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The relationship between prognostic nutritional index and mortality in patients hospitalized with COVID-19 Pneumonia

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Abstract

Objective: We aimed to investigate the ability of the Prognostic Nutritional Index (PNI) score to predict the prognosis and mortality of patients hospitalized for COVID-19 Pneumonia.

Methods: One hundred seventy-three patients were included in the study. The patients were grouped as patients with or without pneumonia, those who were hospitalized in the ward or intensive care unit, who were discharged, or who died. The ability of the PNI score, which was calculated according to the results at the time of admission, to predict hospitalization and mortality in the intensive care unit was evaluated.

Results: The mean age of the patients was found to be 53.9 years. Pneumonia was detected in 72.3% of the patients. The need for intensive care developed in 26% of them. The PNI score was found to be significantly lower ($p<0.05$) in patients with pneumonia compared to patients without pneumonia. The PNI score of the patients hospitalized in the intensive care unit was found to be significantly ($p<0.05$) lower than the patients hospitalized in the ward. The PNI score of the patients who died was found to be significantly lower ($p<0.05$) than the patients who were discharged. The cut-off value of the PNI score was found to be 46.

Conclusion: The PNI score which are among routine blood tests, was found to be effective in predicting intensive care unit admission and mortality. We believe that using the PNI score together with other biomarkers will be beneficial for clinicians in the prediction of the prognosis of patients.

Keywords: Albumin, COVID-19, Lymphopenia, Prognostic Nutritional Index, Prognosis

INTRODUCTION

COVID-19 is defined as an epidemic of viral pneumonia that begins with cold symptoms, progresses to severe pneumonia, and can result in multiple organ failure and ARDS (1). Although COVID-19 can be seen at any age, its frequency increases in advanced age, and critical illness and death are more common. Advanced age, male gender were associated with poor prognosis and mortality (2). Mortality and morbidity were also found to be high in patients who presented with fever, shortness of breath and were found to have pneumonia. It has been reported that the prognosis is poor in those with comorbid diseases. Due to the excessive inflammation seen in the pathogenesis of COVID-19, clinical pictures suggesting cytokine storm or macrophage activation syndrome are seen in the follow-up of these patients after the 7th day (3-7). When biochemical tests are examined, C-Reactive protein (CRP), Procalcitonin (PCT), Ferritin, D-Dimer, Lactate Dehydrogenase (LDH) elevation, hypoalbuminemia are used in clinical practice as a poor prognostic indicator in the diagnosis and follow-up of the disease in the course of COVID-19. Lympopenia has been reported frequently in COVID-19. An excessive immune response is thought to cause lymphopenia (8). Neutrophil/lymphocyte ratio (NLR) is a parameter that has been used for many years to predict prognosis in the course of bacterial and viral infections, and this ratio has been used in many studies. NLR has also been used

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to predict the prognosis of patients in the course of COVID-19 (9). Prognostic nutritional index (PNI) is considered as a parameter that reflects the immunological and nutritional status of patients. Albumin is low in blood levels in cases of inflammation and malnutrition. In the case of malnutrition, the immune system is affected and this situation appears as lymphopenia. This parameter, which predicts the evaluation of immunity, inflammation and malnutrition together, has been used to determine the prognosis and mortality of many diseases (10-16). In this study, it was aimed to investigate the ability of the PNI score to predict the prognosis and mortality of patients hospitalized for COVID-19.

METHODS

Study Design

Our study was planned as a single-centered, retrospective observational cohort study, and patients between March 2020 and March 2021 were screened from the hospital electronic data system. The study protocol was approved by the Turkish Ministry of Health and Sutcu Imam University, Medical Faculty Clinical Ethics Committee. (Decision no: 31.08.2021-277). Declaration of Helsinki criteria was taken into account throughout the study.

Study Population

Patients over the age of 18 who applied to the emergency department or the COVID-19 outpatient clinic and were hospitalized with positive reverse transcription polymerase chain reaction (RT-PCR) were included in the study. Pregnant patients, patients with chronic liver disease, nephrotic syndrome, hematological disease, immunosuppressive patient and malignancy were excluded from the study. According to thorax computed tomography (CT) findings, the patients were divided into groups such as those with or without pneumonia; admitted to the ward or intensive care unit; discharged, and exitus.

