EGYPTIAN JOURNAL OF ANAESTHESIA
2023, VOL. 39, NO. 1, 56–62
https://doi.org/10.1080/11101849.2023.2168853

Platelet indices in critically ill septic patients as a predictor of mortality

Rehab Salah Taha, Mohamed Elsayed Afandy, Abdelaziz Hamid Elbadawi and Mohamed Samir Abd El Ghafar

Anesthesiology, Surgical Intensive Care and Pain Medicine Department, Faculty of Medicine, Tanta University, Tanta, Egypt

ABSTRACT

Background: Platelet (PLT) indices are used to quantify the total number of PLTs, their morphology, and their proliferation kinetics. The aim of this work was to explore whether platelet indices (PLT count, platelet distribution width (PDW), mean platelet volume (MPV) and platelet crit (PCT) can be used to predict mortality in critically ill septic patients.

Methods: This prospective cross-sectional study was carried out on 54 critically ill septic patients according to sequential organ failure assessment (SOFA) scores from May 2020 to May 2021. Patients were grouped into: (1) survivors' group and (2) non-survivors' group. Complete blood count, C-reactive protein (CRP) and procalcitonin serum levels were measured.

Results: A rise in MPV, PDW, procalcitonin and CRP and a fall in PLT and PCT was associated with non-survivors' group. For prediction of mortality, PLT, MPV and PDW at cut-off value ≤183 $*10^3$/dl, >10.9 fl and >14% had (57.89%, 84.21% and 78.95%) sensitivity, (71.43%, 80% and 74.29%) specificity, (52.4%, 69.6% and 62.5%) positive predictive value (PPV), negative predictive value (NPV) (75.8%, 90.3% and 86.7%), (0.672, 0.868 and 0.856) area under the curve (AUC) and (0.038, <0.001 and <0.001) P value respectively. For prediction of mortality, procalcitonin at cut-off value 5.6 ng/dl had 94.74% sensitivity, 85.7% specificity, 78.3% PPV, NPV 96.8, 0.919 AUC and <0.001 P value. In multivariate regression analysis, most affecting factors for mortality were procalcitonin, MPV and PDW (P value<0.05).

Conclusions: Platelet indices are low-cost, readily accessible metrics that have the potential to be valuable prognostic markers in sepsis.

ARTICLE HISTORY
Received 28 November 2022
Revised 30 December 2022
Accepted 9 January 2023

KEYWORDS
Platelet indices; mortality; critically ill; septic patients

1. Introduction

Platelets (PLT), the blood's primary and major significant component, are crucial for both physiological and pathological activities include coagulation, thrombosis, inflammation, and maintaining the integrity of vascular endothelial cells [1]. Platelet indices are collections of variables that are used to assess the quantity and shape of PLTs as well as their rate of proliferation[2].

The most often utilized PLT parameters are plateletcrit, PLT distribution width (PDW), mean PLT volume (MPV), and PLT count (PCT). The MPV is the proportion of PCT to PLT counts. PDW is mathematically equivalent to the coefficient of PLT volume change, which is used to represent the distribution of PLTs volume [3].

It is well known that platelet indices have been used to diagnose disorders of the hematological system. These indicators have been linked in recent years to the prognosis of patients as well as the severity of their illnesses. For patients in an intensive care unit who are critically ill, a decrease in PLT count is considered an independent risk factor [4]. Furthermore, thrombocytopenia is included as a separate risk factor for death in the acute physiology and chronic health evaluation II (APACHE II) system [5].

PLT indices have been found to be changed in neonatal sepsis [6], ascitic fluid infection [7], colorectal cancer [8].

All of these findings suggested that PLT indices will be regarded as indicators for various disorders [9].

For critical patients, platelet indices may be a valuable tool for diagnosis and monitoring as they are simple, inexpensive, and regularly performed in the hospital laboratory. However, the role of PLT indices in the severity of illness assessment in septic patients is currently under research. The aim of this work was to explore whether platelet indices (PLT distribution width (PDW)), PLT count, mean PLT volume (MPV) and PLT crit (PCT) may be used to anticipate death in septic patients who are extremely ill.

