Platelet-to-Lymphocyte ratio (PLR) is a Novel Independent Risk Factor for Newborn Patients in the Neonatal Intensive Care Unit (NICU)

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Research

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Abstract

Objective: To investigate the prognostic significance of the platelet-to-lymphocyte ratio (PLR) for newborn patients in the neonatal intensive care unit (NICU).

Design: A retrospective cohort study.

Setting and participants: Data on 5240 newborn patients in the NICU extracted from the Multiparameter Intelligent Monitoring in Intensive Care III (MIMIC III) database.

Methods: Spearman correlation was used to analyze the association of PLR with length of hospital and ICU stays. The chi-square test was used to analyze the association of PLR with mortality rate. Multivariable logistic regression was used to determine whether the PLR was an independent prognostic factor of mortality. The area under the receiver operating characteristic (ROC) curve was used to assess the predictive ability of models combining PLR with other variables.

Results: PLR was negatively associated with length of hospital stay and ICU stay (hospital stay: Spearman's rho=-0.416, *P*<0.0001; ICU stay: Spearman's rho=-0.442, *P*<0.0001). PLR was significantly correlated with hospital mortality (*P*<0.0001). Lower PLR was associated with higher hospital mortality (OR=0.85, 95% CI=0.75-0.95, *P*=0.005) and 90-day mortality (OR=0.85, 95% CI=0.76-0.96, *P*=0.010). The prognostic predictive ability of models combining PLR with other variables for hospital mortality was moderately good (AUC for Model 1=0.804; AUC for Model 2=0.964).

Conclusion: PLR is a novel independent risk factor for newborn patients in the NICU.

Introduction

The first month of life is riskiest time for child survival, accounting for approximately 40% of all childhood mortality [1–3]. Each year, 2.6 million neonates die globally, with 75% of neonatal deaths occurring in the first week of life and 99% of deaths occurring in low- and middle-income countries [3, 4]. Premature delivery and birth-related complications (such as birth asphyxia and neonatal sepsis) are considered to be the main causes of neonatal death [5].

In recent years, the neutrophil-to-lymphocyte ratio (NLR) [6], lymphocyte-to-monocyte ratio (LMR) [7] and platelet-to-lymphocyte ratio (PLR) [8] have been found to be independent predictors of prognosis in various benign and malignant conditions [9, 10]. Moreover, NLR, LMR and PLR were reported to be related to the outcome of intensive care unit (ICU) patients, because of their rapid response to systemic inflammation and stress [11–13]. However, little is known about the associations of NLR, LMR and PLR with prognosis in newborn patients in the neonatal intensive care unit (NICU).

The primary purpose of this study was to determine the associations of NLR, LMR and PLR with hospital mortality in newborn patients in the NICU. In the present study, we were the first to report that PLR can

serve as an independent risk factor for newborn patients in the NICU.

Methods

Data Source

A retrospective cohort study design was used in this study. Data were obtained from the ICU database, a free accessible critical care database of Medical Information Mart for Intensive Care III (MIMIC-III). The clinical data of patients who stayed in the ICU of Beth Israel Deaconess Medical Center (BIDMC) between 2001 and 2012 were selected [14]. The institutional review boards of both the BIDMC and the Massachusetts Institute of Technology Affiliates approved the access to the database. No informed consent was required because all of the data were deidentified.

Patient Selection

Clinical data of eligible patients in the MIMIC-III database were selected for analysis in this study. The eligibility criteria were (1) newborn patents admitted to the NICU; and (2) patients with routine preoperative blood examinations within 24 hours of admission.