Study Protocol

During hospitalization, the patients were admitted to the ward or intensive care unit according to the case definitions in the Ministry of Health General Directorate of Public Health COVID-19 (SARS-CoV-2) Infection Adult Patient Treatment Guidelines, and the severity of pneumonia was determined according to the same guideline (17).

Cough, shortness of breath, fever and other symptoms, vital signs at the time of admission, saturation values, demographic data and accompanying comorbidities were examined.

The first complete blood count, complete biochemistry, D-Dimer, arterial blood gas (ABG), CRP, Ferritin, Procalcitonin, and coagulation tests during hospitalization were obtained from the hospital data system. PNI scores (PNI = 10 × serum albumin (g/dL) + 0.005 × peripheral lymphocyte count (/mm3)) were calculated from laboratory results (18). Thorax CT images were evaluated from the hospital system or ministry of health personal health record system. Patients with COVID-19 were grouped with and without pneumonia, and prognosis and mortality were compared. In the follow-up of the patients who were admitted to the ward, their admission to the intensive care unit, mortality and whether they were discharged were evaluated. Mortality and discharge of patients hospitalized in the intensive care unit were followed up. The contribution of the laboratory findings obtained at the time of admission to the hospital to the prognosis and mortality in the course of the disease was evaluated.

Statistical Analysis

In the descriptive statistics of the data, mean, standard deviation, median, minimum, maximum, frequency and ratio values were used. The distribution of variables was measured with the Kolmogorov-Smirnov test. ANOVA (Tukey test), Independent Sample T-test, Kruskal-Wallis, and Mann-Whitney u test were used in the analysis of quantitative independent data. The Chi-square test was used in the analysis of qualitative independent data, and the Fisher test was used when the Chi-square test conditions were not met. The effect level was investigated with the ROC curve. SPSS 28.0 program was used for the analyses.

RESULTS

One hundred seventy-three patients were included in the study. The mean age of the patients was 53.9 (19-95) years. The sex distribution of the patients was as follows: 118 males (68.2%) and 55 females (31.8%). Fever was detected during the admission in 45.7% of patients. The three most common symptoms of the patients were cough, shortness of breath and myalgia. Cough was the most prominent symptom with 42.2%. Pneumonia was not detected on thorax CT in 48 patients (27.7%) at the time of admission. The need for intensive care developed in 45 patients (26%). 27 (15.6%) of these patients died. 146 patients (84.4%) were discharged (Table 1). In the group with pneumonia, the rate of comorbid disease was found to be significantly higher ($p<0.05$) when compared to the group without pneumonia. The rate of admission to the intensive care unit in the group with pneumonia (35.2%) was significantly higher than the group without pneumonia, 2.1% ($p<0.05$). Mortality in the group with pneumonia was 21.6%, while mortality was not observed in the group without pneumonia. When we evaluated the laboratory parameters of both groups, oxygen saturations (SpO_2) in the group with pneumonia (mean SpO_2: 94%) were found to be significantly ($p<0.05$) lower than in the group without pneumonia (mean SpO_2: 97%), lymphocyte, hemoglobin and thrombocyte counts in the group with pneumonia were significantly lower