2. Materials and methods

This was a prospective cross-sectional study carried out on 54 septic patients aged from 18 to 65 years old, met criteria of sepsis and septic shock according to sequential organ failure assessment (SOFA) scores with increase of SOFA score 2 or more constituting organ dysfunction, with fully available platelet indices and in hospital information and length of ICU stay more than 24 h.

CONTACT Rehab Salah Taha rehabsalah2017@gmail.com Demonstrator of Anesthesiology, Surgical Intensive Care and Pain Medicine Department, Faculty of Medicine, Tanta University, Tanta 31527, Egypt

The patient or the patient's family members provided their written permission after receiving full information. The research was conducted with institutional and regional ethics committee permission (Approval code: 33753/3/20) and was registered at clinicaltrials.gov (ID: NCT04335955).

We exclude patients with active bleeding, pregnant women, patients with hematological diseases such as hypersplenism, anemia, leukemia and lymphoma, patients with bone marrow diseases and patients with rheumatic diseases. We also exclude individuals who utilized antiplatelet medications before their admission as well as those who had received blood or platelets previous to their admission.

According to 28th day, patients were divided into two groups: (1) the survivors' group and (2) the non-survivors' group.

2.1. Sample collection and measurement

In order to measure the levels of procalcitonin serum, whole blood count, PLT indices, C-reactive protein (CRP) and blood was collected from the peripheral vein, the artery or a central catheter. This procedure was carried out at the time of diagnosis and at 3, 7, 14 and 21 and 28 days after the onset of sepsis. Samples were estimated using the Dirui BCC-3600 cell counter (made in China, 2016), and a concurrent smear examination was also performed.

The subjects were observed until they left the hospital or died. We compared the patients with normal and abnormal PLT indices for a number of different outcomes, including the mortality odds ratio (OR), the performance of receiver operating curves (ROCs) of PLT indices in prediction of mortality and the difference in survival curves between the two groups. We also examined the correlation between procalcitonin and SOFA score and with changes in PLT indices.

2.2. Sample size calculation

MedCalc program version 18.2.1 was used for calculation of the sample size. We follow these criteria in calculating the sample size, with 0.05 alpha error and 80% power of the study, as reported in previous article [3], the area under the curve (AUC) of MPV to predict the primary outcome (mortality) was 0.79 and ratio of survivors to non-survivors was 3.58:1. Four cases were added to overcome dropout, so, the net result was 50 patients.

2.3. Statistical analysis

Data were entered into the computer and analyzed using SPSS Program, version 20.0. Number and percentage were used to describe the qualitative data. To ensure that the distribution's normality, the Kolmogorov-Smirnov test was applied. The range, mean, standard deviation and median were used to describe the quantitative data. We used the Mann Whitney-test was for analyzing the non-parametric quantitative data that were provided as median and interquartile range (IQR). The acquired findings were deemed significant at the 5% level.

3. Results

In this study, 79 patients were assessed for eligibility, 17 patients did not meet the criteria and 8 patients refused to participate in the study. The remaining 54 patients were randomly allocated into two groups (non-survivors' group included 19 patients, and survivors' group included 35 patients). All allocated patients were followed up and analyzed statistically. Figure 1

Age and SOFA score were statistically significantly increased in non-survivors' group compared to survivors' group. Sex, BMI, causes of infection and white blood cells (WBCs) were insignificantly different between both groups. Table 1

PLT was statistically significantly decreased in in the group of non-survivors than in the group of survivors at day 1, 3, 7 of sepsis diagnosis. PCT was statistically significantly decreased in non-survivors' group compared to survivors' group at day 3, 7 of sepsis diagnosis. Compared to the survivors' group, MPV and PDW were statistically significantly higher in the non-survivors' group at day 1, 3, 7 of sepsis diagnosis. Procalcitonin was statistically significant increased in non-survivors' group compared to survivors' group at day 1, 3 and 7. Table 2

