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Practical parameters that can be used for nutritional assessment in patients hospitalized in the intensive care unit with the diagnosis of chronic obstructive pulmonary disease

Prognostic nutritional index, neutrophil-to-lymphocyte, platelet-to-lymphocyte, and lymphocyte-to-monocyte ratio

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Abstract

Malnutrition is an important condition in patients diagnosed with chronic obstructive pulmonary disease (COPD). There is a need for practical and objective nutritional assessment methods in patients hospitalized in the intensive care unit with the diagnosis of COPD. In this study, it was aimed to determine the parameters that can practically evaluate the nutritional status of these patients. It was aimed to determine the relationship between prognostic nutritional index (PNI), and nutritional risk screening (NRS)-2002, nutrition risk in the critical ill (Nutric) Score and to determine a cut-off value for PNI, neutrophil-to-lymphocyte (NLR), platelet-to-lymphocyte ratio (PLR), lymphocyte-to-monocyte ratio (LMR), and other complete blood count parameters.

Hemogram values, albumin values, NLR, PLR, LMR, NRS-2002, PNI and modified Nutric Score calculations of the patients hospitalized in the intensive care unit due to COPD were recorded. The relationship between PNI and NRS-2002 and modified Nutric Score, as well as the relationship between NLR, PLR, LMR, hemogram parameters and PNI were analyzed using statistical methods.

The PNI cut-off value for nutritional assessment in patients hospitalized in the intensive care unit due to COPD was determined as 38.5 (area under curve = 0.891, sensitivity 80.8%, specificity 88.1%, positive predictive value 92.9%, negative predictive value 88%). High-risk group according to PNI compared to low-risk group, lymphocyte count ($P < .001$), basophil count ($P = .004$), red blood cell ($P < .001$), hemoglobin ($P < .001$), hematocrit ($P < .001$), and LMR ($P = .001$) were statistically significantly lower, while NLR ($P < .001$) and PLR ($P = .001$) were statistically significantly higher. Cut-off values for lymphocyte count, basophil count, NLR, PLR, and LMR were found to be 1.18, 0.035, 7.97, 291.10, and 2.606, respectively.

Nutritional risk assessment can be made in a practical way by using PNI in patients hospitalized in intensive care unit due to COPD. For this, the PNI cut-off value was determined as 38.5 in our study. In addition, NLR, PLR, LMR, basophil and lymphocyte values, which can be calculated using complete blood count parameters, may also be useful in the evaluation of nutritional status in these patients. In our study, the cut-off values determined for NLR, PLR, LMR, basophil and lymphocyte were 7.97, 291.10 and 2.606, 0.035 and 1.18, respectively. We think that the results we have obtained can provide preliminary information for future research.

Abbreviations: ASPEN = American Society for Parenteral and Enteral Nutrition, COPD = chronic obstructive pulmonary disease, LMR = lymphocyte/monocytes rate, NLR = neutrophil/lymphocyte rate, NPV = negative predictive value, NRS-2002 =

1. Introduction

Malnutrition is an important condition that is frequently seen in patients with a diagnosis of chronic obstructive pulmonary disease (COPD) and negatively affects morbidity and mortality.[1] Therefore, it is important to evaluate the nutritional status of patients admitted to the intensive care unit with the diagnosis of COPD quickly and practically. The American Society for Parenteral and Enteral Nutrition (ASPEN) recommends nutritional risk screening (NRS) in intensive care patients using NRS-2002 and nutrition risk in the critical ill (Nutric) Score.[2–5] However, it is often not possible to obtain information about the nutritional status of patients hospitalized in the intensive care unit or to make anthropometric measurements.[6] Therefore, there is a need for practical and objective nutritional assessment methods in intensive care patients. In this respect, although albumin is shown as a practical nutritional indicator, there is no consensus on this issue either.[7,8]

ASPEN emphasizes the importance of inflammation in malnourished adults.[9] In addition, due to the catabolic stress caused by the chronic inflammatory process, it negatively affects the nutritional status of the patients.[10] In COPD, chronic inflammation of the airways and lung parenchyma has a critical role.[11] Therefore, a nutritional parameter that can also evaluate the inflammatory process in patients with a diagnosis of COPD can make an effective assessment in these patients. For this purpose, inflammatory parameters used in clinical practice may be useful.

