investigates the prognostic value of MPV/PLT and PDW/PLT ratios in pediatric patients with septic shock. The main findings of this study are as follows. Firstly, MPV/PLT and P DW/PLT ratios were found to be significantly higher in non-survivors than in survivors from admission to the 72nd hour. Secondly, the $MPV_{72h}/PLT_{72h}$ and $PDW_{72h}/PLT_{72h}$ ratios disclosed to be an independent risk factor for septic shock patients, even after adjusting for reasonable peculiar variables. Especially, patients with higher $MPV_{72h}/PLT_{72h}$ and $PDW_{72h}/PLT_{72h}$ ratio should be followed up more closely, as their mortality risk is higher. According to our knowledge, this is the first research to study the relationship between the PDW/PLT, MPV/PLT rate and prognosis of children with septic shock.

Researchers reported that the activation of the coagulation system, inflammatory conditions and thrombotic diseases can alter the volume of thrombocyte indices and severe sepsis or septic shock causes thrombocytopenia (15). Reasons of thrombocytopenia in sepsis are impaired production and increased platelet consumption (16). In critical patients, thrombocytopenia is independent risk parameter and unfavorable prognostic marker for mortality (17, 18). Also, a

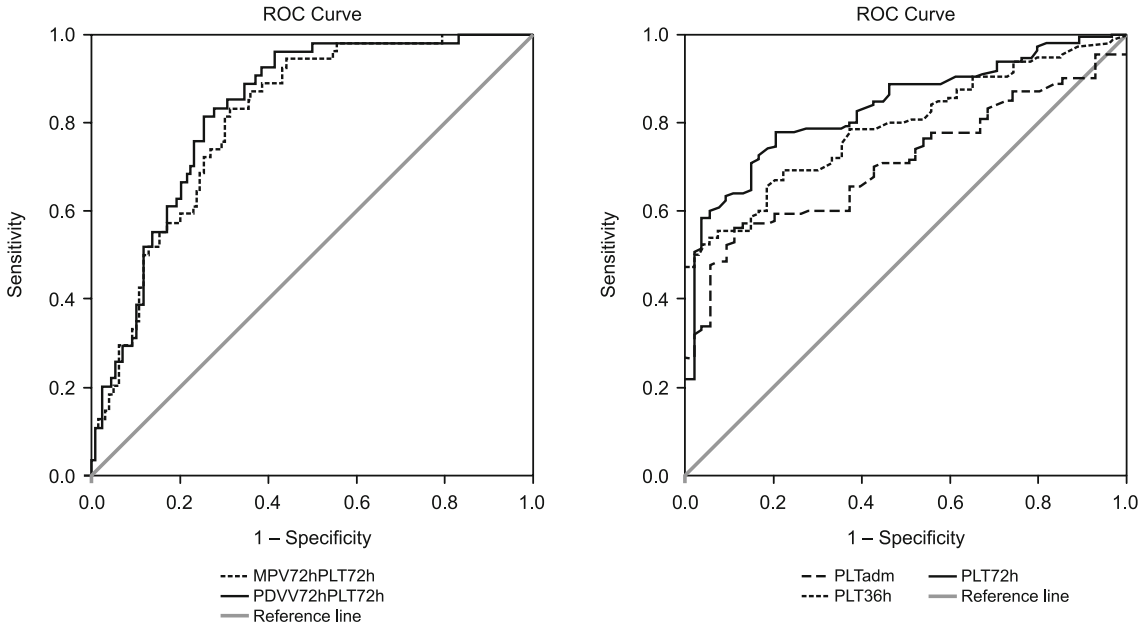


**Fig. 1. $PDW_{72h}/PLT_{72h}$ and $MPV_{72h}/PLT_{72h}$ ROC curve map and $PLT_{adm}$ $PLT_{36h}$ $PLT_{72h}$ ROC curve map.**

recent study showed that mortality was lower in non-thrombocytopenic children at the time of admission than in thrombocytopenic children in intensive care units (19). In septic shock, thrombocytopenia (<100,000/mm³) at the admission is related with mortality (20). Similar findings were shown in our study that first-day platelet count was found approximately 100,000/mm³ in non-survivor patients. First three days thrombocyte counts of non-survivor group were lower than the of survivor group and this finding was an independent risk factor for 28th-day mortality in septic shock patients.