As regards prediction of mortality, we found that these parameters had the highest sensitivity and specificity: Procalcitonin, MPV, PDW at cut-off value 5.6, >10.9, >14 with sensitivity (94.74%, 84.21%, 78.95%) and specificity (85.7%, 80%, 74.29%) respectively. Table 3, Figure 2

In univariate, procalcitonin, MPV, PDW and PLT were significant predictors for mortality (P value<0.05). In multivariate, most affecting factors for mortality were procalcitonin, MPV and PDW (P value<0.05). Table 4

When we used procalcitonin as a standard biomarker in our study we found that: There were negative correlations between procalcitonin and PLT, PCT in both groups and positive correlations with MPV, PDW, CRP, SOFA score and age in both groups. Table 5

There were negative correlations between SOFA and PLT, PCT in both groups and positive correlation with MPV and PDW in both groups. Table 5

4. Discussion

Sepsis is a significant illness that affects millions of individuals each year throughout the globe. Reduced platelet levels correlate with more severe infection

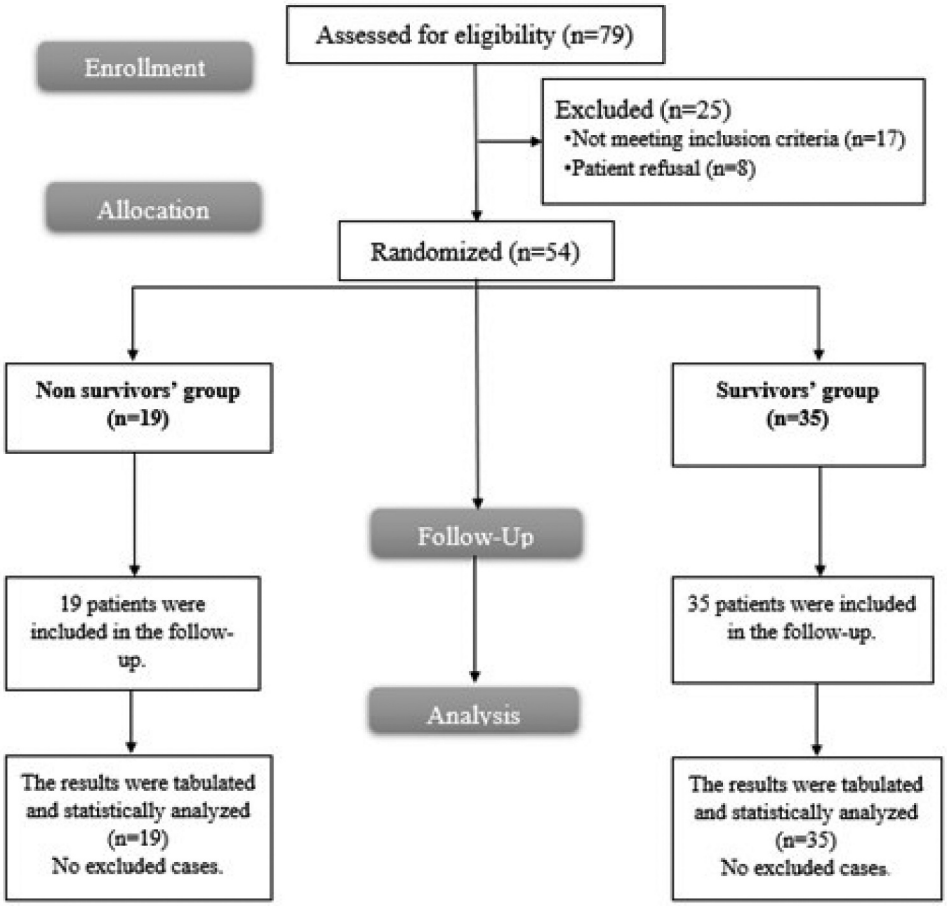

Figure 1. Flowchart of the enrolled patients.

