Original Article

The Value of Prognostic Nutritional Index in Patients with Deep Neck Space Infection

FCS Kundi[1,2], ZB Paksoy[2]

[1]Department of Otorhinolaryngology, Ankara Yildirim Beyazit University, Çankaya, Ankara, [2]Department of Otorhinolaryngology, Ankara City Hospital, Çankaya, Ankara, Turkey

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Abstract

Background: Antibiotic therapy is pivotal in deep neck space infections, yet inappropriate use and antibiotic resistance impact patient outcomes. **Aim:** This study aimed to evaluate the clinical significance of admission prognostic nutritional index (PNI) as a prognostic marker. **Methods:** Data from 81 hospitalized patients (mean age 33.9 years) with deep neck space infections confirmed by CT scans were analyzed (Nov 2020 - Sep 2023). PNI, derived from serum albumin and lymphocyte count, was calculated. Primary outcome was antibiotic resistance; secondary outcome was length-of-stay. **Results:** Patients with antibiotic resistance (n = 24) had significantly lower PNI (mean 47.3, SD = 9.2) compared to the non-resistant group (n = 57, mean 57.5, SD = 12.2), $P < 0.001$. Adjusted multivariable analysis showed PNI as a significant predictor of antibiotic resistance (OR = 0.908, 95% CI 0.837-0.984, $P = 0.004$). ROC analysis established a PNI cut-off of 51.5 with 59% sensitivity and 80% specificity. Linear regression revealed decreasing PNI associated with prolonged length-of-hospital stays (adjusted R-squared = 0.40, $P = 0.010$). **Conclusions:** The study underscores PNI's potential as a prognostic marker for deep neck space infections, particularly in predicting antibiotic resistance and length of hospital stay. Lower PNI values correlate with compromised nutritional and immune status, suggesting its clinical relevance for personalized treatment strategies.

Keywords: *Antibiotic resistance, deep neck infection, prognostic nutritional index*

Introduction

The management of deep neck space infections necessitates a multifaceted approach involving both medical and surgical interventions.[1] Recent data highlight a rising incidence and severity of deep neck infections, posing a substantial challenge to the healthcare system.[2-4] Common symptoms include odynophagia, dysphagia, fever, and trismus, while observable signs encompass neck swelling and an elevated floor of the mouth. Interestingly, the physical examination of patients with deep neck space infections may not consistently align with the length of hospital stay.[5] Despite the significant role of antibiotic therapy in reducing the frequency, morbidity, and mortality associated with deep neck space infections, inappropriate and overuse of antibiotics, including infections with antibiotic-resistant bacteria, lead to a poor prognosis for some individuals.[6,7]

The prognostic nutritional index (PNI) stands out as an inclusive and innovative inflammation biomarker, incorporating albumin levels and lymphocytes.[8] Numerous studies advocate its reliability as a prognostic biomarker in various diseases, including malignancies.[9,10] Previous research has also established PNI as a predictive biomarker for survival and mortality rates in patients with sepsis-induced acute kidney injury.[11,12] C-reactive protein (CRP) is recognized for diagnosing sepsis and predicting its severity and mortality in patients.[13] This collective body of evidence highlights the intricate interplay of diverse biomarkers in assessing and

Address for correspondence: Dr. FCS Kundi, Üniversiteler Mahallesi 1604. Cadde No: 9 Çankaya/ANKARA, 06830, Türkiye.
E-mail: fcsazak@gmail.com

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predicting outcomes in various clinical scenarios.[14] The incorporation of PNI, alongside established markers like CRP, holds the potential to contribute to a more nuanced understanding of inflammatory responses and prognoses in patients, paving the way for a comprehensive and tailored approach to medical interventions.[15-17]

To identify valuable indicators for the initial differential diagnosis, this study aims to assess the clinical utility of admission PNI as a prognostic marker for deep neck space infections, specifically evaluating resistance to treatments, and examining its correlation with the length of admission stay.

