Original Article

Access this article online
Quick Response Code:

Website:
https://eurasianjpulmonol.org
DOI:
10.14744/ejp.2024.38128

Impact of the Glasgow prognostic score on prognosis in patients with community-acquired pneumonia

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Abstract:

BACKGROUND AND AIM: Pneumonia is one of the leading causes of morbidity and mortality worldwide. This study aimed to evaluate the impact of the Glasgow prognostic score (GPS) on the prognosis of patients hospitalized with community-acquired pneumonia (CAP).

METHODS: A retrospective review was conducted on patients hospitalized in our department with CAP. The GPS was calculated based on C-reactive protein (CRP) and albumin levels.

RESULTS: The study included 121 patients, of whom 80 (66.1%) were male. The median age was 70 years. Early mortality occurred in 11 patients (9.1%). Patients with a GPS of 2 had significantly longer hospital stays than those with a GPS≤1 (p=0.002). Similarly, early mortality rates were statistically significantly higher in patients with a GPS of 2 (17.3%) compared to those with a GPS≤1 (2.9%) (p=0.009). A receiver operating characteristic (ROC) curve analysis was performed to determine the cutoff point for predicting mortality using the GPS. GPS values of 1.5 or higher were found to predict mortality with a sensitivity of 81.82% and a specificity of 60.91%. Age, average length of hospital stay, and the incidence of malignancy were significantly higher in patients who died within 30 days compared to survivors (p=0.011, p=0.001, and p=0.041, respectively). Upon evaluating the effects of age, length of hospital stay, GPS, and malignancy—which were found to be significant in univariate analyses—using logistic regression analysis, GPS was not identified as having a significant impact on mortality.

CONCLUSIONS: The GPS is associated with early mortality in patients with CAP. However, its independent impact on mortality is not statistically significant when considering other factors such as age, length of hospital stay, and malignancy. This suggests that while GPS can be a useful indicator for initial assessments, its prognostic value may be limited when other clinical variables are considered.

Keywords:

CAP, community-acquired pneumonia, glasgow prognostic score, GPS, mortality, prognosis

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Received: 13-06-2024
Revised: 17-08-2024
Accepted: 16-09-2024
Published: 27-01-2025

How to cite this article: Eraslan BZ, İçmeli ÖS, Havan A, Demirer E, Şener Cömert S. Impact of the Glasgow prognostic score on prognosis in patients with community-acquired pneumonia. Eurasian J Pulmonol 2025;27:35-42.

Introduction

Community-acquired pneumonia (CAP) is a leading cause of significant morbidity and mortality, ranking first among infection-related deaths in both the United Kingdom and the United States of America.[1,2] Mortality rates range from 1% to 5% in patients treated on an outpatient basis and can rise to 12% in hospitalized patients.[2,3] In the assessment of CAP, the CURB-65 score (Confusion, Urea nitrogen, Respiratory rate, Blood pressure, and age ≥65 years) and the Pneumonia Severity Index (PSI) are the most commonly used scoring systems to determine prognosis.[4,5] While CURB-65 score is simple to remember and calculate, the PSI score involves a large number of parameters. However, neither scoring system can assess the host's inflammatory response to microorganisms, which significantly influences prognosis.

Despite numerous studies on biomarkers indicating the inflammatory response in CAP, C-reactive protein (CRP) and procalcitonin (PCT) are the most widely used in daily clinical practice to evaluate inflammation and response to treatment.[6,7] CRP is an acute-phase protein produced by the liver in response to interleukin-6 (IL-6) and is one of the most commonly used biomarkers to guide clinical decisions for patients hospitalized with CAP.[8] Andersen et al.[9] demonstrated that CRP levels measured on the third day of hospitalization were independent predictors of 30-day mortality in CAP patients. Serum albumin, a plasma protein produced by the liver, also plays a critical role in the clinical management of hospitalized patients. Low serum albumin levels are frequently observed in individuals suffering from a wide range of diseases. Hypoalbuminemia serves as a marker of disease severity and reflects the body's stress response to illness. In conditions such as pneumonia, trauma, malignancies, rheumatoid arthritis, and ischemic situations, hypoalbuminemia may indicate the presence of inflammation, malnutrition, or tissue damage.[9–14]