Table 1. Comparison between the two studied groups according to patients' characteristics and causes of infection of the studied groups.

		Non-Survivors (n = 19)	Survivors (n = 35)	P value
Sex	Male	11(57.9%)	20(57.1%)	0.957
	Female	8(42.1%)	15(42.9%)	
Age (years)		54.37 ± 9.30	40.54 ± 9.56	<0.001*
BMI (kg/m^2)		29.33 ± 5.28	29.72 ± 5.85	0.810
SOFA score at admission		10.0(10.0–12.0)	6.0(5.0–7.0)	<0.001*
WBCs (*10^3/dl) at admission		22.43 ± 4.71	20.05 ± 5.71	0.128
Causes of infection				
Intra-abdominal infection		6(31.6%)	10(28.6%)	0.615
Chest infection		6(31.6%)	7(20%)	
C.N.S infection		4(21.1%)	5(14.3%)	
Surgical wound infection		3(15.8%)	7(20%)	
Urinary tract infection		0(0%)	3(8.6%)	
Bed sores & central line infection		0(0%)	3(8.6%)	

Data are presented as mean ± SD, frequency (%) or median (IQR), BMI: Body mass index, WBCs: white blood cells, C.N.S: Central nervous system, *: significant P value

[10]. Destructive thrombocytopenia has high MPV levels and hypo-proliferative thrombocytopenia has low MPV levels [11]. PDW is a measure of platelet size variation [12].

As regards PLT count, PLT was significantly decreased in non-survivors group compared to survivors' group at day 1, 3, 7 of sepsis diagnosis.

Kim et al. [13] reported similar results in the prospective study and examined MPV to forecast the 28-day mortality in sepsis patients during the first day of hospital admission and 72 hours later (MPV72h-adm) and found that platelets in non-survivors showed a significant decrease compared to the survivors' group.

In contrary, Guclu et al. [10] conducted a retrospective cohort study on 145 sepsis patients and 143 control to investigate the MPV and PDW in severe sepsis, as well as the platelet count and reported that the PLT count in non-survivors' group was significantly increased compared to survivors' group.

Our study showed that the PLT count can predict mortality at cut-off ≤183 PLT with 57.89% sensitivity, 71.43% specificity, 52.4% PPV and 75.8% NPV with AUC of 0.672 (95% C.I: 0.520–0.824)

Table 2. Comparison between the two studied groups according to platelet count, plateletcrit and mean platelet volume.

	N	Non-survivors (n = 19)	N	Survivors (n = 35)	P value
Platelet count (*10^3/dl)					
Day 1	19	183.05 ± 34.31	35	209.89 ± 41.72	0.020*
Day 3	13	178.92 ± 19.60	34	252.47 ± 42.81	<0.001*
Day 7	4	164.25 ± 16.50	26	283.50 ± 48.29	<0.001*
Day 14	0	-	7	331.86 ± 29.05	-
Day 21	0	-	1	392.0	-
Day 28	0	-	1	395.0	-
PCT (%)					
Day 1	19	0.18 ± 0.04	35	0.20 ± 0.05	0.259
Day 3	13	0.16 ± 0.03	34	0.25 ± 0.05	<0.001*
Day 7	4	0.15 ± 0.05	26	0.27 ± 0.05	<0.001*
Day 14	0	-	7	0.32 ± 0.02	-
Day 21	0	-	1	0.39	-
Day 28	0	-	1	0.39	-
MPV (fl)					
Day 1	19	11.47 ± 0.97	35	10.57 ± 0.45	0.001*
Day 3	13	11.37 ± .38	34	10.07 ± 0.59	<0.001*
Day 7	4	11.45 ± 0.44	26	9.30 ± 0.70	<0.001*
Day 14	0	-	7	8.64 ± 0.56	-
Day 21	0	-	1	8.0	-
Day 28	0	-	1	8.0	-
PDW (%)					
Day 1	19	15.49 ± 1.35	35	13.34 ± 1.34	<0.001*
Day 3	13	16.19 ± 0.71	34	11.81 ± 1.35	<0.001*
Day 7	4	16.63 ± 0.80	26	10.69 ± 1.01	<0.001*
Day 14	0	-	7	10.09 ± 0.65	-
Day 21	0	-	1	9.30	-
Day 28	0	-	1	9.0	-
Procalcitonin (ng/dl)					
Day 1	19	13.68 ± 6.44	35	4.06 ± 2.09	6.331*
Day 3	13	14.80 ± 6.60	34	1.66 ± 1.25	7.128*
Day 7	4	15.45 ± 10.11	26	0.60 ± 0.54	2.937*
Day 14	0	-	7	0.34 ± 0.15	-
Day 21	0	-	1	0.10	-
Day 28	0	-	1	0.10	-