(p<0.05) when compared to the group without pneumonia, and there was no significant difference in leukocyte count (p>0.05). When the biochemical parameters were evaluated CRP, Ferritin, D-Dimer, Procalcitonin and lactate dehydrogenase (LDH) were found to be significantly higher (p<0.05) in the pneumonia group. When the PNI score was evaluated between the groups with and without pneumonia, the average PNI score was significantly lower (p<0.05) in the group with pneumonia, with 44.6. The mean PNI score was found to be significantly lower (p<0.05). The PNI score of the patients admitted to the ward or intensive care unit at the time of admission was found to be significantly lower (p<0.05) in the patients admitted to the intensive care unit. NLR was found to be significantly higher (p<0.05) in patients admitted to intensive care. (Table 2). When the groups of patients who were discharged and those who died were compared, when the PNI score was evaluated, the PNI score (mean 34.9) in the group who died were found to be significantly (p<0.05) lower than the group who were discharged (mean 55.1). When NLR was evaluated, NLR (median 9) was found to be significantly higher in the group who died than in the group who were discharged (median 2.4) (Table 3). The sensitivity of 46 cut-off values of the PNI score was 88.9%, the positive predictive value was 58.8%, the specificity was 77.3%, and the negative predictive value was 95.2% in differentiating patients admitted to the ward or intensive care unit (Table 4). The sensitivity of the 46-cut-off value of the PNI score was 92.6%, the positive predictive value was 36.2%, the specificity was 69.9%, and the negative predictive value was 97.1% in separating the discharged patients from the dead. It was found that 92.5% of patients who died had a PNI score below 46. The PNI score of 88.9% of the patients hospitalized in the intensive care unit was below 46.

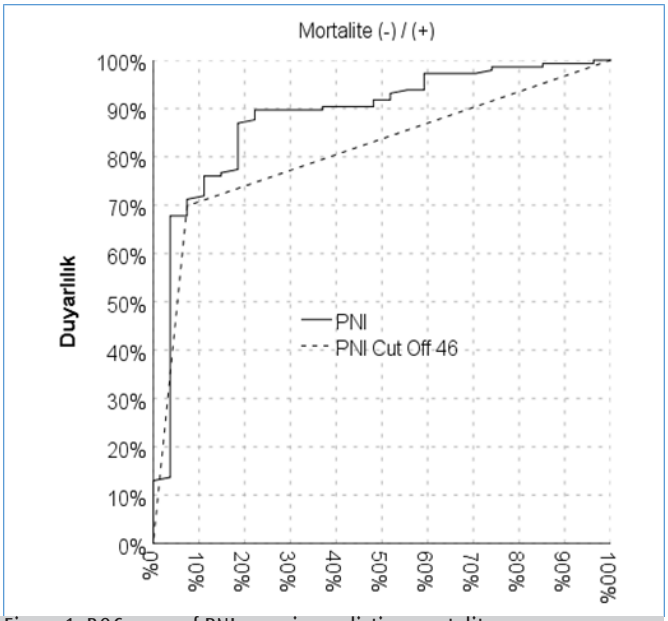

Figure 1. ROC curve of PNI score in predicting mortality

Table-1 Clinical findings of the patients included in the study

		Min-Max			Median	Mean±sd/n-%		
Age		19.0	-	95.0	55.0	53.9	±	19.4
Sex	Female					55		31.8%
	Male					118		68.2%
Comorbidities	No					79		45.7%
	Yes					94		54.3%
HT						59		34.1%
Asthma-COPD						21		12.1%
DM						33		19.1%
Pneumonia	No					48		27.7%
	Yes					125		72.3%
Fever	No					94		54.3%
	Yes					79		45.7%
Symptom	No					24		13.9%
	Yes					149		86.1%
Cough						73		42.2%
Dyspnea						56		32.4%
Myalgia						28		16.2%
Disease severity	Light					112		64.7%
	Moderate					36		20.8%
	Severe					25		14.5%
Need for Intensive Care	No					128		74.0%
	Yes					45		26.0%
Result	Discharged					146		84.4%
	Exitus					27		15.6%

HT: Hypertension, COPD: Chronic Obstructive Pulmonary Disease, DM: Diabetes Mellitus

DISCUSSION

It has been reported in studies that a large number of factors play a role in mortality in COVID-19 (19-21). In this study, the effect of the PNI score on mortality was evaluated. The PNI score was found to be significantly lower in the group with pneumonia, who are admitted to the intensive care unit and died, when compared to the group without pneumonia, admitted to the ward and discharged. Again, cut-off values of the PNI score were determined to evaluate prognosis and mortality.