Recently, the prognostic nutritional index (PNI) has been emphasized as an index that can be calculated by serum albumin and lymphocyte value and shows chronic inflammation, nutritional status and prognosis in patients.[12] PNI, which is generally used to evaluate the prognosis in cancer patients, is also evaluated as a prognostic indicator in different diseases.[6,13] However, the number of studies evaluating PNI in intensive care patients is quite limited.[14] In addition, studies focus on prognosis rather than nutritional assessment, and there is no cut-off value determined for nutritional assessment in patients with COPD in the literature. However, PNI, which can evaluate both inflammatory and nutritional aspects, can be used as an objective and practical nutritional marker in patients admitted to the intensive care unit due to COPD.

Neutrophil-lymphocyte ratio (NLR), lymphocyte-monocyte ratio (LMR) and platelet-lymphocyte ratio (PLR) are stated as inflammatory factors that are used to determine the prognosis of patients in various clinical conditions and can measure the degree of systemic inflammation.[15] The critical role of chronic inflammation in COPD patients and the negative impact of nutritional status due to catabolic stress caused by chronic inflammation may reveal a link between inflammatory parameters such as NLR, PLR, LMR, and nutritional status in these patients. For this purpose, it will be very useful in clinical practice to determine a cut-off value for these parameters that

can be used in the evaluation of nutritional status in COPD patients in intensive care.

In this study, it was aimed to determine the parameters that can practically evaluate the nutritional status of patients hospitalized in the intensive care unit with the diagnosis of COPD. For this purpose, it was aimed to determine the relationship between PNI and NRS-2002 and Nutric Score, and to determine a cut-off value for PNI that can be used in the evaluation of nutritional status in COPD patients in intensive care. Secondly, it was aimed to determine a cut-off value for NLR, PLR, LMR and other complete blood count parameters that can be used in the evaluation of nutritional status in COPD patients in intensive care and to determine the relationship between NLR, PLR, LMR, and PNI.

2. Materials and methods

Following the approval of the Ethics Committee (Date: 14.09.2021, number: 2012-KAEK-15/2362), this retrospective study was conducted by examining the data of patients hospitalized in the tertiary intensive care unit in the tertiary chest diseases center between January 2018 and January 2019. Patients over the age of 18 who were admitted to the intensive care unit due to COPD were included in the study. Demographic data such as age, gender, height, weight, body mass index, hospitalization diagnoses and complete blood count values on the day of admission to the intensive care unit, albumin values, NLR, PLR, LMR, NRS-2002, PNI and Nutric Score calculations were recorded. NLR was calculated by dividing the absolute neutrophil count by the absolute lymphocyte count. PLR was calculated by dividing the absolute platelet count by the absolute lymphocyte count. LMR was calculated by dividing the absolute lymphocyte count by the absolute monocyte count. NRS-2002 calculation is based on body mass index, weight loss, appetite status, and severe illness in the last 3 months. Nutric Score calculation is based on patient's age, Acute Physiology and Chronic Health Evaluation-II score, SOFA score (Sequential Organ Failure Assessment score), number of co-morbidities, interleukin-6 and the length of hospital stay before admission to the intensive care unit.[16] In our study, the modified Nutric score (mNutric score) calculated without taking into account interleukin-6 was used. PNI was calculated from the formula $10 \times$ serum albumin (g/dL) $+ 0.005 \times$ lymphocyte count/mm3.[17] The nutritional risk status of the patients was determined as follows: PNI ≥ 45; (low risk), PNI < 45; (high risk), albumin ≥ 35 g/L (low risk), albumin < 35 g/L (high risk), NRS-2002 ≤ 4; (low risk), NRS-2002 > 4; (high risk), Nutric Score ≤ 4; (low risk), Nutric Score > 4; (high risk).[4,13,16,17] Those who were admitted to the intensive care unit for a reason other than COPD, those with a diagnosis of malignancy, those under the age of 18, those who were hospitalized in the intensive care unit for less than 24 hours, and those who lacked the necessary tests for the study were excluded from the study.

2.1. Statistical analysis

Data analyses were performed by using SPSS for Windows, version 22.0 (SPSS Inc., Chicago, IL). Whether the distribution of continuous variables were normal or not was determined by Kolmogorov–Smirnov test. Levene test was used for the evaluation of homogeneity of variances. Unless specified otherwise, continuous data were described as mean ± standard deviation for normal distributions, and median (interquartile range) for skewed distributions. Categorical data were described as number of cases (%). Statistical analysis differences in normally distributed variables between two independent groups were compared by Student's t test, Mann–Whitney U test were applied for comparisons of the not normally distributed data. Categorical variables were compared using Pearson's chi-square test or fisher's exact test. Receiver operating characteristic curve analysis was used to determine the cutoff value of the Albumin, NRS-2002 and Nutric Score associated with the risk of PNI. It was evaluated degrees of relation between variables with spearman correlation analysis. PNI was evaluated by Cohen's Kappa analysis to agree between the album, NRS-2002, Nutric Score. First of all, it was used univariate logistic regression with risk factors that are thought to be related with PNI. Risk factors that have P-value < .25 univariate variable logistic regression was included to model on multivariable logistic regression. The backward LR method was used in multivariate logistic regression analysis. The results of the last step, the 14th step, are given. Whether every independent variables were significant on the model was analyzed with Wald statistic. It was evaluated with Nagelkerke R2 how much independent variable explained dependent variable. Besides, it was evaluated model adaptation of estimates with Hosmer and Lemosow model adaptation test. It was accepted P-value < .05 as significant level on all statistical analysis.