The sensitivity and specificity of biomarkers in predicting the severity of CAP are variable; therefore, additional biomarkers are needed to assess disease severity. The Glasgow prognostic score (GPS), first described by Forrest et al.,[15] is an indicator of inflammation that can be easily calculated using CRP and serum albumin levels. The GPS has been associated with poor prognosis in many malignancies.[16–20] However, no studies have investigated the relationship between the GPS and mortality in patients with CAP, leaving its significance in this context unknown.

In this study, we aimed to examine the impact of the GPS on prognosis and length of hospital stay in patients hospitalized with CAP.

Materials and Methods

This retrospective study was conducted at a tertiary care hospital in Türkiye and included patients treated for CAP in our clinic between January 2023 and December 2023. Only patients aged 18 years and older with a confirmed diagnosis of CAP were included in the study. Exclusion criteria were as follows: patients with a history of aspiration, those diagnosed with hospital-acquired or viral pneumonia, patients hospitalized for pneumonia within the past month, those with incomplete laboratory data, and patients without imaging evidence of infiltration. The following data were recorded for each patient: Age, gender, comorbid diseases (hypertension, diabetes mellitus, chronic cardiovascular disease, malignancy, thyroid disease, asthma, chronic obstructive pulmonary disease), laboratory values (C-reactive protein, procalcitonin, leukocyte, platelet, albumin, creatinine, alanine aminotransferase), systolic and diastolic blood pressure, peripheral oxygen saturation in room air (SpO_2), length of hospital stay, and 30 days mortality status. All patient data included in the study were retrieved from the electronic health records.

The GPS was calculated using the levels of albumin and CRP at the time of hospitalization. Patients with a CRP level >10 mg/dL and a serum albumin level <3.5 g/dL are assigned a GPS value of 2. If only one of these biochemical abnormalities is present, the GPS value is 1. If neither of these conditions is met, the GPS value is 0 points.[15]

The CURB-65 score for each patient was calculated based on the following criteria: new-onset confusion, blood urea nitrogen levels greater than 7 mmol/L (19 mg/dL), a respiratory rate of 30 breaths per minute or more, systolic blood pressure of 90 mmHg or lower, diastolic blood pressure of 60 mmHg or lower, and an age of 65 years or older. Each criterion met added one point to the total score.[4]

Patients were divided into two groups based on their GPS values: those with a GPS of ≤1 and those with a GPS of 2. The variables between these two groups were compared. Furthermore, the group with observed mortality within 30 days was compared with the group without mortality during the same period.

A receiver operating characteristic (ROC) curve analysis was conducted to determine the optimal cut-off point for predicting mortality for the prognostic scores GPS and CURB-65.

Our study was approved by Kartal Dr. Lütfi Kırdar City Hospital Scientific Research Ethics Committee (Approval Number: 010.99.53, Date: 28.02.2024) and conducted in accordance with the Declaration of Helsinki. Due to the retrospective design of the study, the requirement for written informed consent was waived.

Data analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) Statistics for Windows®, version 20.0 (IBM Corp., Armonk, NY, USA). The suitability of parameters for normal distribution was assessed using the Kolmogorov-Smirnov test. In analyzing the study data, descriptive statistical methods (minimum, maximum, average, standard deviation, median, and frequency) were used. Student's t-test was employed to compare quantitative data between groups when the parameters followed a normal distribution. For parameters that did not exhibit normal distribution, the Mann-Whitney U test was applied. Qualitative data were analyzed using the Chi-square test, Fisher's exact Chi-square test, Fisher-Freeman-Halton exact Chi-square test, and continuity (Yates) correction. Multivariate analysis was conducted using logistic regression. The diagnostic and decision-making characteristics of prognostic scores in predicting mortality were assessed using ROC curve analysis. Results were evaluated at a significance level of $p<0.05$ within a 95% confidence interval.