Data Extraction

All of the data were obtained and extracted by using the Structured Query Language (SQL), and pgAdmin4 for PostgreSQL was used as the administrative platform. The extracted data mainly included age, sex, birthweight, heart rate (HR), laboratory parameters (red blood cell count (RBC), peripheral white blood cell count (WBC), platelet count, lymphocyte count, neutrophil count, monocytes count), comorbidities (congestive heart failure, cardiac arrhythmias, valvular disease, pulmonary circulation disorder, hypertension, liver disease and renal failure), the Simplified Acute Physiology Score (SAPS) II, the Sequential Organ Failure Assessment (SOFA) score and the model for end-stage liver disease (MELD) score. PLR was calculated by dividing the platelet count by the lymphocyte count. NLR was calculated by dividing the neutrophil count by the lymphocyte count. LMR was calculated by dividing the lymphocyte count by the monocyte count. Given that the proportion of missing data for each variable was < 1.5%, we directly omitted these data in further analyses.

Outcome Variables

The following outcome variables were extracted: hospital mortality, length of ICU stay, length of hospital stay and 90-day mortality (post-ICU admission). Because a patient may have had more than one ICU admission during a single hospitalization, the length of ICU stay was entirely determined by the first ICU hospitalization.

Statistical Analysis

Continuous variables are presented as the mean ± standard deviation or the median (interquartile range), and were compared via *t*-test or the Mann-Whitney U test. Categorical data are presented as numbers with

proportions and were analyzed via the χ^2 test. Correlation of length of ICU stay and hospital stay with the laboratory parameters were assessed with the nonparametric Spearman's rank correlation test. Logistic regression with the univariate and multivariate analyses was used to identify independent prognostic factors of mortality (hospital mortality and 90-day mortality) for newborn NICU patients. Two different models were designed to adjust for potential confounders. Model 1 was adjusted for NLR, LMR, MELD, SAPS II and liver disease. Moreover, Model 2 was adjusted for NLR, LMR and MELD. Receiver operating characteristic (ROC) curves were constructed, and the area under the curve (AUC), sensitivity and specificity were calculated. *P*-values of less than 0.05 were considered to indicate statistical significance.

Results

Baseline Characteristics of the Study Population

In total, 5240 patients who met the selection criteria were enrolled in our study, among whom 43 patients (0.82%) died in the hospital. The baseline characteristics of the enrolled patients are summarized in the Table 1.

Table 1
Baseline characteristics of the study population with different survival status in hospital

	Survivors (n = 5197)	Nonsurvivors (n = 43)	*P* value
Demographics			
Age	0.00139 ± 0.00001	0.00150 ± 0.00011	0.311
Male, n (%)	2823 (53.87%)	26 (0.50%)	0.420
Birthweight (kg)	1.63 (1.10–2.48)	0.84 (0.62–1.59)	< 0.0001
Heart rate (bpm)	152 (140–169)	150 (140–168)	0.001
Laboratory events			
RBC, 10^6/L	4.14 (3.70–4.62)	3.80 (3.45–4.23)	0.001
WBC, 10^9/L	15.3 (10.9–19.8)	8.8 (4.7–11.4)	< 0.0001
Lymphocytes, %	29 (21–42)	54.55 (33–67)	< 0.0001
Neutrophils, %	57 (42.9–66)	27 (19–46)	< 0.0001
Monocytes, %	7 (4-9.2)	7 (4–11)	0.707
Platelets, 10^9/L	284 (232–338)	212 (174–240)	< 0.0001
LMR	4.33 (2.75–7.4)	7.67 (4.17-13)	< 0.0001
NLR	2 (1.02–3.13)	0.55 (0.28–1.64)	0.0008
PLR	9.77 (6.15–14.36)	3.67 (2.73–5.72)	< 0.0001
Comorbidities			
Congestive heart failure	14 (0.27%)	0 (0.00%)	0.736
Cardiac arrhythmias	19 (0.36%)	0 (0.00%)	0.694
Valvular disease	8 (0.15%)	0 (0.00%)	0.799
Pulmonary circulation disorder	5 (0.10%)	0 (0.00%)	0.840
Hypertension	10 (0.19%)	0 (0.00%)	0.773
Liver disease	2 (0.03%)	1 (0.015%)	< 0.0001
Renal failure	0 (0.00%)	1 (0.015%)	< 0.0001
Scores			
SAPS II	18.86 ± 0.15	37.58 ± 0.81	< 0.0001

	Survivors (n = 5197)	Nonsurvivors (n = 43)	*P* value
SOFA	2.75 ± 0.05	10.91 ± 0.41	< 0.0001
MELD	7.97 ± 0.05	11.64 ± 0.70	< 0.0001

Values are presented as the mean ± standard deviation, median (interquartile range), or number of patients (%).