Data are presented as mean ± SD, *: significant P value ≤ 0.05, PCT: Plateletcrit, MPV, Mean platelet volume, PDW: platelet distribution width

Table 3. Validity (AUC, sensitivity, specificity) for different parameters to predict mortality.

	AUC	p	95% C. I	Youden Index J	Cut-Off#	Sensitivity	Specificity	PPV	NPV
Procalcitonin	0.919	<0.001*	0.822–1.016	0.805	>5.6	94.74	85.71	78.3	96.8
MPV	0.868	<0.001*	0.743–0.993	0.684	>10.9	84.21	80.00	69.6	90.3
PDW	0.856	<0.001*	0.756–0.957	0.561	>14	78.95	74.29	62.5	86.7
CRP	0.850	<0.001*	0.749–0.951	0.605	>50	63.16	74.29	57.1	78.8
PLT	0.672	0.038*	0.520–0.824	0.317	≤183	57.89	71.43	52.4	75.8
PCT	0.593	0.261	0.428–0.758	0.197	≤0.17	52.63	57.14	40.0	69.0

*: Significant P value ≤ 0.05. PDW: platelet distribution width, MPV, Mean platelet volume, PLT: Platelet, CRP: C-reactive protein, PCT: Plateletcrit, NPV: Negative predictive value, PPV: Positive predictive value. CI: Confidence Intervals.

This was similar with Zhang et al. [14], who developed the PLT ROC and determined the diagnostic parameters for each PLT index. With an area under ROC of 0.79, the PLT had the largest area.

As regards PCT, PCT at day 1 was insignificantly different between both groups, PCT was significantly decreased at day 3 and day 7 in non-survivors group compared to survivors group.

This is similar to Sayed et al. [15] who determined the prognostic value of platelet count and indices regarding pediatric sepsis and reported that PCT was significantly decreased in non-survivor s than survivors .

As regards MPV, MPV was significantly increased in non-survivors' group compared to survivors' group after 1, 3 and 7 days of sepsis.

Similar to this, Mangalesh et al. [16] showed that the MPV was considerably higher in the non-survivors' group than in the survivors' group on the first day of admission, the third, fifth and final days of hospitalisation.

Our results revealed that MPV can predict mortality at cut-off >10.9, with 84.21% sensitivity, 80% specificity, 69.6% PPV and 90.3% NPV with AUC of 0.868 (95% C.I: 0.743–0.993). According to Gao et al. [17], the MPV had the greatest AUC and the best accuracy rate, both of which were (0.81) 75.6%, respectively. The MPV threshold was proposed to be above 10.5, at which there may be a reasonable likelihood of mortality, as a predictive prognostic indicator.