3. Results

A total of 351 patients admitted to the intensive care unit were identified. 116 patients were excluded from the study because they were admitted to the intensive care unit for a reason other than COPD, and 13 patients were excluded because their data

were missing (Fig. 1). Data from a total of 222 patients hospitalized in the intensive care unit due to COPD were analyzed (Fig. 1). The demographic data of the patients, intensive care scores and the proportion of patients receiving mechanical ventilator support are given in Table 1.

Table 2 shows the distribution of patients in terms of nutritional scores (PNI, albumin, NRS-2002, and Nutric Score).

Cohen's Kappa analysis was used to assess whether there was agreement between PNI, albumin, NRS-2002, and Nutric Score tests (Table 3). A statistically low degree of agreement was found between PNI and albumin ($\kappa = 0.269$, $P < .001$) and between PNI and NRS-2002 ($\kappa = 0.118$, $P = .013$) in the kappa analysis. A statistically low degree of agreement was also found between Nutric Score and NRS-2002 tests ($\kappa = 0.249$, $P < .001$) (Table 3).

Cut-off values for PNI determined according to Nutric Score, NRS-2002 and Albumin are given in Table 4. The highest sensitivity and specificity were found at the cut-off value calculated according to the albumin value (sensitivity 80.8%, specificity 88.1%, positive predictive value [PPV], 92.9% negative predictive value [NPV], 88%, and area under curve [AUC] = 0.891) (Table 4, Fig. 2).

High-risk group according to PNI compared to low-risk group, lymphocyte count ($P < .001$), basophil count ($P = .004$), red blood cell ($P < .001$), hemoglobin ($P < .001$), hematocrit ($P < .001$) value and LMR($P = .001$) was statistically significantly lower, while NLR ($P < .001$) and PLR ($P = .001$) were statistically significantly higher. There was no statistically significant difference between the groups in terms of other hemogram values ($P > .05$) (Table 5).

When the PNI cut-off value is 38.5, the cut-off values determined for lymphocyte count, basophil count, NLR, PLR and LMR are given in Table 6. According to the spearman correlation analysis results there is a statistically low level of negative correlation between PNI and NLR ($P < .001$, $r = -0.296$) and PNI and PLR ($P < .001$, $r = -0.323$). There is a statistically low level of positive correlation between PNI and lymphocyte count ($P < .001$, $r = 0.456$), PNI and basophil count ($P = .002$, $r = 0.210$), PNI and red blood cell ($P < .001$, $r = 0.333$), PNI and hemoglobin ($P < .001$, $r = 0.312$), PNI and hemotocrit
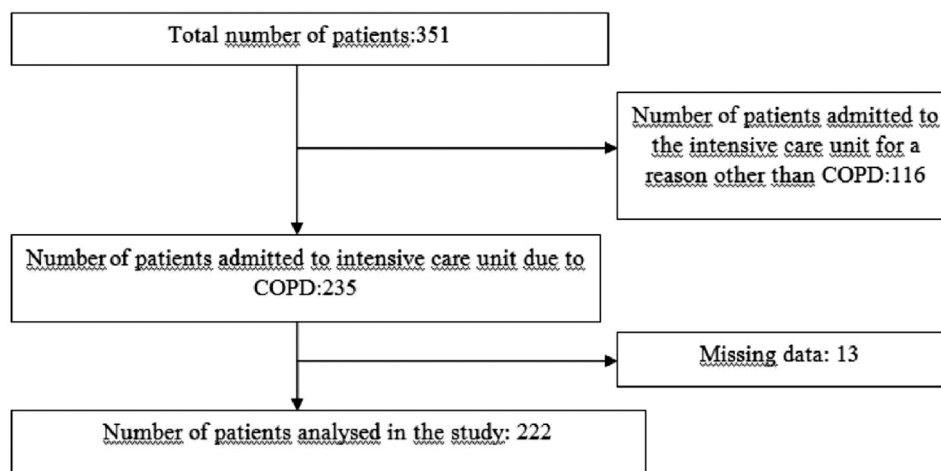

Figure 1. Flow chart of the patients.