WBC, white blood cell; SAPS II, Simplified Acute Physiology Score II; SOFA, Sequential Organ Failure Assessment; MELD, model for end-stage liver disease

The demographic characteristics of the survivors and nonsurvivors are presented in Table 1. No significant differences were observed for age and sex between nonsurvivors and survivors. Nonsurvivors had a higher birthweight and HR. Moreover, nonsurvivors had much higher RBCs, WBCs, neutrophils, platelets, NLRs and PLRs. Nonsurvivors tended to have lower lymphocytes, LMRs, SAPS II scores, SOFA scores and MELD scores, as well as a history of liver disease and renal failure (Table 1).

Association of Inflammatory Markers with Length of Hospital Stay and ICU Stay in Newborn Patients in the NICU

LMR, NLR and PLR were reported to be related to the outcome of various diseases. To investigate the associations of these inflammatory markers with the length of hospital stay and ICU stay in newborn patients in the NICU, Spearman's rank correlation test was used, and the results are shown in Table 2. LMR was significantly positively associated with length of hospital stay and ICU stay (hospital stay: Spearman's rho = 0.228, $P < 0.0001$; ICU stay: Spearman's rho = 0.254, $P < 0.0001$). Both NLR and PLR were negatively associated with length of hospital stay and ICU stay (for NLR, hospital stay: Spearman's rho=-0.427, $P < 0.0001$; ICU stay: Spearman's rho=-0.448, $P < 0.0001$. For PLR, hospital stay: Spearman's rho=-0.416, $P < 0.0001$; ICU stay: Spearman's rho=-0.442, $P < 0.0001$).

Table 2
The correlation of LMR, NLR and PLR with hospital stay and ICU stay

	Length of Hospital stay		Length of ICU stay	
	Spearman's Rho	P value	Spearman's Rho	P value
LMR	0.228	< 0.0001	0.254	< 0.0001
NLR	-0.427	< 0.0001	-0.448	< 0.0001
PLR	-0.416	< 0.0001	-0.442	< 0.0001

Association of Inflammatory Markers with Hospital Mortality in Newborn Patients in the NICU

In the present study, the correlation of the inflammatory markers with the mortality in the newborn patients in the NICU was investigated. Quartiles of LMR, NLR and PLR were significantly correlated with hospital mortality (all $P < 0.0001$) (Table 3). A higher rate of hospital mortality was observed in patients in the fourth LMR quartile than is those in the first, second and third quartiles. For NLR and PLR, a higher rate of hospital mortality was observed in patients in the first quartile than in those in other quartiles.

Table 3
The relationship between LMR, NLR and PLR with Hospital mortality

	Q1	Q2	Q3	Q4	*P* value
LMR					
Survivors	1364(26.03%)	1288(24.58%)	1288(24.58%)	1257(23.99%)	< 0.0001
Nonsurvivors	3(0.06%)	5(0.10%)	6(0.11%)	29(0.55%)	
NLR					
Survivors	1285(24.52%)	1277(24.37%)	1284(24.50%)	1351(25.78%)	< 0.0001
Nonsurvivors	31(0.59%)	4(0.076%)	4(0.076%)	4(0.076%)	
PLR					
Survivors	1258(24.01%)	1283(24.48%)	1288(24.58%)	1368(26.11%)	< 0.0001
Nonsurvivors	32(0.61%)	5(0.10%)	2(0.038%)	4(0.076%)	

Q, Quartiles of LMR, NLR and PLR.