Material and Methods

Study population

After obtaining approval from the Ankara City Hospital Ethics Committee and securing informed consent, we prospectively enrolled individuals aged 18 and above, hospitalized with confirmed deep neck space infections via computerized tomography at our clinic from November 2020 to September 2023. Patients with autoimmune or chronic inflammatory disorders, a history or current diagnosis of cancer, chronic obstructive pulmonary diseases, connective tissue diseases, obstructive sleep apnea syndrome, hypertension, diabetes mellitus, active smoking, renal failure, liver failure, alcohol abuse, and the use of medical treatments that could influence blood parameters (such as antihyperlipidemic drugs) were excluded.

Covariates

Deep neck space infection locations were recorded as neck, parapharyngeal, and peritonsillar. Additionally, the size of the space was determined by multiplying the two longest diameters obtained from the computerized tomography. Blood samples, including albumin, complete blood cell counts, and CRP, were collected before incision and drainage. These samples were obtained on the day of admission, following a fasting period of at least 12 hours. PNI was calculated as follows: serum albumin (g/L) + (5 × lymphocyte count) (10^9/L).[18]

Treatment approach and outcomes

In the early stages, all patients underwent incision and drainage, with pus samples subjected to culture and sensitivity analysis before initiating antibiotic therapy. Initially, all patients received a prescription for a combination of third-generation cephalosporins, gentamicin, and metronidazole. The primary outcome was determined by the identification of antibiotic resistance, marked by adjustments in antibiotic regimens based on culture sensitivity reports or in cases of clinical unresponsiveness. The secondary outcome was defined by the length of stay.

Statistical analyses

Stata 17.0 (MP) software was employed for data analysis. Quantitative variables were presented as means ± standard deviations (SD), while categorical variables were expressed as percentages. Differences in resistant status were evaluated using either the Student's *t*-test or Mann-Whitney U-test for continuous variables, and Chi-square test or Fisher's exact test for categorical data, as appropriate. In relation to the antibiotic resistance status, a Quantile-Quantile plot was created. The boxes depicted on the plot represent the interquartile range, spanning from the 25th to the 75th percentiles, while the horizontal bars situated in the center of the boxes denote the median values.

Univariable logistic regression analyses were performed to explore potential independent predictors of antibiotic-resistant patients. Subsequently, predictors with a *P* value less than 0.2 were included in a multivariable logistic regression analysis to identify independent significant predictors of antibiotic-resistant patients. The receiver operating characteristics (ROC) curve was employed to establish the optimal cut-off PNI value for predicting sensitivity and specificity in antibiotic-resistant patients, utilizing Youden's index.[19] Finally, baseline characteristics of patients, length of stay, and the status of antibiotic resistance were presented based on the determined optimal cut-off PNI value.

Results

The study included a total of 81 patients diagnosed with deep neck space infections, with a mean age of 33.9 years (SD = 13.6). Among the participants, 67% were male. Table 1 presents the demographic and clinical characteristics of the patients, stratified by antibiotic resistance status. The mean age, gender distribution,

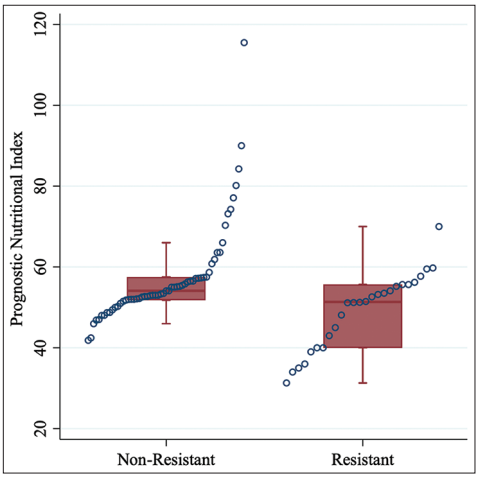

Figure 1: Combined Quantile-Quantile (Q-Q) plot and box plot to illustrate the distribution of the prognostic nutritional index (PNI) across different antibiotic resistance groups