Thrombotic and inflammatory situations might alter the sizes of thrombocyte. Some studies showed that inflammation and thrombotic conditions cause alteration of platelet size, higher than normal size, and these alterations are associated with increasing of mortality and morbidity in patients with different diseases (21, 22). Several different researches have showed that survivors had appreciably lower mean MPV value than non-survivors in patients with sepsis (17, 23). In septic patients, endothelial damage, bone marrow suppression and production of many cytokines may be the main reason of this condition (17). An investigation made by Isguder et al. showed that children with sepsis had high baseline MPV values and cases whose MPV values increased during follow up had high mortality risk because pathophysiological conditions can prevent thrombocyte regeneration, enhancement of their activation or accelerate their decease once overwhelming the capacity of self-regulation will induce alteration in both thrombocyte number and morphology and thus results in an alteration in thrombocyte indices and this results in increase in MPV value (24). In the current study, it was found that MPV values were higher in non-survivor group but this difference was not statistically significant.

Activation of platelet causes some changes of platelets morphologies, including both spherical shape and pseudopodia formation. Thrombocytes with increased count and volume of pseudopodia are altered in volume, which affects the value of PDW (13). Guclu et al showed that PDW was the only significant distinctive laboratory parameter different between survivors and non-survivors in severe sepsis (17). In an animal experimental research, PDW level increased in the presence of endotoxemia (25). Conflicting results have been reported in respect to the relationship of PDW with mortality. Although several adult and pediatric studies commonly suggested that PDW is useful to predict risk of mortality in septic patients, some other studies hypothesized that PDW values should not be used as a prognostic marker in patients with critical disease (17, 26, 27). In this research, there was no difference found between the PDW levels of groups.

Some researches hypothesized that total thrombocyte number is inversely related with MPV (16, 28). A recent study showed that high MPV value and a low thrombocyte number increased thrombocytes reactivity and aggregation; in non-ST-elevation myocardial infarction analysis, MPV/platelet ratio was found superior to MPV alone (28). And the author hypothesized that an inverse relationship between thrombocyte count and MPV could act as a predictor for early mortality in critically ill patients with suspected sepsis receiving early goal-directed therapy (28). Therefore, impact of MPV/platelet and PDW/platelet ratio on mortality was evaluated in our study. In univariate analysis, the present research displayed that higher MPV/PLT and MPV/PLT ratios were found statistically significant in non-survivor group in the evaluation of the first three days, but only $PDW_{72h}/PLT_{72h}$ and $MPV_{72h}/PLT_{72h}$ were found significant in multivariate logistic regression analysis. Odds ratio of $MPV_{72h}/PLT_{72h}$ was found to be the highest (OR 7.41). Therefore, keeping MPV/PLT and PDW/PLT ratios monitored may be useful to extrapolate mortality risk in pediatric patients with septic shock. Our findings are compatible with previous studies that reported MPV/PLT and PDW/PLT ratios as predictors of mortality in children with sepsis (16, 29).

Simple combination of laboratory tests could be used to early diagnose the severity of septic shock and risk of mortality. Thrombocyte number and their indices are cheap and evaluated by the automatic analyzer in the complete blood count that are commonly used in patients with septic shock to assess the hematological status. Therefore, PDW/platelet and MPV/platelet ratio can be used as a predictor for mortality in pediatric septic shock patients.

In conclusion, this current study demonstrated that MPV/PLT and PDW/PLT ratios at 72nd hour are independent risk factors for mortality. Higher MPV/PLT and PDW/PLT ratios are ominous signs that should be taken seriously in septic shock patients. Larger prospective multicenter researches are needed to approve the practicability of the MPV/PLT and PDW/PLT ratio as a predictive indicator in septic shock patients.

## Limitations

This study has some limitations, as being a single center retrospective research with limited patients' number. We are also aware that drugs including antibiotics may have an effect on the platelet indices causing bias of our results.

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