There have been studies evaluating the prognostic value of CRP, ferritin, procalcitonin, LDH, D-Dimer and albumin levels, neutrophil, lymphocyte and platelet counts in the diagnosis and follow-up of patients in the course of COVID-19 (22-24). Among these studies, 32 studies were reviewed in a compilation by Malik et al., the data of a total of 10491 COVID-19 patients

Table 2. Laboratory findings of the ward and intensive care patients

	Intensive Care (-)		Intensive care (+)		p	
	Mean+sd	Median I.Q-3.Q	Mean+sd	Median I.Q-3.Q		
Sp O_2 %	95.8±2.1	96.0 95.0-97.0	83.5±11.9	88.0 82.0-91.0	<0.001	m
Hemoglobin (g/dl)	14.2±1.8	14.5 13.2-15.5	13.4±2.2	13.7 11.9-14.8	0.008	m
WBC (x10^9/l)	6.0±2.2	5.6 4.5-7.3	9.3±5.0	8.2 5.9-11.9	<0.001	m
Neutrophil (x10^9/l)	3.9±1.9	3.3 2.6-4.9	7.6±4.6	6.1 4.4-9.7	<0.001	m
Lymphocytes (x10^9/l)	1.7±1.8	1.5 1.1-1.9	1.0±0.7	0.8 0.5-1.3	<0.001	m
Platelets (x10^9/l)	206.4±62.5	195.0 167.0-237.8	202.4±80.8	182.0 148.5-245.0	0.434	m
NLR	3.1±2.9	2.3 1.6-3.3	11.9±12.5	6.24 4.0-15.5	<0.001	m
CRP (mg/l)	17.5±23.2	8.1 3.1-19.3	123.0±92.6	109.0 38.7-184.5	<0.001	m
Ferritin (ug/l)	190.2±167.8	129.0 69.5-249.3	728.7±767.3	502.0 294.5-1017.5	<0.001	m
D-Dimer (mg/l)	0.6±0.9	0.4 0.2-0.7	4.7±12.6	1.2 0.6-3.1	<0.001	m
Prokalcitonin (ug/l)	0.1±0.2	0.1 0.0-0.1	3.2±14.9	0.3 0.1-0.9	<0.001	m
PNI Score	57.1±50.6	50.7 46.2-55.7	37.3±9.3	38.1 33.0-43.3	<0.001	m

[m] Mann-whitney U test WBC:White Blood Cell, NLR:Neutrophil-Lymphocytes Ratio, CRP: C-Reactive Protein PNI:Prognostıc Nutrituonal Index

Table 3. Laboratory findings of patients who were discharged and are exitus

	Discharged			Exitus		p	
	mean±sd	Median		mean±sd	Median		
SpO_2 %	95.1 ± 2.7	96.0		78.9 ± 13.5	84.0	<0.001	m
Hemoglobin (g/dl)	14.1 ± 1.8	14.3		13.5 ± 2.5	13.7	0.112	m
WBC (x10^9/l)	6.2 ± 2.3	5.7		10.5 ± 5.6	9.3	<0.001	m
Neutrophil (x10^9/l)	4.1 ± 2.2	3.5		8.6 ± 5.1	7.9	<0.001	m
Lymphocytes (x10^9/l)	1.6 ± 1.7	1.4		1.0 ± 0.8	0.8	<0.001	m
Platelets (x10^9/l)	202.9 ± 64.1	192.0		218.5 ± 84.0	201.0	0.567	m
NLR	3.9 ± 4.9	2.4		13.6 ± 13.8	9.0	<0.001	m
CRP (mg/l)	25.7 ± 38.4	10.0		149.1 ± 99.0	147.0	<0.001	m
Ferritin (ug/l)	245.1 ± 259.0	161.0		790.9 ± 932.7	550.0	<0.001	m
D-Dimer (mg/l)	0.7 ± 0.9	0.4		7.3 ± 15.9	1.9	<0.001	m
Prokalcitonin (ug/l)	0.2 ± 1.4	0.1		4.4 ± 19.0	0.4	<0.001	m
PNI Score	55.1 ± 47.7	49.5		34.9 ± 10.5	36.8	<0.001	m

[m] Mann-Whitney U test WBC: White Blood Cell, NLR: Neutrophil-Lymphocytes Ratio, CRP: C-Reactive Protein PNI: Prognostic Nutritional Index

Table- 4 Analysis of the distribution of the cut-off value of the PNI score by patient groups