Table 1: Baseline characteristics of patients according to antibiotic resistance groups

	Total *n*=81	Non-Resistant *n*=57	Resistant *n*=24	*P*
Age	33.9 (13.6)	33.2 (12.0)	35.4 (17.0)	0.52
Gender				
Female	27 (33%)	22 (39%)	5 (21%)	0.12
Male	54 (67%)	35 (61%)	19 (79%)	
Space Area	3.7 (4.6)	3.3 (3.5)	4.7 (6.4)	0.20
Space Location				
Neck	26 (32%)	20 (35%)	6 (25%)	0.42
Parapharyngeal	6 (7%)	3 (5%)	3 (12%)	
Peritonsillar	49 (60%)	34 (60%)	15 (62%)	
Albumin	43.6 (4.1)	43.6 (3.7)	43.6 (5.1)	0.96
White Blood Cell	13.2 (5.6)	11.7 (4.5)	17.0 (6.3)	<0.001
Lymphocyte	2.4 (2.0)	2.7 (2.0)	1.9 (1.7)	0.13
Neutrophil	10.0 (5.6)	8.3 (4.5)	14.0 (5.9)	<0.001
Hemoglobin	13.9 (1.8)	13.7 (1.7)	14.4 (1.9)	0.11
Platelet	289.1 (73.6)	293.3 (73.4)	279.0 (74.9)	0.43
C-reactive Protein	70.3 (89.8)	56.3 (85.0)	103.6 (93.9)	0.029
Prognostic Nutritional Index	55.1 (11.9)	57.5 (12.2)	47.3 (9.2)	<0.001
Length of Stay, days	5.9 (4.4)	4.1 (2.9)	10.0 (4.6)	<0.001

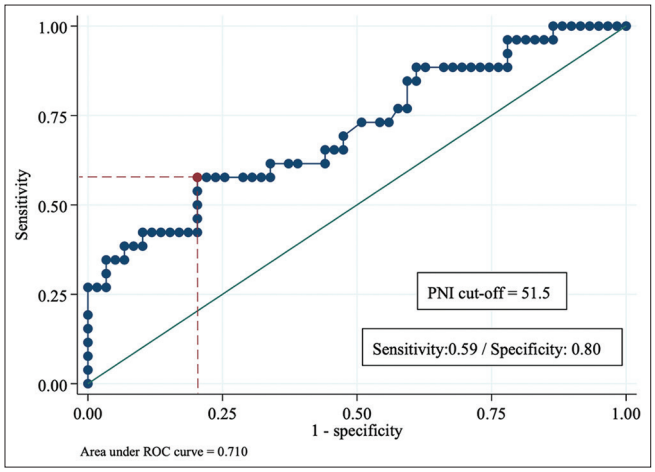

Figure 2: ROC curve analyses for the prognostic nutritional index to predict antibiotic resistance groups

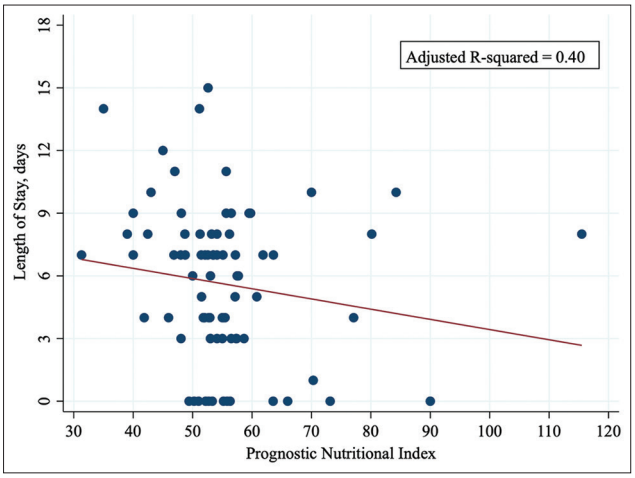

Figure 3: Association between the length of hospital stay and the prognostic nutritional index