Table 1

Demographic data of patients. Intensive care scores and proportion of patients receiving mechanical ventilator support.

n = 222	All patients
Gender, n (%)	
Male	136 (61.3)
Female	86 (38.7)
Age, $\overline{X} \pm SD$	71.11 ± 11.39
BMI, median (IQR)	24.75 (7.6)
Mechanical ventilator support, n (%)	83 (37.4)
Intensive care scores	
Apache-II, median (IQR)	20 (8)
Charlson comorbidity, median (IQR)	6 (3)
SOFA, median (IQR)	6 (2)

Continuous variables are expressed as either the mean ± standard deviation (SD) or median (IQR) and categorical variables are expressed as either frequency (percentage).
Apache-II = acute physiology and chronic health evaluation-II, BMI = body mass index, IQR = interquartile range, SOFA = sequential organ failure assessment.

Table 2

Distribution of patients in terms of nutritional scores.

	All patients
PNI	
≥45 (low risk)	28 (12.6%)
<45 (high risk)	194 (87.4%)
Albumin (g/L)	
≥35 (low risk)	76 (34.2%)
<35 (high risk)	146 (65.8%)
NRS-2002	
≤4 (low risk)	102 (45.9%)
>4 (high risk)	120 (54.1%)
Nutric Score	
≤4 (low risk)	73 (32.9%)
>4 (high risk)	149 (67.1%)

Categorical variables are expressed as either frequency (%).
NRS-2002 = nutritional risk screening-2002, Nutric = nutrition risk in the critical Ill, PNI = prognostic nutritional index.

($P < .001$, $r = 0.334$), PNI and LMR ($P < .001$, $r = 0.281$) (Table 7).

According to univariate regression analysis, lymphocyte, NLR and PLR can predict low and high-risk patients in terms of PNI. According to multivariate regression analysis, lymphocytes can predict patients with low and high risk for PNI (Table 8).

4. Discussion

In this study, the PNI cut-off value for nutritional assessment in patients hospitalized in the intensive care unit due to COPD was determined as 38.5 (AUC = 0.891, sensitivity 80.8%, specificity 88.1%, PPV 92.9%, and NPV 88%). The cut-off values for lymphocyte count, basophil count, NLR, PLR and LMR, which were statistically significantly different between the high-risk group and the low-risk group according to PNI, were found to be 1.18, 0.035, 7.97, 291.10, and 2.606, respectively. The cut-off values obtained may be useful for nutritional risk assessment in patients admitted to the intensive care unit with the diagnosis of COPD.

There is a chronic inflammatory process in patients with a diagnosis of COPD.[11] Studies have shown that serum inflammatory marker levels are also increased in these patients.[18] Systemic inflammatory process causes catabolic stress in patients.[10] With the effect of systemic inflammatory stress, malnutrition is a common condition in patients with COPD.[1] Patients with COPD may need to be admitted to the intensive care unit, especially during acute exacerbations. Nutritional risk screening is recommended for every patient admitted to the intensive care unit.[2–5] In addition to the general condition disorder that causes hospitalization to the intensive care unit, the catabolic stress associated with chronic inflammation in patients with COPD increases the risk of malnutrition. Therefore, rapid and practical evaluation of nutritional status in patients with COPD who need intensive care will be very beneficial for patients.

Table 3

Cohen's Kappa analysis results between nutritional scores.

	PNI	Albumin	NRS-2002	Nutric Score				
	κ	P	κ	P	κ	P	κ	P
PNI	1		**0.269**	**<.001**	**0.118**	**.013**	−0.053	.342
Albumin			1		0.112	.084	0.101	.132
NRS-2002					1		**0.249**	**<.001**
Nutric Score							1	

NRS-2002 = nutritional risk screening-2002, Nutric = nutrition risk in the critical Ill, PNI = prognostic nutritional index.
Statistically significant values are in bold.

Table 4

Cut-off values for prognostic nutritioanl index by Nutric Score, NRS-2002, and albumin (receiver operating curve analysis).