Sample size calculation

The sample size was determined using the G*Power 3.1.9.2 software (Heinrich-Heine-University Düsseldorf, Germany). Assuming an expected mortality rate of 2.7% (Lüthi-Corridori et al., 2023),[21] with a 5% margin of error, 95% power, and a medium effect size (0.35), the required sample size was calculated as 111. The power analysis was conducted using the Exact - Proportion: Difference from constant (binomial test, one-sample case). For a two-tailed test, the α error probability was set at 0.05, power (1-β error probability) at 0.95, and the constant proportion at 0.027. Based on this analysis, the minimum required sample size was calculated as 111, and the study was planned accordingly.

Results

The study included a total of 121 patients, of whom 80 (66.1%) were male, with ages ranging from 19 to 89 years. The average age was 68.36±14.25 years, and the median age was 70 years. The average length of hospital stay was 9.02±5.38 days, with a median duration of 7 days. Thirty-day mortality occurred in 11 patients (9.1%). Most patients (89.2%) had comorbidities, with the most common being hypertension (54.5%), cardiovascular disease (42.1%), diabetes mellitus (35.5%), and chronic obstructive pulmonary disease (32.2%). Regarding smoking status, 34.7% of the patients had never smoked, 43.8% were former smokers, and 21.5% were current smokers.

No statistically significant differences were observed between the GPS groups in terms of average age, sex distribution, smoking status, or cigarette consumption in pack-years ($p>0.05$). Similarly, no statistically significant differences were found between the groups regarding oxygen saturation percentages, average systolic and diastolic blood pressure, presence of comorbidities, or incidence of malignancies ($p>0.05$). There were also no statistically significant differences between the groups concerning other laboratory parameters, except for CRP and albumin levels (Table 1).

In patients with a GPS of 2, both the length of hospital stay and the 30-day mortality rates were statistically significantly higher compared to patients with a GPS of 1 ($p=0.002$ and $p=0.009$, respectively) (Table 1).

The evaluation of demographic characteristics, comorbidities, vital signs, and laboratory findings based on 30-day mortality

In the group that experienced mortality from any cause within 30 days, the average age, length of hospital stay, and rates of malignancy were significantly higher compared to those in the group that survived ($p=0.011$, $p=0.001$, and $p=0.041$, respectively). Serum albumin and alanine transaminase (ALT) levels were significantly lower in the mortality group compared to the non-mor-

Table 1: Demographic characteristics, comorbidities, and biochemical and vital sign assessments by Glasgow prognostic score (GPS) groups