space area, space location, and albumin levels did not show significant differences between the non-resistant and resistant groups. However, white blood cell count, neutrophil count, and CRP levels were significantly higher in the resistant infection group compared to the non-resistant group. In contrast, the PNI in the resistant group was significantly lower, with a mean (SD) of 47.3 (9.2), compared to the non-resistant group, which had a mean (SD) of 57.5 (12.2), $P < 0.001$. In Figure 1, the Quantile-Quantile plot illustrates the disparities in PNI between the antibiotic non-resistance and resistance groups. Univariable logistic regression analyses [Table 2] explored that higher white blood cell count, higher neutrophil count, higher C-reactive protein levels, and lower PNI were associated with increased odds of having a resistant infection. Multivariable analysis, adjusted for potential confounders, revealed that PNI remained a significant predictor of infection resistance, with an odds ratio and 95% confidence intervals of 0.908 (0.837-0.984), $P = 0.004$.

The ROC curve analysis demonstrated that the discrimination of PNI for predicting the antibiotic resistance group was 0.710, and the cut-off value for PNI as determined by Youden's index was 51.5 with a 59% sensitivity and 80% specificity [Figure 2].

As presented in Table 3, patients with PNI <51.5 exhibited higher white blood cell counts, higher neutrophil counts, and higher CRP levels compared to those with PNI ≥51.5, supporting the role of PNI in inflammatory status. Additionally, patients with lower PNI had a longer length of hospital stay, with a

Table 2: Univariable and multivariable logistic regression results for predicting antibiotic resistant patients

	Univariable Logistic Regression Odds Ratio (95%CIs)	*P*	Multivariable Logistic Regression Odds Ratio (95%CIs)	*P*
Age	1.017 (.0984-1.050)	0.301		
Male	2.129 (0.743-6.096)	0.159	1.749 (0.439-6.696)	0.427
Space Area	1.082 (0.982-1.192)	0.108	1.040 (0.910-1.189)	0.562
Space Location	1.038 (0.627-1.719)	0.883		
Albumin	0.977 (0.877-1.089)	0.681		
White Blood Cell	1.199 (1.081-1.331)	0.001	0.854 (0.517-1.413)	0.541
Lymphocyte	0.709 (0.462-1.088)	0.216		
Neutrophil	1.224 (1.099-1.364)	<0.001	1.383 (0.813-2.339	0.225
Hemoglobin	1.218 (0.927-1.599)	0.145		
Platelet	0.999 (0.992-1.005)	0.707		
C-reactive Protein	1.006 (1.000-1.011)	0.050	1.002 (0.995-1.009)	0.137
Prognostic Nutritional Index	0.890 (0.826-0.959)	0.001	0.908 (0.837-0.984)	0.004

Table 3: The study population characteristics based on the optimal cut-off value of prognostic nutritional index

	Total *n*=81	PNI <51.5 *n*=56	PNI ≥15 *n*=25	*P*
Age	33.9 (13.6)	34.0 (12.3)	33.7 (16.5)	0.93
Gender				
Female	27 (33%)	18 (32%)	9 (36%)	0.73
Male	54 (67%)	38 (68%)	16 (64%)	
White Blood Cell	13.2 (5.6)	12.2 (4.3)	15.5 (7.4)	0.013
Neutrophil	10.0 (5.6)	8.7 (4.3)	12.7 (7.1)	0.003
Hemoglobin	13.9 (1.8)	14.0 (1.7)	13.6 (2.1)	0.38
Platelet	289.1 (73.6)	292.2 (80.0)	282.1 (57.8)	0.57
C-reactive Protein	70.3 (89.8)	60.8 (80.8)	91.6 (106.0)	0.16
Length of Stay	5.9 (4.4)	5.1 (3.5)	7.7 (5.6)	0.012
Resistant Infection				
Non-Resistant	57 (70%)	44 (79%)	13 (52%)	0.016
Resistant	24 (30%)	12 (21%)	12 (48%)	