PNI	AUCROC	SE	P	95% CI	CP	Sens.	Spec.	PPV	NPV
PNI (by albumin)	0.891	0.021	<.001	0.850–0.933	38.50	80.8%	88.2%	92.9%	88%
PNI (by NRS-2002)	0.637	0.037	<.001	0.563–0.710	39.38	75.8%	50%	64.1%	50%
PNI (by Nutric Score)	0.592	0.039	.026	0.515–0.669	39.38	69.8%	47.9%	73.2%	47.9%

AUCROC = area under curve receiver operating curve, CI = confidence interval, CP = cut-off point, NPV = negative predictive value, NRS-2002 = nutritional risk screening-2002, Nutric = nutrition risk in the critical ill, PNI = prognostic nutritional index, PPV = positive predictive value, SE = standard error, Sens. = sensitivity, Spec. = specificity.
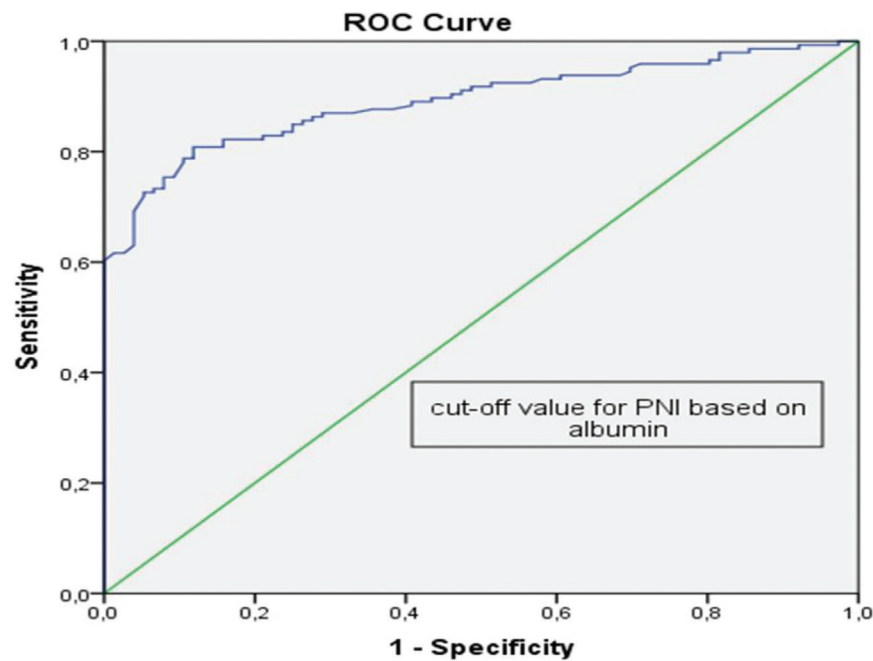
Figure 2. ROC curve of cut off value for PNI. PNI=prognostic nutritional index, ROC=receiver operating characteristic.

ASPEN recommends screening for nutritional risk using NRS-2002 and Nutric Score in patients hospitalized in the intensive care unit.[2–5] While NRS-2002 includes parameters such as weight loss and change in food intake, Nutric Score includes disease severity scoring of patients in intensive care unit. Patients with a Nutric Score >4 are stated to be at high risk for malnutrition[16] Although an NRS-2002 value has not been determined for intensive care patients, ASPEN recommends that aggressive nutritional therapy be given in patients with NRS-2002≥5.[4] In our study, NRS-2002≤4 determined as low risk, NRS-2002≥5 determined as high risk. In studies in the literature in which NRS-2002≥5 in intensive care was determined as high risk, it was reported that this situation was associated with worse clinical outcomes.[19] Although the recommendations are in this direction, it has not been possible to reach a consensus on the best nutritional assessment tool for patients admitted to the intensive care unit.[2] NRS-2002 and Nutric Score, Acute Physiology and Chronic Health Evaluation-II, Sequential Organ Failure Assessment, patient's age, number of co-morbidities, body mass index, weight loss, appetite status, and severe illness in the last 3 months include many parameters and some clinical information about the patient. Therefore, in order to calculate these scores, many parameters must be calculated and clinical information should be obtained from the patient or patient's relatives. In addition, it is often not possible to obtain detailed information about the nutritional status of patients hospitalized in the intensive care unit. It may be necessary to make do with the information given by the relatives of the patient. Therefore, there is a need for objective parameters that can evaluate the nutritional status of patients, apart from clinical information. In this respect, the basic laboratory parameters required from almost all patients can be an objective and practical method.