		PNI ≤ 46		PNI > 46		Sensitivity	Positive Estimation	Specificity	Negative Estimation
		n	%	n	%				
Disease severity	Light	19	27.5%	93	89.4%	82.0%	72.5%	83.0%	89.4%
	Moderate-severe	50	72.5%	11	10.6%				
Pneumonia	(-)	5	7.2%	43	41.3%	51.2%	92.8%	89.6%	41.3%
	(+)	64	92.8%	61	58.7%				
Need for Intensive Care	(-)	29	42.0%	99	95.2%	88.9%	58.8%	77.3%	95.2%
	(+)	40	58.0%	5	4.8%				
Result	Discharged	44	63.8%	102	98.1%	92.6%	36.2%	69.9%	97.1%
	Ex	25	36.2%	2	1.9%				

were evaluated, and lymphopenia, thrombocytopenia, high CRP, procalcitonin, LDH, and D-Dimer levels were reported to be associated with critical illness in COVID-19 patients (22). In a study conducted in Iran, the data of 233 patients were examined. Lymphopenia was observed in 79% of the patients in the mortal group. It has been reported that a high neutrophil/lymphocyte (NLR) ratio and platelet/lymphocyte ratio (PLR) are independent risk factors for mortality (23). In the meta-analysis of Huang et al. (24), it was reported that high CRP, procalcitonin, ferritin and D-Dimer levels are associated with poor prognosis in COVID-19 patients . In another meta-analysis, in which 30 studies were compiled, the risk factors for severe COVID-19 disease were examined. It has been reported that lymphopenia, high CRP, LDH levels, and hypoalbuminemia have prognostic significance for severe disease (25). In our study, similar to the other studies, when CRP, procalcitonin, ferritin, D-Dimer, and LDH levels are evaluated; in patients with pneumonia, who were admitted to the intensive care unit and who died; it was found to be significantly higher than the patient groups without pneumonia, hospitalized and discharged. The albumin levels and lymphocyte counts were found to be statistically significantly lower in the patient groups with pneumonia and those who were hospitalized in the intensive care unit, and those who died. The neutrophil count was found to be significantly higher in the patient group hospitalized in the intensive care unit and in the group who died, and when the platelet count was evaluated for all patient groups, no significant difference was observed. Elevated levels of CRP, procalcitonin, LDH, ferritin, D-Dimer, lymphopenia, and hypoalbuminemia were associated with being taken to the intensive care and mortality. We think that the results of our study were similar to the literature due to the fact that the studies were conducted in the first year of the pandemic, the vaccination had not started, and the treatment regimens were similar.

PNI score is a parameter obtained from albumin and lymphocyte counts and it reflects the nutritional and inflammatory status of the patients and has been used to show prognosis in many diseases (9-10). In a study conducted by Song et al. (26), the ability of parameters reflecting the malnutrition at the time of admission to indicate in-hospital mortality was evaluated. In this study, PNI, Controlled Nutrition Index (CONUT) and Geriatric Nutritional Risk Index (GNRI) scores were used. All three scores were found to be independent risk factors for mortality. The elevation of D-Dimer and CRP were found to be associated with poor prognosis. Albumin levels were found to be significantly lower in severe patients. No significant difference was observed between the body mass index and lipid panel of severe patients. In this study, it was reported that a PNI score below 44 was associated with in-hospital mortality. Similar to our study, it was stated that a low PNI score may be a risk factor for in-hospital mortality.

In a study conducted with 295 COVID-19 patients in China, risk factors for mortality were retrospectively investigated according to the findings at the time of admission. It was observed that the mortality of patients with advanced age (>74), male sex and hypertension was high. In our study, we also found that advanced age and co-morbid hypertension are risk factors for mortality. In this study, it was also reported that platelet count, LDH and PNI score were independent risk factors for mortality (25). The authors stated that a PNI score below

33.4 may be an important risk factor for mortality. In our study, we also determined that a PNI below 46 is a risk factor for mortality.