Prognostic Significance of PLR in Newborn Patients in the NICU

Univariate logistic regression analysis was performed. As shown in Table 4, PLR, NLR and LMR were associated with hospital mortality and 90-day mortality (PLR for hospital mortality: OR = 0.76, 95% CI = 0.69–0.83, $P < 0.0001$. NLR for hospital mortality: OR = 0.50, 95% CI = 0.37–0.69, $P < 0.0001$. LMR for hospital mortality: OR = 1.03, 95% CI = 1.01–1.05, $P < 0.0001$. PLR for 90-day mortality: OR = 0.76, 95% CI = 0.69–0.84, $P < 0.0001$. NLR for 90-day mortality: OR = 0.49, 95% CI = 0.36–0.68, $P < 0.0001$. LMR for 90-day mortality: OR = 1.04, 95% CI = 1.02–1.05, $P < 0.0001$).

Table 4
Univariate Logistic regression analyses for prognosis in newborn patients

Outcome	OR	95% CI	*P* value
Hospital mortality			
PLR	0.76	0.69–0.83	< 0.0001
NLR	0.50	0.37–0.69	< 0.0001
LMR	1.03	1.01–1.05	< 0.0001
MELD	1.19	1.12–1.25	< 0.0001
SAPS II	1.17	1.13–1.21	< 0.0001
Liver disease	63.18	5.62-710.58	0.001
90-day mortality			
PLR	0.76	0.69–0.84	< 0.0001
NLR	0.49	0.36–0.68	< 0.0001
LMR	1.04	1.02–1.05	< 0.0001
MELD	1.18	1.12–1.25	< 0.0001
SAPS II	1.17	1.13–1.22	< 0.0001
Liver disease	63.18	5.62-710.58	0.001

The results of the multivariate analysis are summarized in Table 5, and only PLR was significantly associated with hospital mortality (Model 1: OR = 0.85, 95% CI = 0.75–0.95, $P = 0.005$; Model 2: OR = 0.75, 95% CI = 0.67–0.84, $P < 0.0001$) and 90-day mortality (Model 1: OR = 0.85, 95% CI = 0.76–0.96, $P = 0.010$; Model 2: OR = 0.79, 95% CI = 0.71–0.89, $P < 0.0001$) in all models. In the multivariate analysis, Model 1 was adjusted for NLR, LMR, MELD, SAPS II and Liver disease. Model 2 was adjusted for NLR, LMR and Meld. The data suggested that PLR could be an independent risk factor for hospital mortality and 90-day mortality in the newborn patients in the NICU.

Table 5
Association between PLR with Prognosis of newborn patients

	Model 1		Model 2	
Variable	**OR (95%CI)**	P **value**	**OR (95%CI)**	P **value**
Hospital Mortality				
PLR	0.84 (0.75–0.95)	0.005	0.75 (0.67–0.84)	< 0.0001
NLR	1.37 (0.98–1.90)	0.063	1.18 (0.85–1.65)	0.315
LMR	1.01 (0.99–1.03)	0.253	1.01 (0.99–1.03)	0.377
MELD	0.89 (0.80–0.99)	0.028	1.11 (1.05–1.19)	< 0.0001
SAPS II	1.19 (1.14–1.26)	< 0.0001		
Liver disease	11.39 (0.84-154.04)	0.067		
90-day Mortality				
PLR	0.85 (0.76–0.96)	0.010	0.79 (0.71–0.89)	< 0.0001
NLR	1.32 (0.94–1.86)	0.106	1.15 (0.82–1.63)	0.417
LMR	1.01 (0.99–1.03)	0.182	1.01 (0.99–1.03)	0.232
MELD	0.88 (0.79–0.98)	0.017	1.12 (1.04–1.19)	0.001
SAPS II	1.20(1.14–1.27)	< 0.0001		
Liver disease	11.53 (0.83-159.82)	0.068		
Model 1 was adjusted for NLR, LMR, Meld, SAPS II and Liver disease.				
Model 2 was adjusted for NLR, LMR and MELD.				