The chronic inflammatory process in patients with a diagnosis of COPD distinguishes these patients from many patient groups hospitalized in the intensive care unit. Therefore, malnutrition assessment may be specific for the COPD patient group. Therefore, PNI, which is a parameter that can evaluate the inflammatory process and nutritional status together, may be useful in the evaluation of nutritional status in patients with COPD. PNI was first developed by Onodera et al.[13] PNI is an objective indicator calculated using serum albumin level and lymphocyte count.[20] While PNI was initially used for the postoperative risk assessment of patients, it has also been used for the evaluation of prognosis in other patient groups and patients hospitalized in the intensive care unit in recent years.[6,12,21,22] Studies investigating the effect of PNI on prognosis tried to find cut-off values for different patient groups. In these studies, the cut-off value for PNI ranged between 35 and 53.85.[23,24] However, these studies on PNI focused on the prognosis of the patients rather than the relationship between PNI and the nutritional status of the patients. PNI is scoring that does not need clinical evaluation, which can be calculated simply by albumin level and lymphocyte count. Therefore, determining the relationship of PNI with nutritional parameters such as NRS-2002 and Nutric Score will reveal a very practical method for nutritional assessment in intensive care patients. However, we could not find any study in the literature that revealed the relationship between PNI and nutritional scores. Our study is the first in the literature investigating the relationship between PNI and nutritional scores such as NRS-2002 and Nutric Score in patients with COPD. For this, in our study, cut off values for PNI were determined according to albumin, nutric Score and NRS-2002 (Table 4). Since the cut-off value calculated according to the albumin value has higher sensitivity and specificity (AUC= 0.891, sensitivity 80.8%, specificity 88.1%, PPV 92.9%, NPV, 88%) In our study, the correlation of other parameters with PNI was calculated using the PNI cut-off value determined according

Table 5

Neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio, lymphocyte-to-monocyte ratio, and hemogram values of patients according to prognostic nutritional index risk status.

	PNI < 38.5 (high risk)	PNI ≥ 38.5 (low risk)	P
WBC, ×10³/μL	10.10 (8.00)	11.60 (5.70)	.058
Lymphocyte, ×10³/μL	0.71 (0.76)	1.25 (1.35)	<.001
Monocyte, ×10³/μL	0.44 (0.54)	0.59 (0.59)	.096
Neutrophil, ×10³/μL	8.67 (7.68)	9.06 (5.92)	.495
Eosinophil, ×10³/μL	0.01 (0.05)	0.02 (0.11)	.143
Basophil, ×10³/μL	0.03 (0.04)	0.05 (0.06)	**.004**
RBC, ×10⁶/μL	4.17 (1.08)	4.76 (1.24)	<.001
Hemoglobin, g/dL	10.90 (3.40)	12.70 (3.80)	<.001
Hematocrit, %	35.00 (10.30)	41.25 (12.80)	<.001
MCV, femtoliter	88.00 (10.60)	87.10 (9.90)	.475
MCH, pictogram	27.60 (4.30)	27 (3.90)	.161
MCHC, g/dL	31.36 ± 1.76	30.98 ± 1.72	.112
RDW, %	17 (4.90)	17.30 (4.00)	.680
PLT (Platelets), ×10³/μL	217 (136)	233.50 (123)	.124
MPV, femtoliter	8.60 (1.76)	8.55 (1.90)	.613
PCT, %	0.19 (0.10)	0.21 (0.11)	.053
PDW, %	17.70 (2.30)	17.60 (2.40)	.997
NLR	12.69 (16.03)	7.40 (9.48)	<.001
PLR	294.87 (317.67)	196.55 (222.05)	**.001**
LMR	1.77 (1.69)	2.64 (3.34)	**.001**

Continuous variables are expressed as either the mean ± standard deviation (SD) or median (interquartile range). Continuous variables were compared with Student t test or Mann–Whitney U test. Statistically significant P-values are in bold.
LMR = lymphocyte/monocyte ratio, MCH = mean corpuscular hemoglobin, MCHC = mean corpuscular hemoglobin concentration, MCV = mean corpuscular volume, MPV = mean platelet volume, NLR = neutrophil/lymphocyte ratio, PCT = platelet crit, PDW = platelet distribution width, PLR = platelet/lymphocyte ratio, PNI = prognostic nutritional index, RBC = red blood cell, RDW = red cell distribution width, WBC = white blood cell.

Table 7

Spearman correlation analysis between prognostik nutritional index and lymphocyte, basophil, RBC, hemoglobin, hematocrit, neutrophil/lymphocyte ratio, lymphocyte/monocyte ratio, and platelet/lymphocyte ratio.