	GPS≤1 (n=69) mean±SD (median)		GPS 2 (n=52) mean±SD (median)		p[1]
	n	%	n	%	
Age (years)	68.74±13.91 (70)		67.85±14.82 (70.5)		0.894
Sex (male)	47	68.1	33	63.5	0.733[2]
Saturation (SpO_2 %)	91.99±4.54 (93)		92.52±3.83 (93)		0.668
Systolic pressure (mmHg)	118.42±15.29 (110)		118.77±17.7 (110)		0.907
Smoking pack (years)	27.52±29.89 (20)		29.63±32.77 (25)		0.748
Active smoker	12	17.4	14	26.9	
Never smoked	25	36.2	17	32.7	0.448[4]
Ex-smoker	32	46.4	21	40.4	
Comorbidity	63	91.3	45	86.5	0.588[2]
Hypertension	39	56.5	27	51.9	0.615[4]
Diabetes mellitus	29	42	14	26.9	0.127[2]
Cardiovascular disease	30	43.5	21	40.4	0.733[4]
COPD	28	40.6	11	21.2	0.039*[2]
Cerebrovascular disease	7	10.1	9	17.3	0.379[2]
Chronic renal failure	10	14.5	6	11.5	0.838[2]
Asthma	4	5.8	5	9.6	0.496[3]
Thyroid disease	8	11.6	2	3.8	0.185[3]
Malignancy	10	14.5	14	26.9	0.142[2]
C-reactive protein (mg/L)	131.14±105.48 (108.4)		199.17±106.55 (189.2)		0.001*
Procalcitonin (ng/mL)	4.47±11.18 (0.3)		2.91±6.78 (0.4)		0.501
Leukocyte ($10^3/\mu L$)	13.27±6.24 (12.6)		13.55±8.46 (10.9)		0.535
Platelet ($10^3/\mu L$)	250.1±86.33 (238)		274.87±132.73 (257.5)		0.544
Albumin (g/dL)	3.89±0.29 (3.9)		3.05±0.33 (3.2)		0.001*[5]
Creatinine (mg/dL)	1.16±0.62 (1)		1.29±1.05 (0.9)		0.581
Alanine aminotransferase (U/L)	20.75±15.27 (15)		25.4±25.71 (15.5)		0.956
Length of hospital stay (day)	7.97±3.97 (7)		10.4±6.43 (8.5)		0.002*
Mortality	2	2.9	9	17.3	0.009*[3]

[1]: Mann-Whitney U Test, [2]: Continuity (Yates) correction, [3]: Fisher's Exact test, [4]: Chi-square test, [5]: Student's t-test, *: p<0.05. SD: Standard deviation, COPD: Chronic obstructive pulmonary disease

tality group (p=0.001 and p=0.011, respectively). No statistically significant differences were found between the two groups for other laboratory parameters (Table 2).

The results of logistic regression analysis to identify variables affecting mortality

Variables significantly associated with mortality (p<0.05) in univariate analyses, including age, length of hospital stay, ALT, GPS, and malignancy, were included in the logistic regression analysis. The Nagelkerke R-square value was 0.488, indicating a reasonable fit of the analysis to the data. The predictive accuracy of the analysis was 94.2%, suggesting a strong level of predictive performance.

In the logistic regression analysis, age, length of hospital stay, and the presence of malignancy were statistically significant predictors of mortality (p<0.05). Specifically, age increased the risk of mortality by 1.164 times, length of hospital stay increased the risk by 1.232 times, and malignancy increased the risk by 7.529 times. However, the effects of ALT and GPS on mortality were not statistically significant (p>0.05) (Table 3).

ROC curve analysis

A ROC curve analysis was performed to determine the optimal cut-off points for predicting mortality using the prognostic scores GPS and CURB-65 (Table 4) [Fig. 1]. For GPS, values of 1.5 or higher predicted mortality with a sensitivity of 81.82% and a specificity of 60.91%. The area under the curve (AUC) was 0.719 (p=0.017; 95% confidence interval [CI]: 0.577–0.860). For CURB-65, values of 1.5 or higher predicted mortality with a sensitivity of 100.00% and a specificity of 53.64%. The AUC for CURB-65 was determined to be 0.825 (p<0.001; 95% CI: 0.726–0.924).

Table 2: Evaluation of 30-day mortality according to demographic characteristics, comorbidities, vital signs, and biochemical parameters