PNI=Prognostic nutritional index

mean (SD) of 7.7 (5.6) vs 5.1 (3.5), $P = 0.012$, and a higher proportion of resistant infections (48% vs 21%, $P = 0.016$). In linear regression analyses with length of stay as the outcome, it was found that a decrease in PNI values was associated with a prolonged length of stay, yielding an adjusted R-squared of 0.40, $P = 0.010$ [Figure 3].

Discussion

Deep neck space infections present a significant clinical challenge due to their potential severity and the necessity for a comprehensive approach encompassing both medical and surgical interventions. Our study focused on assessing the prognostic value of the PNI in deep neck space infections, particularly in relation to antibiotic resistance and length of hospital stay.

The rising incidence and severity of odontogenic infections underscore the importance of identifying reliable prognostic markers to guide timely and effective interventions.[20] The current study contributes to the existing literature by evaluating the potential of PNI, an inclusive inflammation biomarker, in predicting outcomes in deep neck space infections. PNI, which combines albumin levels and lymphocyte count, has been previously recognized as a prognostic biomarker in various medical conditions, including malignancies and sepsis-induced acute kidney injury.[21-23] The incorporation of PNI alongside established markers like CRP provides a more comprehensive understanding of the inflammatory responses in deep neck space infections.[15-17,24]

Our findings demonstrate that PNI is significantly lower in patients with antibiotic-resistant infections, emphasizing its potential utility as a prognostic marker for treatment outcomes. The lower PNI values in the resistant group suggest a compromised nutritional and immune status, which may contribute to the challenges in effectively managing these infections. The multivariable logistic regression analysis further establishes PNI as an independent predictor of antibiotic resistance, reinforcing its potential clinical relevance.

The ROC curve analysis revealed that PNI has good discriminatory power in predicting antibiotic resistance, with a cut-off value of 51.5. This indicates that patients with PNI values below this threshold are more likely to exhibit antibiotic resistance. The sensitivity and specificity values further support the clinical utility of PNI in identifying patients at higher risk of developing resistance to initial antibiotic therapy.

Importantly, our study also highlights the association between PNI and the length of hospital stay in patients with deep neck space infections. Lower PNI values were associated with a prolonged hospital stay, indicating that patients with compromised nutritional and immune status may experience delayed recovery. The linear regression

analysis further confirms the significant impact of PNI on the length of stay, emphasizing the potential role of PNI not only as a prognostic marker for resistance but also as an indicator of the overall disease severity and treatment complexity.

The clinical implications of our findings are noteworthy. Incorporating PNI into the initial assessment of patients with deep neck space infections may assist clinicians in identifying those at higher risk of antibiotic resistance and prolonged hospitalization. This information could guide more personalized and targeted treatment strategies, including the consideration of alternative antibiotic regimens or closer monitoring for patients with lower PNI values.

Limitations

Despite the strengths of our study, including a prospective design and a well-defined study population, there are limitations that warrant consideration. The single-center nature of the study and relatively small sample size may limit the generalizability of the findings, and additional multicenter studies are needed to validate our results across diverse patient populations. Moreover, the specific mechanisms underlying the association between PNI and antibiotic resistance require further investigation to enhance our understanding of the pathophysiological processes involved.

Conclusions

In conclusion, our study underscores the potential of PNI as a valuable prognostic marker in the management of deep neck space infections. The association between lower PNI values and antibiotic resistance, as well as prolonged hospital stay, suggests that PNI could serve as a clinically relevant tool for risk stratification and treatment optimization in these challenging clinical scenarios. Further research is warranted to validate our findings and explore the underlying mechanisms linking PNI to treatment outcomes in deep neck space infections.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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