	PNI
Lymphocyte	
r	0.456
P	<0.001
Basophil	
r	0.210
P	0.002
RBC	
r	0.333
P	<0.001
Hemoglobin	
r	0.312
P	<0.001
Hemotokrit	
r	0.334
P	<0.001
NLR	
r	−0.296
P	<0.001
PLR	
r	−0.323
P	<0.001
LMR	
r	0.281
P	<0.001

LMR = lymphocyte/monocyte ratio, NLR = neutrophil/lymphocyte ratio, PLR = platelet/lymphocyte ratio, PNI = prognostic nutritional index, r = correlation coefficient, RBC = red blood cell.

to albumin. In our study, the cut-off value that can be used in the evaluation of nutritional status for PNI in patients hospitalized in the intensive care unit with the diagnosis of COPD was determined as 38.5.

Recently, there has been an increasing interest in studies aiming to predict the prognosis of patients with simple blood tests.[15] For this purpose, the parameters that can be calculated by complete blood count, which is a practical method and performed in almost all patients for whom blood tests are requested, are emphasized. NLR, especially as a prognostic biomarker, has received increasing attention in many inflammatory diseases.[25,26] In addition, NLR has been shown to be an independent predictor of prognosis in patients with COPD.[25,27] Studies have reported that NLR is significantly higher in patients with COPD exacerbation.[25,26] There are studies stating that

NLR > 10.23 is associated with poor prognosis in COPD exacerbation, a cutoff value of 10,345 can predict the need for invasive ventilation, and NLR > 16 is an independent mortality risk factor in patients requiring intensive care.[26,28,29] In our study, the cut-off value of NLR was determined as 7.972 in terms of nutritional risk assessment in patients hospitalized in the intensive care unit due to COPD (AUC = 0.351, sensitivity 56.4%, specificity 67.7%, P < .001). Our study is the first in the literature investigating the relationship between NLR and nutritional status in patients with COPD.

In our study, the relationship between nutritional status with LMR and PLR, which are used as inflammatory and prognostic markers in many studies, was also investigated in patients with COPD hospitalized in the intensive care unit.[30,31] We could not find any studies investigating the relationship between these

Table 6

Cut-off values for lymphocyte, basophil, neutrophil/lymphocyte ratio, lymphocyte/monocyte ratio, and platelet/lymphocyte ratio when cut-off value for prognostic nutritional index is 38.5 (ROC analysis).

PNI	AUCROC	SE	P	95% CI	CP	Sens.	Spec.
Lymphocyte (×10³/μL)	0.708	0.035	<.001	0.639–0.778	1.18	54.3%	77.2%
Basophil (×10³/μL)	0.614	0.039	.004	0.538–0.690	0.035	59.6%	63.8%
NLR	0.351	0.037	<.001	0.279–0.424	7.972	56.4%	67.7%
PLR	0.350	0.037	<.001	0.277–0.422	291.10	69.1%	52.8%
LMR	0.637	0.038	.001	0.562–0.711	2.606	52.1%	73.2%

AUCROC = area under curve receiver operating curve, CI = confidence interval, CP = cut off point, LMR = lymphocyte/monocyte ratio, NLR = neutrophil/lymphocyte ratio, PLR = platelet/lymphocyte ratio, SE = standard error, Sens. = sensitivity, Spec. = specificity.

Table 8

Univariate and multivariate logistic regression analysis for risk factors thought to be associated with PNI.

PNI	Univariate logistic regression				Multivariate logistic regression (Backward LR Method-Step 14)			
	Wald	P	OR	95% CI for OR	Wald	P	OR	95% CI for OR
Age	3.946	**.047**	1.025	1.000–1.050	11.008	**<.001**	1.011	0.862–0.962
Gender	0.266	.606	1.155	0.668–1.996				
BMI	17.510	**<.001**	0.902	0.860–0.947				
WBC	2.015	**.156**	0.972	0.935–1.011				
Lymphocyte	26.580	**<.001**	0.285	0.177–0.459	25.171	**<.001**	0.256	0.151–0.436
Monocyte	3.368	**.066**	0.549	0.289–1.042				
Neutrophil	0.513	.474	0.988	0.955–1.022				
Eosinophil	2.221	**.136**	0.153	0.013–1.806				
Basophil	0.245	.621	0.824	0.383–1.772				
RBC	16.482	**<.001**	0.528	0.388–0.718				
Hemoglobin	13.917	**<.001**	0.803	0.716–0.901				
Hematocrit	16.534	**<.001**	0.929	0.897–0.963	25.203	**<.001**	0.894	0.856–0.934
MCV	0.356	.551	1.010	0.977–1.045				
MCH	1.680	**.195**	1.059	0.971–1.154				
MCHC	2.508	**.113**	1.134	0.971–1.324				
RDW	0.793	.373	1.034	0.961–1.111				
PLT (Platelets)	2.492	**.114**	0.998	0.995–1.001				
MPV	0.708	.400	0.929	0.783–1.102				
PCT	4.024	**.030**	0.030	0.001–0.923				
PDW	0.021	.886	0.989	0.852–1.148				
NLR	10.024	**.002**	1.046	1.017–1.075				
PLR	12.969	**<.001**	1.003	1.001–1.004				
LMR	2.156	**.142**	0.941	0.868–1.020				

Statistically significant *P*-values are in bold.