	Survivors (n=110) mean±SD (median)		30-day mortality cases (n=11) mean±SD (median)		p[1]
	n	%	n	%	
Age (years)	67.37±14.3 (70)		78.18±9.69 (80)		0.011*
Sex (male)	72	65.5	8	72.7	0.748[2]
Saturation (%)	92.25±4.33 (93)		91.82±3.34 (92)		0.520
Systolic pressure (mmHg)	118.96±15.51 (120)		114.64±23.33 (110)		0.113
Smoking pack (years)	28.91±31.81 (20)		23.64±22.48 (20)		0.846
Active smoker	25	22.7	1	9.1	
Never smoked	38	34.5	4	36.4	0.654[3]
Ex-smoker	47	42.7	6	54.5	
Comorbidity	97	88.2	11	100	0.606[2]
Hypertension	61	55.5	5	45.5	0.751[4]
Diabetes mellitus	41	37.3	2	18.2	0.324[2]
Cardiovascular disease	46	41.8	5	45.5	1.000[2]
Cerebrovascular disease	13	11.8	3	27.3	0.161[2]
Chronic renal failure	14	12.7	2	18.2	0.638[2]
COPD	38	34.5	1	9.1	0.102[2]
Asthma	8	7.3	1	9.1	0.589[2]
Thyroid disease	9	8.2	1	9.1	1.000[2]
Malignancy	19	17.3	5	45.5	0.041*[2]
C-reactive protein (mg/L)	159.27±109.4 (143.5)		171.45±129.09 (139)		0.850
Procalcitonin (ng/mL)	4.13±9.95 (0.3)		0.55±0.59 (0.4)		0.722
Leukocyte ($10^3/\mu L$)	13.39±7.48 (11.8)		13.39±4.54 (12.6)		0.579
Platelet ($10^3/\mu L$)	266.67±107.71 (245)		201.45±107.83 (206)		0.112
Albumin (g/dL)	3.58±0.49 (3.6)		2.98±0.58 (3.1)		0.001*[4]
Creatinine (mg/dL)	1.18±0.77 (1)		1.54±1.31 (1)		0.433
Alanine aminotransferase (U/L)	23.75±21.01 (15.5)		12.73±9.41 (9)		0.011*
Length of hospital stay (days)	8.53±5.15 (7)		13.91±4.11 (13)		0.001*

[1]: Mann-Whitney U test, [2]: Fisher's Exact test, [3]: Fisher-Freeman-Halton Exact test, [4]: Student's t-test, *: p<0.05. SD: Standard deviation, COPD: Chronic obstructive pulmonary disease

Table 3: Logistic regression analysis of factors affecting mortality

Variables	95% Confidence interval			p
	OR	Lower boundary	Upper boundary	
Age	1.164	1.029	1.317	0.016*
Length of hospital stay	1.232	1.062	1.428	0.006*
ALT	0.967	0.894	1.047	0.407
GPS	3.752	0.618	22.783	0.151
Malignancy	7.579	0.989	58.078	0.048*

OR: Odds ratio, ALT: Alanine transaminase, GPS: Glasgow prognostic score

Table 4: Receiver operating characteristic (ROC) analysis of prognostic scores

	GPS	CURB-65
Cut-off value	≥1.5	≥1.5
AUC (95% CI)	0.719 (0.577–0.860)	0.825 (0.726–0.924)
Sensitivity (95% CI)	81.82 (48.22–97.72)	100.00 (71.51–100.00)
Specificity (95% CI)	60.91 (51.14–70.07)	53.64 (43.88–63.20)
PPV (95% CI)	17.31 (12.70–23.14)	17.74 (15.00–20.87)
NPV (95% CI)	97.10 (90.46–99.16)	100.00 (93.94–100.00)
Accuracy (95% CI)	62.81 (53.56–71.42)	57.85 (48.54–66.77)
Youden index	42.73	53.64

GPS: Glasgow prognostic score, CURB: Confusion, Urea nitrogen, Respiratory rate, Blood pressure, AUC: Area under the curve, CI: Confidence interval, PPV: Positive predictive value, NPV: Negative predictive value

Discussion

The results of this study indicate that patients admitted with CAP and a GPS of 2 at admission had a 30-day mortality rate of 17.3%, compared to a mortality rate of 2.9% in those with a GPS of ≤1. This difference was found to be statistically significant (p=0.009). However, when other variables were included in a logistic regression analysis, GPS alone was not identified as a significant independent predictor of mortality, suggesting that its prognostic