Prognostic Predictive Ability of Models Combining PLR with Other Variables for Hospital Mortality in Newborn Patients in the NICU

To evaluate the predictive ability of models combining PLR and other clinical variables for hospital mortality, ROC curve analysis was performed, and the AUC for Model 1 (Model 1: PLR, LMR and NLR) was 0.804 (95% CI = 0.73–0.88, $P < 0.0001$) and for Model 2 (Model 2: PLR, LMR, NLR, SOFA and MELD) was 0.964 (95% CI = 0.95–0.98, $P < 0.0001$) (Fig. 1).

Discussion

In the present study, we found that LMR was significantly positively was associated with length of hospital stay and ICU stay while both NLR and PLR were negatively associated with length of hospital

stay and ICU stay. PLR, NLR and LMR were associated with hospital mortality and 90-day mortality, but only PLR was significantly associated with hospital mortality and 90-day mortality in the multivariate analyses. The prognostic predictive ability of models combining PLR with other variables for hospital mortality was moderately good. To our knowledge, this is the first investigation to demonstrate that PLR can serve as an independent risky factor for newborn patients of NICU.

Inflammatory cells, including WBCs and their subtypes (such as lymphocytes, monocytes and neutrophils), have been well validated to play an indispensable role in various benign and malignant conditions. Moreover, platelets could play a critical role in the immunomodulatory and inflammatory process[15], by inducing the release of inflammatory cytokines and interacting with different kinds of immune cells, such as neutrophils, T-lymphocytes, and macrophages (the precursors of macrophages are monocytes), which contribute to the initiation or exacerbation of the inflammatory process[16, 17]. Low lymphocyte counts could represent a suppressed immune and inflammatory response, which is related to inflammatory disease[18, 19]. Thus, PLR was proposed to serve as a novel systematic inflammatory indicator[20].

The association between PLR and outcomes was different in different cohorts. Both high and low PLR were associated with increased mortality, among critically ill patients with acute kidney injury (AKI)[21]. In another study, high PLR was positively associated with increased epicardial adipose tissue deposition in diabetes patients[22]. Wang et al showed that high PLR was independently associated with shorter disease-free days and lower overall survival rates in lung adenosquamous carcinoma[23]. For fetal malnutrition, cord-blood PLR negatively correlated with term fetal malnutrition gestational age neonates[24]. Maternal PLR was negatively correlated with the week of birth and birth weight of the infant[25]. Our data showed that PLR was associated with the prognosis of newborn patients in the NICU. PLR was negatively associated with length of hospital stay and ICU stay. A higher rate of hospital mortality was observed in patients in the first PLR quartile than in those in the other quartiles. The prognostic predictive ability of models combining PLR with other variables for hospital mortality was moderately good (AUC for Model1 = 0.804; AUC for Model2 = 0.964). These data suggested that PLR can serve as an independent risky factor for newborn patients in the NICU.

Conclusion

In summary, we demonstrated that lower PLR was significantly associated with higher hospital mortality. The prognostic predictive ability of models combining PLR with other variables for hospital mortality was moderately good. PLR is a novel independent risk factor for newborn patients in the NICU.

List of Abbreviations

AKI, acute kidney injury; AUC, area under the curve; BIDMC, Beth Israel Deaconess Medical Center, HR, heart rate; ICU, intensive care unit; LMR, lymphocyte-to-monocyte ratio; MIT, Massachusettes Institute of Technology; MELD, model for end-stage liver disease score; MIMIC III, Multiparameter Intelligent

Monitoring in Intensive Care III database; NLR, neutrophil-to-lymphocyte ratio; NICU, neonatal intensive care unit; PLR, platelet-to-lymphocyte ratio; RBC, red blood cell; ROC, receiver operating characteristic curve; SOFA, Sequential Organ Failure Assessment score; SAPS II, Simplified Acute Physiology Score II; SQL, Structured Query Language; WBC, white blood cell.