BMI = body mass index, CI = confidence interval, LMR = lymphocyte/monocyte ratio, MCH = mean corpuscular hemoglobin, MCHC = mean corpuscular hemoglobin concentration, MCV = mean corpuscular volume, MPV = mean platelet volume, NLR = neutrophil/lymphocyte ratio, OR = odds radio, PCT = platelet crit, PDW = platelet distribution width, PLR = platelet/lymphocyte ratio, PNI = prognostic nutritional index, RBC = red blood cell, RDW = red cell distribution width, Wald = test statistics, WBC = white blood cell.

parameters and nutritional status in the literature. However, in one study, the average LMR and PLR determined in healthy adults are 5.31 and 132.4.[15] In our study, in terms of nutritional risk assessment in patients hospitalized in the intensive care unit with the diagnosis of COPD, LMR and PLR cut-off values were 2.606 (AUC = 0.637, sensitivity 52.1%, specificity 73.2%, $P = .001$) and 291.1 (AUC = 0.350, sensitivity 69.1%, specificity 52.8%, $P < .001$).

There are studies showing the relationship between low lymphocyte count and poor prognosis in patients with COPD.[32] In addition, the relationship between eosinophils and basophils and COPD has been demonstrated in different studies[33–35] However, in our study, no statistically significant correlation was found between eosinophil values and PNI. The cut-off value was 1.18 (AUC = 0.708, sensitivity 54.3%, specificity 77.2%, $P < .001$) for lymphocyte value and 0.035 (AUC = 0.614, sensitivity 59.6%, specificity 63.8%, $P = .004$) for basophil value. In addition, a statistically low and positive correlation was found between PNI and lymphocyte count ($P < .001$, $r = 0.456$) and basophil count ($P = .002$, $r = 0.210$). Also, according to multivariate regression analysis, lymphocyte count can predict patients with low and high risk for PNI.

According to the univariate regression analysis we performed in addition to the correlation analysis, lymphocyte, NLR and PLR can predict low and high-risk patients in terms of PNI. According to multivariate regression analysis, only lymphocytes can predict low and high-risk patients for PNI. However, most predictive analytics that we also use in our study make use of generalized linear models. This is limited to model assumptions that include linearity between response variables and additional

interactions between variables. For the most part, the complex relationships between predictors and response variables are often unknown.[36] In order to eliminate this deficiency, it is stated in the literature that machine learning algorithms can be used to model basic data.[36] The advantage of machine learning algorithms is that they can learn complex functional forms using a nonparametric approach.[36] Two or more machine learning models can be synthesized to further improve prediction accuracy. Such an approach is called ensemble modeling and has been used in many industries.[36] However, this approach has not been widely reported in the literature on ICU patients and nutritional status due to its complexity in both model training and interpretation. In our study, estimators that are frequently used in practice were also used. However, in future studies, it will be useful to evaluate the nutritional status determinants in COPD patients in intensive care with the ensemble modeling method and to compare the predictive power between models.

There are some limitations in our study. First; our study is a retrospective study. Second; the effects of the parameters determined in our study that can be used for nutritional assessment could not be evaluated on the prognosis of the patients. Third; the relationship between the specified parameters and the nutritional therapy applied to the patients could not be determined. Therefore, in our study, an evaluation was made between the laboratory parameters checked during admission to the intensive care unit and the nutritional status. After the nutritional therapy was applied to the patients, the relationship between the nutritional status of the patients and the parameters examined could not be evaluated. However, our results will be instructive for future studies on this subject.

As a result, nutritional risk assessment can be made in a practical way by using PNI in patients hospitalized in intensive care unit due to COPD. For this, the PNI cut-off value was determined as 38.5 in our study. In addition, NLR, PLR, LMR, basophil and lymphocyte values, which can be calculated using complete blood count parameters, may also be useful in the evaluation of nutritional status in these patients. In our study, the cut-off values determined for NLR, PLR, LMR, basophil and lymphocyte were 7.97, 291.10 and 2.606, 0.035 and 1.18, respectively. We think that the results we have obtained can provide preliminary information for future research.

Author contributions

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