As regards PDW, the value of PDW in the non-survivors' group recorded a significant increase

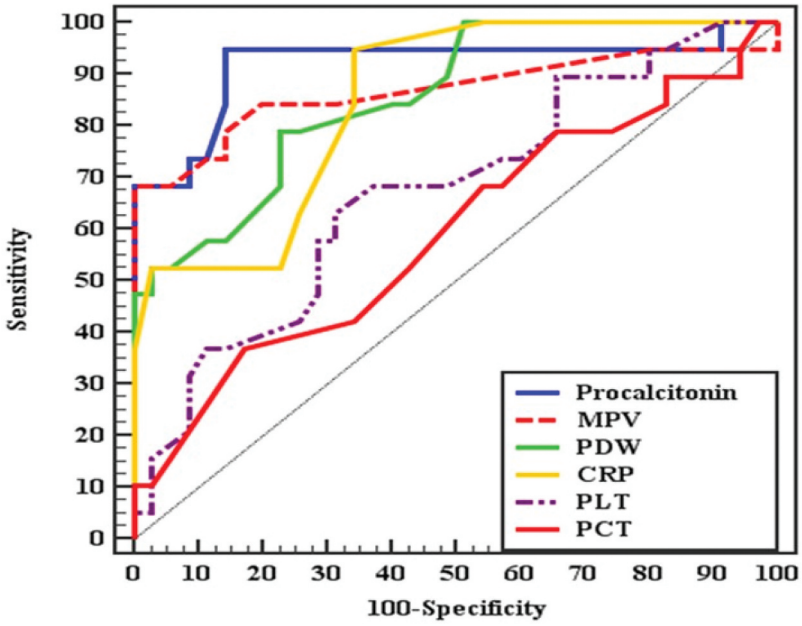

Figure 2. ROC curve of different parameters to discriminate non-survivor's from survivors' groups.

Table 4. Univariate and multivariate logistic regression analysis for the parameters affecting mortality.

	Univariate		#Multivariate	
	p	OR (95%C.I)	p	OR (95%C.I)
Procalcitonin	0.003*	1.786(1.220–2.615)	0.009*	1.701(1.145–2.528)
MPV	<0.001*	7.970(2.621–24.238)	0.007*	2.290(1.254–3.544)
PDW	<0.001*	3.141(1.706–5.781)	0.035*	4.837(1.117–2.094)
PLT	0.027*	0.980(0.962–0.998)	0.544	1.010(0.978–1.042)

OR: Odd's ratio, C.I: Confidence interval, LL: Lower limit, UL: Upper Limit, #: All variables with $p < 0.05$ was included in the multivariate, PDW: platelet distribution width, MPV, Mean platelet volume, PLT: Platelets, *: Statistically significant at $p \leq 0.05$.

compared to the survivors' group after 1, 3 and 7 days of sepsis diagnosis.

Similarly, Mangalesh et al. [16] found that by the time the PDW level in non-survivors' group was significantly elevated compared to the survivors' group.

Likewise, the ROC curve of our study showed that the PDW can predict mortality at cut-off >14 with 78.95% sensitivity, 74.29% specificity, 62.5% PPV and 86.7% NPV with AUC of 0.856 (95% C.I: 0.756–0.957).

Similarly, Zhang et al. [14] estimated the predictive value of PDW to predict mortality in septic patients; the obtained ROC curve reported that the PDW obtained 0.68 areas under ROCs with 16.1 cut-off, 60% sensitivity and 67.5 specificity.

Table 5. Correlation between Procalcitonin and SOFA score with different parameters.

	Non-Survivors (n = 19)		Survivors (n = 35)	
	r	p	r	p
Procalcitonin				
PLT-	−0.551*	0.014*	−0.396*	0.019*
PCT-	−0.523*	0.022*	−0.355*	0.036*
MPV+	0.626*	0.004*	0.549*	0.001*
CRP+	0.744*	<0.001*	0.682*	<0.001*
PDW+	0.476*	0.039*	0.607	<0.001*
Age+	0.639*	0.003*	0.517	0.001*
SOFA score+	0.525*	0.021*	0.585	<0.001*
SOFA score				
PLT-	−0.492*	0.018*	−0.371*	0.024*
PCT-	−0.437*	0.041*	−0.352*	0.038*
MPV+	0.592*	0.007*	0.634*	<0.001*
PDW+	0.492*	0.013*	0.687	<0.001*

PDW: platelet distribution width, CRP: C reactive protein, PLT: Platelet, PCT: Plateletcrit, MPV, Mean platelet volume, r: Pearson coefficient, *: Statistically significant at $p \leq 0.05$

As regards procalcitonin, procalcitonin concentration was significantly increased in the non-survivors' group compared to the survivors' group on day 1, day 3 and day 7.