In the study conducted by Doğancı et al. (27) with 397 patients, the prognostic factors in COVID-19 patients were investigated. It has been reported that having a PNI score below 44.7 is associated with a poor prognosis. In another study by Nalbant et al. (28) with 118 patients, the importance of PNI and systemic inflammatory index were investigated in showing the prognosis of patients with COVID-19. Elevated CRP, procalcitonin, ferritin, D-Dimer and LDH levels were found to be significantly higher in intensive care patients. Albumin and lymphocyte counts were also found to be significantly lower. In addition, it was reported that the PNI score was lower in intensive care patients with a mean value of 34.1, compared to the other group. Again, in the same study, when the cut-off value of the PNI score was ≤36.7%, it was reported that the PNI score had a sensitivity of 73.4% and a specificity of 70.8% in predicting the severity of the disease. In this study, results similar to our study were reported in many aspects. The fact that both studies were conducted in Turkey on the same dates, included a similar number of patients, and the absence of race and sex differences support the similar results. In both studies, it was observed that a low PNI score was associated with increased intensive care hospitalization. In another Turkey-based study with the number of 1579 patients (29), PNI scores were found to be significantly lower in patients who had to be hospitalized in the intensive care unit and died, similar to our study.

Limitations of the Study

The limitations of the study can be stated as that our study was single-center, retrospective, did not include patients with negative COVID-19 RT-PCR test but with typical involvement of Thorax CT, not being the optimum treatment method, and being administered before vaccination.

CONCLUSION

As a result, albumin and lymphocyte counts are used as parameters that reflect the inflammation and malnutrition status of the patients. In our study, the PNI score of the patients hospitalized with the diagnosis of COVID-19 was calculated; It was found that the prognosis of the patients was poor and the morbidity and mortality were high in case of PNI <46. It is thought that this situation occurs secondary to a decrease in albumin and lymphocyte counts in cases of excessive inflammation in COVID-19 patients. It is known that the prognosis of patients is poor, morbidity and mortality are high in case of excessive inflammation. As a result, we think that PNI score calculated using albumin and lymphocyte count can be used together with other biomarkers to predict the prognosis of patients, but new studies are needed.

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Conflict of Interest

The authors declare that they have no conflict of interests regarding content of this article..

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Previously presented

Some part of this study was presented as oral presentation at the 25th annual congress of the Turkish Thoracic Society in Antalya.

This study was prepared by rearrangement of the specialty thesis by Muhammed Şahin, entitled as “Covid-19 Pnömonisi ile Yatan Hastalarda Prognostik Nutrisyonel İndeks- Mortalite İlişkisi”.

Ethical Declaration

Ethical permission was obtained from the Sutcu Imam University, Medical Faculty Clinical / Human Research Ethics Committee for this study with date 31.08.2021.and number 277, and Helsinki Declaration rules were followed to conduct this study.

This study is a rearranged version of the thesis named “Covid-19 Pnömonisi ile Yatan Hastalarda Prognostik Nutrisyonel İndeks- Mortalite İlişkisi

Authorship Contributions

Concept: MŞ, BA, Design: BA, MŞ, Supervising: BA, MŞ, Financing and equipment: NA, FB, HK, BK, MŞ, BA, Data collection and entry: MŞ, Analysis and interpretation: BA, MŞ, Literature search: BA, MŞ, FB, Writing: MŞ, BA, Critical review: BA, HK.

REFERENCES

1. Guo YR, Cao QD, Hong ZS, Tan YY, Chen SD, Jin HJ, et al.The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak - an update on the status. Mil Med Res. 2020 Mar 13;7 (1):11. doi: 10.1186/s40779-020-00240-0. PMID: 32169119; PMCID: PMC7068984.)
2. Stokes EK, Zambrano LD, Anderson KN, Marder EP, Raz KM, El Burai Felix S, et al. Coronavirus Disease 2019 Case Surveillance - United States, January 22-May 30, 2020. MMWR Morb Mortal Wkly Rep. 2020 Jun 19;69 (24):759-765. http://dx.doi.org/10.15585/mmwr.mm6924e2
3. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical

Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus-Infected Pneumonia in Wuhan, China. JAMA. 2020 Mar 17;323 (11):1061-1069. http://doi.org/10.1001/jama.2020.1585