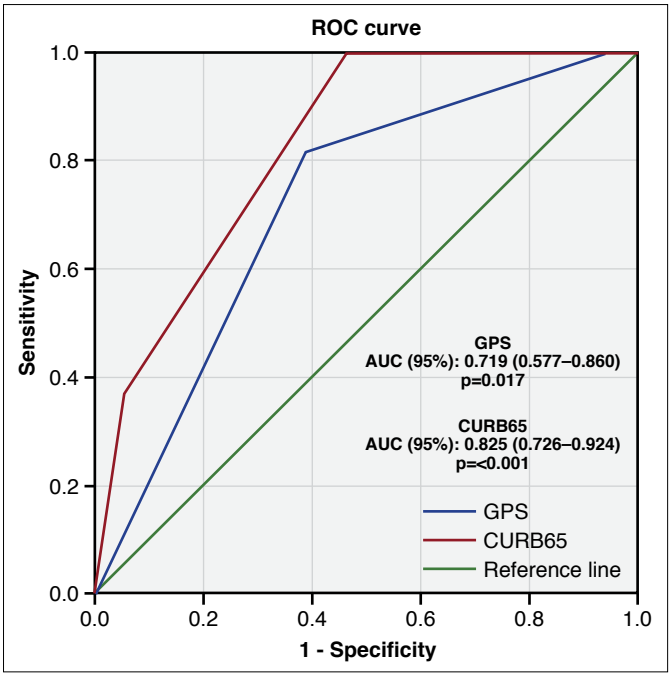

Figure 1: Receiver operating characteristic (ROC) curve for mortality based on Glasgow prognostic score (GPS) and CURB-65 scores

CURB: Confusion, Urea nitrogen, Respiratory rate, Blood pressure

value for mortality may be limited when evaluated independently. In this study, the cutoff point for predicting mortality using the GPS was determined to be 1.5 through ROC curve analysis. This value was found to predict mortality with a sensitivity of 81.82% and a specificity of 60.91%. These findings suggest that the GPS provides reasonable accuracy in predicting mortality risk when it exceeds a certain threshold. However, the specificity of 60.91% indicates that the GPS may have limited accuracy in predicting mortality risk in patients with lower scores. Previous studies have shown that GPS is an independent predictor of mortality in patients with malignancies.[16–20]

A retrospective analysis by Shimoyama et al.,[22] involving 33 pneumonia patients treated in the intensive care unit (ICU), found no association between inflammation-based prognostic factors, including the GPS, and mortality, except for the neutrophil-to-lymphocyte ratio (NLR).[22] In contrast, our study evaluated 121 pneumonia patients treated in the general ward, providing an opportunity to assess the prognostic value of the GPS in a larger patient population. Consistent with Shimoyama et al.'s[22] findings, our study also found that GPS alone was not a significant independent predictor of mortality in this group of pneumonia patients, suggesting that the prognostic utility of GPS may be limited in this patient population.

In our study, patients with a GPS of 2 had significantly longer hospital stays compared to those with a GPS of ≤1 (p=0.002). Additionally, the group that experienced mortality had a longer duration of hospital stay (p=0.001). Logistic regression analysis revealed that each additional day of hospital stay increased the risk of mortality by 1.26 times. These findings suggest that the length of hospital stay is an independent risk factor for mortality.

In the management of CAP, the PSI and CURB-65 scoring systems are important tools used to assess disease severity and guide treatment decisions. These scoring systems help physicians classify patients as high or low risk, facilitating the identification of those with severe illness and ensuring they receive appropriate treatment. Despite their widespread use, concerns regarding the moderate sensitivity and specificity of these scoring systems have been noted in the literature.[23]

In our study, CURB-65 scores of 1.5 or higher were found to predict mortality with a sensitivity of 100% and a specificity of 53.64%. This indicates that CURB-65 is highly effective in identifying high-risk patients, as a sensitivity of 100% means that all high-risk patients were correctly identified. However, the specificity of 53.64% suggests that nearly half of the low-risk patients may be misclassified as high-risk. This misclassification could lead to unnecessary treatments and hospital admissions, resulting in an inefficient use of healthcare resources.