Declarations

Ethics approval and consent to participate

The institutional review boards of the MIT (Cambridge, Massachusetts) and BIDMC (Boston, Massachusetts) reviewed and approved studies involving human participants. According to national laws and institutional requirements, this study does not require written informed consent.

Consent for publication

Not applicable.

Availability of data and materials

Authors will provide raw data to support the conclusions of this research without reservation.

Competing interests

The authors declare that the study was conducted in the absence of any commercial or financial relationship that could be constructed as a potential conflict of interest.

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Authors' contributions

YZ, YT and GX conceived and designed the study. GX and RS administratively supported this work. YT, YT, LX, DC, XJ, WL, XJ, WZ, and BH provided, selected, assembled, analyzed and interpretated data. All authors contributed toward data analysis, drafting and critically revising the paper, and agree to be accountable for all aspects of the work. All authors have read and confirmed that they meet ICMJE criteria for authorship.

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References

1. Orsido TT, Asseffa NA, Berheto TM. Predictors of Neonatal mortality in Neonatal intensive care unit at referral Hospital in Southern Ethiopia: a retrospective cohort study. BMC Pregnancy Childbirth. 2019;19:83.
2. Collaborators GBDCM. Global, regional, national, and selected subnational levels of stillbirths, neonatal, infant, and under-5 mortality, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016;388:1725–74.
3. *Lancet*. 2014;384:957 – 79.
4. Liu L, Johnson HL, Cousens S, Perin J, Scott S, Lawn JE, Rudan I, Campbell H, Cibulskis R, Li M, Mathers C, Black RE, Child Health Epidemiology Reference Group of WHO and Unicef. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. Lancet. 2012;379:2151–61.
5. Mekonnen Y, Tensou B, Telake DS, Degefie T, Bekele A. Neonatal mortality in Ethiopia: trends and determinants. BMC Public Health. 2013;13:483.
6. Teng JJ, Zhang J, Zhang TY, Zhang S, Li BS. Prognostic value of peripheral blood lymphocyte-to-monocyte ratio in patients with solid tumors: a meta-analysis. Onco Targets Ther. 2016;9:37–47.
7. Chiriac S, Stanciu C, Singeap AM, Sfarti CV, Cuciureanu T, Trifan A. Prognostic value of neutrophil-to-lymphocyte ratio in cirrhotic patients with acute-on-chronic liver failure. Turk J Gastroenterol. 2020;31:868–76.
8. Smith RA, Bosonnet L, Raraty M, Sutton R, Neoptolemos JP, Campbell F, Ghaneh P. Preoperative platelet-lymphocyte ratio is an independent significant prognostic marker in resected pancreatic ductal adenocarcinoma. Am J Surg. 2009;197:466–72.
9. Wang C, He W, Yuan Y, Zhang Y, Li K, Zou R, Liao Y, Liu W, Yang Z, Zuo D, Qiu J, Zheng Y, Li B, Yuan Y. Comparison of the prognostic value of inflammation-based scores in early recurrent hepatocellular carcinoma after hepatectomy. Liver Int. 2020;40:229–39.
10. Proctor MJ, Morrison DS, Talwar D, Balmer SM, Fletcher CD, O'Reilly DS, Foulis AK, Horgan PG, McMillan DC. A comparison of inflammation-based prognostic scores in patients with cancer. A Glasgow Inflammation Outcome Study. *Eur J Cancer*. 2011;47:2633-41.
11. Liu Y, Zheng J, Zhang D, Jing L. Neutrophil-lymphocyte ratio and plasma lactate predict 28-day mortality in patients with sepsis. J Clin Lab Anal. 2019;33:e22942.
12. Karagoz I, Yoldas H. Platelet to lymphocyte and neutrophil to lymphocyte ratios as strong predictors of mortality in intensive care population. *Rev Assoc Med Bras (*1992*)*. 2019;65:633–636.
13. Junare PR, Debnath P, Nair S, Chandnani S, Udgirkar S, Thange R, Jain S, Deshmukh R, Debnath P, Rathi P, Contractor Q, Deshpande A. Complete hemogram: simple and cost-effective in staging and predicting outcome in acute pancreatitis. *Wien Klin Wochenschr*. 2021.
14. Johnson AE, Pollard TJ, Shen L, Lehman LW, Feng M, Ghassemi M, Moody B, Szolovits P, Celi LA, Mark RG. MIMIC-III, a freely accessible critical care database. Sci Data. 2016;3:160035.