4. Chang MC, Park YK, Kim BO, Park D. Risk factors for disease progression in COVID-19 patients. BMC Infect Dis. 2020 Jun 23;20 (1):445. http://doi.org/10.1186/s12879-020-05144-x

5. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet. 2020 Mar 28;395 (10229):1054-1062. http://doi.org/10.1016/S0140-6736 (20)30566-3

6. Xu J, Yang X, Yang L, Zou X, Wang Y, Wu Y, et al. Clinical course and predictors of 60-day mortality in 239 critically ill patients with COVID-19: a multicenter retrospective study from Wuhan, China. Crit Care. 2020 Jul 6;24 (1):394. http://doi.org/10.1186/s13054-020-03098-9

7. Fang B, Meng QH. The laboratory's role in combating COVID-19. Crit Rev Clin Lab Sci. 2020 Sep;57 (6):400-414. http://doi.org/10.1080/10408363.2020.1776675

8. Yang AP, Liu JP, Tao WQ, Li HM. The diagnostic and predictive role of NLR, d-NLR and PLR in COVID-19 patients. Int Immunopharmacol. 2020 Jul;84:106504. http://doi.org/10.1016/j.intimp.2020.106504

9. Okui M, Horio H, Asakawa A, Yamamichi T, Harada M. The prognostic nutritional index in resected high-grade pulmonary neuroendocrine carcinoma. Gen Thorac Cardiovasc Surg. 2020 Jan;68 (1):43-48. http://doi.org/10.1007/s11748-019-01150-2

10. Wang D, Hu X, Xiao L, Long G, Yao L, Wang Z, et al. Prognostic Nutritional Index and Systemic Immune-Inflammation Index Predict the Prognosis of Patients with HCC. J Gastrointest Surg. 2021 Feb;25 (2):421-427. http://doi.org/10.1007/s11605-019-04492-7

11. Mirili C, Yılmaz A, Demirkan S, Bilici M, Basol Tekin S. Clinical significance of prognostic nutritional index (PNI) in malignant melanoma. Int J Clin Oncol. 2019 Oct;24 (10):1301-1310. http://doi.org/10.1007/s10147-019-01461-7

12. Wang Z, Wang Y, Zhang X, Zhang T. Pretreatment prognostic nutritional index as a prognostic factor in lung cancer: Review and meta-analysis. Clin Chim Acta. 2018 Nov;486:303-310. http://doi.org/10.1016/j.cca.2018.08.030

13. Xiao FK, Wang L, Zhang WC, Wang LD, Zhao LS. Preoperative Prognostic Nutritional Index is a Significant Predictor of Survival in Esophageal Squamous Cell Carcinoma Patients. Nutr Cancer. 2021;73 (2):215-220. http://doi.org/10.1080/01635581.2020.1757129

14. Oba T, Maeno K, Ono M, Ito T, Kanai T, Ito KI. Prognostic Nutritional Index Is Superior to Neutrophil-to-lymphocyte Ratio as a Prognostic Marker in Metastatic Breast Cancer Patients Treated With Eribulin. Anticancer Res. 2021 Jan;41 (1):445-452. http://doi.org/10.21873/anticanres

15. Yasar HA, Bir Yucel K, Arslan C, Ucar G, Karakaya S, Bilgin B, et al. The relationship between prognostic nutritional index and treatment response in patients with metastatic renal cell cancer. J Oncol Pharm Pract. 2020 Jul;26 (5):1110-1116. http://doi.org/10.1177/1078155219883004

16. Bailón-Cuadrado M, Pérez-Saborido B, Sánchez-González J, Rodríguez-López M, Velasco-López R, C Sarmentero-Prieto J, et al. Prognostic Nutritional Index predicts morbidity after curative surgery for colorectal cancer. Cir Esp (Engl Ed). 2019 Feb;97 (2):71-80. English, Spanish. http://doi.org/10.1016/j.ciresp.2018.08.015

17. https://covid19.saglik.gov.tr/Eklenti/43095/0/covid-19rehberieriskinhastayonetimivetedavi-12042022pdf.pdf (Date of access: 28/11/2022)

18. Hua X, Long ZQ, Huang X, Deng JP, He ZY, Guo L, et al. The Value of Prognostic Nutritional Index (PNI) in Predicting Survival and Guiding Radiotherapy of Patients With T1-2N1 Breast Cancer. Front Oncol. 2020 Jan 30;9:1562. doi: 10.3389/fonc.2019.01562. PMID: 32083015; PMCID: PMC7002465.