Similarly, Jeon et al. [18] presented a significant elevation of procalcitonin concentration in the non-survivors' group compared to survivors' groups.

In our study, procalcitonin ROC curve revealed that it can significantly predict mortality at cut-off >5.6, with 94.74% sensitivity, 85.71% specificity, 78.3% PPV and 96.8% NPV with AUC of 0.919 (95% C.I: 0.822–1.016).

Similarly, Mangalesh et al. [16] constructed ROC curves to evaluate procalcitonin in predicting mortality; procalcitonin had a slightly high AUC 0.909 (95% C.I: 0.838–0.980) with cut-off < 1.08 ng/ml 81.1% sensitivity, 92.2% specificity that recommend procalcitonin as the best predictor for mortality in sepsis patients.

As regards CRP, CRP concentration at day 1, day 3 and day 7 was significantly increased in the non-survivors group' compared to the survivors' group.

Similarly, Kim et al. [13] reported that the CRP level was significantly elevated in non-survivors compared to the survivors' group.

In contrary, Guclu et al. [10] showed that CRP level was elevated in both survivors' and non-survivors' groups. Hence, the CRP concentration was not useful in differential diagnosis of sepsis and severe sepsis.

One of significant findings regarding the ROC curve was that the CRP level can significantly predict mortality with AUC of 0.850 (95% C.I: 0.749–0.951) at cut-off >50. Additionally, the CRP level can significantly predict mortality with 63.16% sensitivity, 74.29% specificity, 57.1% PPV and 78.8% NPV.

Similarly, Li et al. [19] showed that the CRP level can predict mortality with AUC of 0.731 (95% C.I: 0.661–0.793) at cut-off 107.6 mg/L, 71.40% sensitivity, 68.90% specificity, 40.00% PPV and 89.20% NPV.

Our findings showed that there was a negative significant correlation between procalcitonin with PLT and PCT in both survivors' and non-survivors' group.

Similarly, Jiang et al. [20] showed that the serum procalcitonin level was negatively correlated with PLT in the urosepsis patients.

Moreover, our results found a significant positive correlation between procalcitonin with each of MPV, CRP, PDW, age and SOFA was detected in both survivors' and non-survivors' group.

Similarly, İşgüder et al. [21] found a significant positive correlation between procalcitonin and MPV level.

In our study, we found that procalcitonin, MPV, PDW and PLT were all significant predictors of mortality in patients with severe sepsis. When multivariate linear regression analysis was used to determine their independent association with mortality, procalcitonin, MPV and PDW were found to be significant predictors of mortality.

Similarly, Mangalesh et al. [16] used binary logistic regression to determine the predictive value of platelet indices, patient age and concomitant conditions. MPV and PDW were independent predictors of death in multivariate analysis.

4.1. Limitations

It was a single centric study. There are effects of specific therapeutic choices for each patient on outcomes that cannot be investigated, and the study lacked bacterial culture data, such as percentage of positive culture or the most common bacteria and their resistance profile.

5. Conclusions

Platelet indices are affordable, accessible parameters that might be beneficial sepsis prognostic markers. In this research, a decline in PLT and PCT and an increase in MPV, PDW, procalcitonin and CRP were related with death. Effective predictors of death included procalcitonin at a threshold of 5.6 ng/ml, MPV at a cut-off of 10.9 fl and PDW at a cut-off of 14%.

Acknowledgments

There is nothing to be declared.

Disclosure statement

The authors report no conflict of interest.

Funding statement

This research did not receive any specific grant from any funding agency in the public, commercial, or not-for-profit sector.

References

[1] Golebiewska EM, Poole AW. Platelet secretion: from haemostasis to wound healing and beyond. Blood Rev. 2015;29:153–162.