15. Liu C, Zhou Y, He X, Ma J, Guo W, Dong B, Liang W, Wu Y, Owusu-Agyeman M, Xue R, Zhao J, Wu Z, Dong Y. Mean platelet volume/platelet count ratio predicts long-term mortality in patients with infective endocarditis. Biomark Med. 2020;14:293–302.
16. Nording HM, Seizer P, Langer HF. Platelets in inflammation and atherogenesis. Front Immunol. 2015;6:98.
17. Kim CH, Kim SJ, Lee MJ, Kwon YE, Kim YL, Park KS, Ryu HJ, Park JT, Han SH, Yoo TH, Kang SW, Oh HJ. 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.
18. Manzoli TF, Delgado AF, Troster EJ, de Carvalho WB, Antunes AC, Marques DM, Zamberlan P. Lymphocyte count as a sign of immunoparalysis and its correlation with nutritional status in pediatric intensive care patients with sepsis: A pilot study. Clinics. 2016;71:644–9.
19. Felmet KA, Hall MW, Clark RS, Jaffe R, Carcillo JA. Prolonged lymphopenia, lymphoid depletion, and hypoprolactinemia in children with nosocomial sepsis and multiple organ failure. J Immunol. 2005;174:3765–72.
20. Akboga MK, Canpolat U, Yayla C, Ozcan F, Ozeke O, Topaloglu S, Aras D. Association of Platelet to Lymphocyte Ratio With Inflammation and Severity of Coronary Atherosclerosis in Patients With Stable Coronary Artery Disease. Angiology. 2016;67:89–95.
21. Zheng CF, Liu WY, Zeng FF, Zheng MH, Shi HY, Zhou Y, Pan JY. Prognostic value of platelet-to-lymphocyte ratios among critically ill patients with acute kidney injury. Crit Care. 2017;21:238.
22. Akbas EM, Hamur H, Demirtas L, Bakirci EM, Ozcicek A, Ozcicek F, Kuyrukluyildiz U, Turkmen K. Predictors of epicardial adipose tissue in patients with type 2 diabetes mellitus. Diabetol Metab Syndr. 2014;6:55.
23. Wang YQ, Zhi QJ, Wang XY, Yue DS, Li K, Jiang RC. Prognostic value of combined platelet, fibrinogen, neutrophil to lymphocyte ratio and platelet to lymphocyte ratio in patients with lung adenosquamous cancer. Oncol Lett. 2017;14:4331–8.
24. Can E, Can C. The value of neutrophil-to-lymphocyte ratio (NLR) and platelet-to-lymphocyte ratio (PLR) parameters in analysis with fetal malnutrition neonates. J Perinat Med. 2019;47:775–9.
25. Akgun N, Namli Kalem M, Yuce E, Kalem Z, Aktas H. Correlations of maternal neutrophil to lymphocyte ratio (NLR) and platelet to lymphocyte ratio (PLR) with birth weight. J Matern Fetal Neonatal Med. 2017;30:2086–91.