19. Long B, Carius BM, Chavez S, Liang SY, Brady WJ, Koyfman A, et al. Clinical update on COVID-19 for the emergency clinician: Presentation and evaluation. Am J Emerg Med. 2022 Apr;54:46-57. doi: 10.1016/j.ajem.2022.01.028. Epub 2022 Jan 21. PMID: 35121478; PMCID: PMC8779861.

20. Zhang JJ, Dong X, Liu GH, Gao YD. Risk and Protective Factors for COVID-19 Morbidity, Severity, and Mortality. Clin Rev Allergy Immunol. 2023 Feb;64 (1):90-107. doi: 10.1007/s12016-022-08921-5. Epub 2022 Jan 19. PMID: 35044620; PMCID: PMC8767775.

21. Alharthy A, Aletreby W, Faqihi F, Balhamar A, Alaklobi F, Alanezi K, et al. Clinical Characteristics and Predictors of 28-Day Mortality in 352 Critically Ill Patients with COVID-19: A Retrospective Study. J Epidemiol Glob Health. 2021 Mar;11 (1):98-104. doi: 10.2991/jegh.k.200928.001.

22. Malik P, Patel U, Mehta D, Patel N, Kelkar R, Akrmah M, et al. Biomarkers and outcomes of COVID-19 hospitalisations: systematic review and meta-analysis. BMJ Evid Based Med. 2021 Jun;26 (3):107-108. http://doi.org/10.1136/bmjebm-2020-111536

23. Rokni M, Ahmadikia K, Asghari S, Mashaei S, Hassanali F. Comparison of clinical, para-clinical and laboratory findings in survived and deceased patients with COVID-19: diagnostic role of inflammatory indications in determining the severity of illness. BMC Infect Dis. 2020 Nov 23;20 (1):869. https://doi.org/10.1186/s12879-020-05540-3

24. Huang I, Pranata R, Lim MA, Oehadian A, Alisjahbana B. C-reactive protein, procalcitonin, D-dimer, and ferritin in severe coronavirus disease-2019: a meta-analysis. Ther Adv Respir Dis. 2020 Jan-Dec;14:1753466620937175. http://doi.org/10.1177/1753466620937175

25. Wei W, Wu X, Jin C, Mu T, Gu G, Min M, et al. Predictive Significance of the Prognostic Nutritional Index (PNI) in

Patients with Severe COVID-19. J Immunol Res. 2021 Jul 9;2021:9917302. http://doi.org/10.1155/2021/9917302

26. Song F, Ma H, Wang S, Qin T, Xu Q, Yuan H, et al. Nutritional screening based on objective indices at admission predicts in-hospital mortality in patients with COVID-19. Nutr J. 2021 May 25;20 (1):46. http://doi.org/10.1186/s12937-021-00702-8

27. Doganci S, Ince ME, Ors N, Yildirim AK, Sir E, Karabacak K, et al. A new COVID-19 prediction scoring model for in-hospital mortality: experiences from Turkey, single center retrospective cohort analysis. Eur Rev Med Pharmacol Sci. 2020 Oct;24 (19):10247-10257. http://doi.org/10.26355/eurrev_202010_23249

28. Nalbant A, Demirci T, Kaya T, Aydın A, Altındiş M, Güçlü E. Can prognostic nutritional index and systemic immune-inflammatory index predict disease severity in COVID-19? Int J Clin Pract. 2021 Oct;75 (10):e14544. http://doi.org/10.1111/ijcp.14544

29. Arslan K. , Baş S. The relationship between the prognostic nutritional index and the clinical course of COVID-19: a single-center experience. Journal of Medicine and Palliative Care. 2022; 3 (2): 92-97.