The area under the ROC curve was determined to be 0.825, indicating that CURB-65 performs well in predicting mortality. The closer the AUC is to 1, the better the overall performance of the model. However, due to its low specificity, relying solely on this score for clinical decisions may be risky. Other prognostic factors and clinical evaluations should be considered in conjunction with the CURB-65 score in clinical practice.

In a review by Zaki et al.,[24] both the PSI and CURB-65 scores were found to have high sensitivity but low specificity. This finding aligns with our study, where we also observed that although CURB-65 effectively identifies high-risk patients, its low specificity may result in the misclassification of low-risk patients as high-risk.

This implies that in some cases, patients' risk statuses may be inaccurately assessed. Specifically, some high-risk patients could be classified as low-risk, and vice

versa. Such misclassification could lead to inappropriate decisions in treatment management. Furthermore, the PSI and CURB-65 scoring systems do not provide information about the patient's inflammatory response. This is particularly notable as a shortcoming in situations where inflammation significantly affects the severity of the disease and the response to treatment. Incorporating additional inflammation biomarkers to evaluate the host's inflammatory response could enable a more comprehensive assessment of the disease, leading to more effective treatment planning.

Therefore, in the management of CAP, it is essential to use additional tools and biomarkers alongside PSI and CURB-65 to achieve a more holistic evaluation of the disease. This approach can provide physicians with more accurate risk stratification and treatment planning information, ultimately improving patient outcomes.

Pneumonia tends to have a higher mortality rate in elderly patients. Our study found that the average age in the group experiencing mortality was significantly higher. Logistic regression analysis revealed that age increased the risk of mortality by a factor of 1.18. Similarly, Lüthi-Corridori et al.[21] reported that in patients hospitalized for CAP, advanced age and the presence of active cancer were associated with 30-day mortality. Consistent with these findings, our study also observed that mortality was significantly higher in patients with concomitant malignancies, with further statistical analysis showing that the presence of malignancy increased the risk of mortality by 9.8 times.

When biochemical parameters were analyzed in our study, only serum albumin and ALT levels were found to be significantly lower in the group with mortality compared to the group without mortality. However, further statistical analysis indicated that the difference in ALT levels was not statistically significant.

Our study has several limitations. Primarily, it is single-centered and retrospective in design. As a result, larger-scale, well-designed, multicenter prospective studies are needed to validate our findings and conclusions.

Conclusion

The initial observation that the GPS was associated with mortality in patients hospitalized for CAP suggests that, at first glance, there appeared to be a link between the score and the likelihood of death from the illness. However, this association lost its significance when the analysis was adjusted to include other important variables. In more detailed statistical analyses, factors such as age, malignancy, and hospitalization duration were considered, diminishing the apparent impact of the GPS on mortality.

In simpler terms, while the GPS might initially seem to predict mortality, its effect diminishes when broader clinical factors influencing prognosis are considered.

Ethics Committee Approval

The study was approved by the Kartal Dr. Lütfi Kırdar City Hospital Scientific Research Ethics Committee (No: 010.99.53, Date: 28/02/2024).

Authorship Contributions

Concept – B.Z.E.; Design – B.Z.E.; Supervision – Ö.S.İ.; Funding – Ö.S.İ.; Materials – S.Ş.C., E.D.; Data collection &/or processing – E.D., A.H.; Analysis and/or interpretation – S.Ş.C., E.D., A.H., Ö.S.İ.; Literature search – B.Z.E.; Writing – B.Z.E.; Critical review – B.Z.E., S.Ş.C.

Conflicts of Interest

There are no conflicts of interest.

Use of AI for Writing Assistance

Artificial intelligence (AI)-enabled technologies, such as large language models (LLM), chatbots, or image generators, were not used in this article.

Financial Support and Sponsorship

Nil.

Peer-review

Externally peer-reviewed.

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