Figures

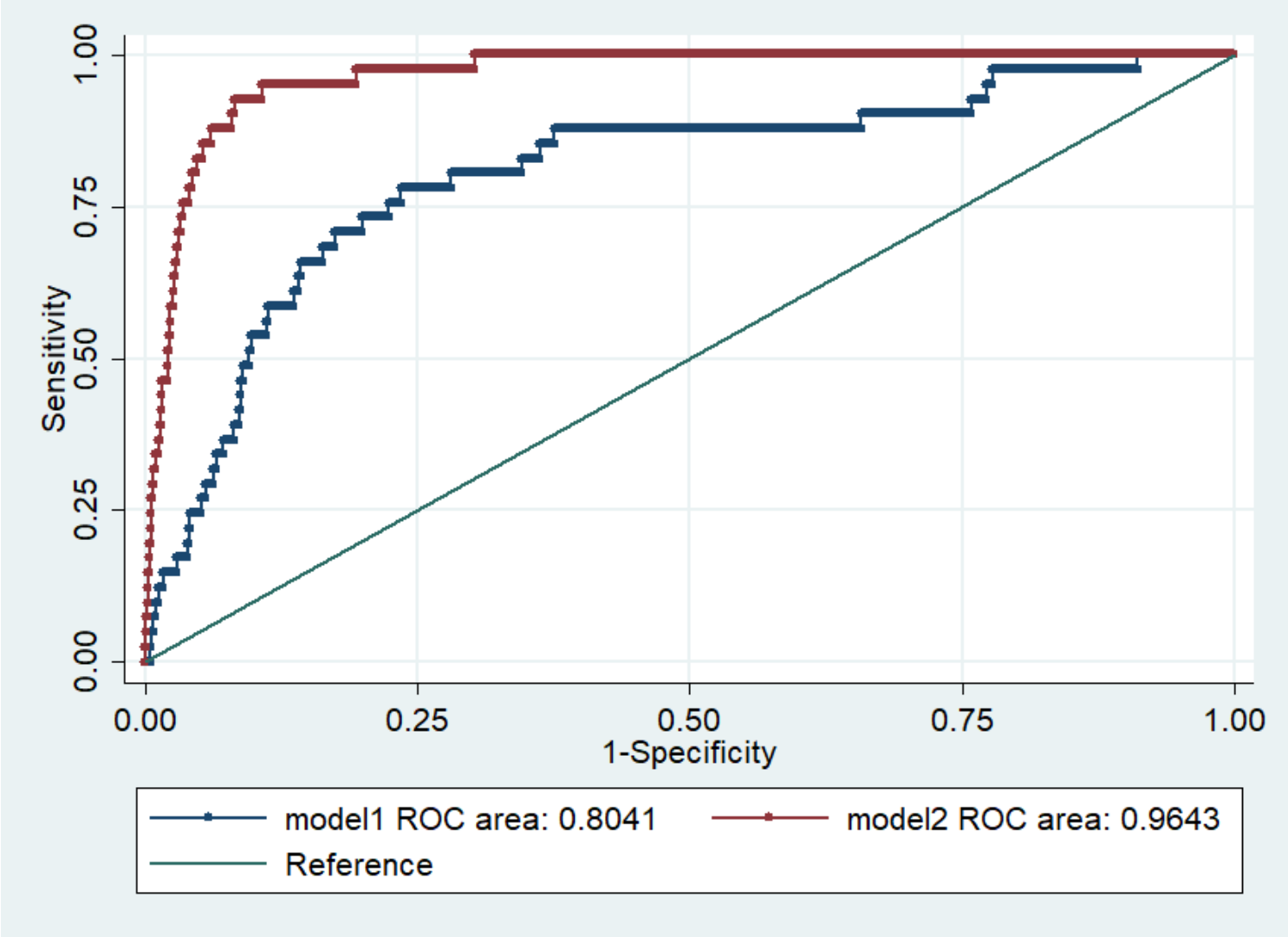

Figure 1

ROC curve for the predictive models for hospital mortality. Note: Model 1 included PLR, LMR and NLR. Model 2 included PLR, LMR, NLR, SOFA and MELD scores. AUC, area under the curve; ROC, receiving operating characteristic.