[2] Guclu E, Durmaz Y, Karabay O. Effect of severe sepsis on platelet count and their indices. Afr Health Sci. 2013;13:333–338.

[3] Zhang Z, Ni H, Deng H. Platelet indices are novel predictors of hospital mortality in intensive care unit patients. J Crit Care. 2014;29:85–88.

[4] Sezgi C, Taylan M, Kaya H, et al. Alterations in platelet count and mean platelet volume as predictors of patient outcome in the respiratory intensive care unit. Clin Respir J. 2015;9:403–408.

[5] Akavipat PTJ, Thikhamrop B, Sriraj W. Acute physiology and chronic health evaluation (APACHE) II score – the clinical predictor in neurosurgical intensive care unit. Acta Clin Croat. 2019;58:50–55.

[6] Catal F, Tayman C, Tonbul A, et al. Mean platelet volume (MPV) may simply predict the severity of sepsis in preterm infants. Clin Lab. 2014;60:1193–1200.

[7] Abdel-Razik A, Eldars W, Rizk E. Platelet indices and inflammatory markers as diagnostic predictors for ascitic fluid infection. Eur J Gastroenterol Hepatol. 2014;26:1342–1347.
[8] Li XT, Yan Z, Wang RT, Yu KJ. Preoperative mean platelet volume and platelet distribution width predict postoperative sepsis in patients with colorectal cancer. Biomed Res Int. 2019;2019:17–32.
[9] Budak YU, Polat M, Huysal K. The use of platelet indices, plateletcrit, mean platelet volume and platelet distribution width in emergency non-traumatic abdominal surgery: a systematic review. Biochem Med. 2016;26:178–193.
[10] Guclu E, Durmaz Y, Karabay O. Effect of severe sepsis on platelet count and their indices. Afr Health Sci. 2013;13:333–338.
[11] Dursun A, Ozsoylu S, Akyildiz BN. Neutrophil-to-lymphocyte ratio and mean platelet volume can be useful markers to predict sepsis in children. Pak J Med Sci. 2018;34:918–922.
[12] Farias MG, Schunck EG, Dal BS, et al. Definition of reference ranges for the platelet distribution width (PDW): a local need. Clin Chem Lab Med. 2010;48:255–257.
[13] Kim CH, Kim SJ, Lee MJ, et al. An increase in mean platelet volume from baseline is associated with mortality in patients with severe sepsis or septic shock. PloS One. 2015;10:e0119437.
[14] Zhang S, Cui Y-L, Diao M-Y, et al. Use of platelet indices for determining illness severity and predicting prognosis in critically ill patients. Chin Med J. 2015;128:2012.
[15] Sayed SZ, Mahmoud MM, Moness HM, et al. Admission platelet count and indices as predictors of outcome in children with severe sepsis: a prospective hospital-based study. BMC Pediatr. 2020;20:387.
[16] Mangalesh S, Dudani S, Malik A. Platelet indices and their kinetics predict mortality in patients of sepsis. Indian J Hematol Blood Transfus. 2021;2021:1–9.
[17] Gao Y, Li Y, Yu X, et al. The impact of various platelet indices as prognostic markers of septic shock. PLoS One. 2014;9:e103761.
[18] Jeon K, Na SJ, Oh DK, et al. Characteristics, management and clinical outcomes of patients with sepsis: a multicenter cohort study in Korea. Acute Crit Care. 2019;34:179.
[19] Li X, Shen H, Zhou T, et al. Early elevation of thioredoxin-1 serum levels predicts 28-day mortality in patients with sepsis. J Inflamm Res. 2021;14:3837–3848.
[20] Jiang L, Lin S-H, Wang J, et al. Prognostic values of procalcitonin and platelet in the patient with urosepsis. Medicine (Baltimore). 2021;100:e26555–e.
[21] İşgüder R, Ceylan G, Ağın H, et al. Increased mean platelet volume in children with sepsis as a predictor of mortality. Turk J Pediatr. 2016;58:503.