THE INJECTOR

DOI: 10.5281/zenodo.8350562
The Injector 2023;2(3):147-156

Original Article

Association between Prognostic Nutritional Index and community-acquired pneumonia in children with parapneumonic effusion: A retrospective analysis

Özlem Erdede, Erdal Sarı

University of Health Sciences, Zeynep Kamil Maternity and Children's Disease Training and Research Hospital, Department of Pediatrics, İstanbul, Turkey

Abstract

Objective: Biomarkers for predicting disease severity in patients with clinical pneumonia have been increasingly reported. The association of Prognostic Nutritional Index (PNI), an inflammation-based marker, with community-acquired pneumonia (CAP) is uncertain. This study ascertained the relationship between PNI and CAP in children with parapneumonic effusion (PPE).

Methods: This single-center study retrospectively included 679 children hospitalized with lobar pneumonia between January 1, 2012, and July 31, 2022, and subdivided the cohort by PPE presence (n=209) or absence (n=470). The length of hospital stay and PNI at hospitalization were compared among patients with only lobar pneumonia; pneumonia + PPE; and PPE + use of chest tube drainage (PPE+tube drainage).

Results: Significant intergroup differences (p=0.0001) in PNI were observed among the lobar pneumonia, PPE, and PPE+tube drainage groups: PNI in the PPE+tube drainage group was significantly lower than that in the lobar pneumonia and PPE groups, and PNI of the PPE group was significantly lower than that in the lobar pneumonia group. The area under the PNI receiver operating characteristics curve (with 95% CI) was 0.671 (0.633–0.707) and 0.921 (0.894–0.943) for PPE and PPE+tube drainage, respectively. A PNI cut-off ≤38.01 for PPE+tube drainage showed sensitivity of 87.88, specificity of 88.30, positive predictive value of 34.50, negative predictive value of 99.00, and likelihood ratio (+) of 7.51. The length of hospital stay (days) was longer in the PPE+tube drainage group.

Conclusion: PNI at admission may constitute an independent predictor of CAP prognosis in patients who require tube drainage.

Keywords: Children, lobar pneumonia, parapneumonic effusion, Prognostic Nutritional Index.

Address for correspondence: Özlem Erdede, Zeynep Kamil Maternity and Children's Disease Training and Research Hospital, 34668, İstanbul, Turkey
Phone: +90 532 650 21 45 **E-mail:** ozlem@erdede.com.tr **ORCID:** 0000-0002-5490-5361
Received: 1 August 2023 **Revised:** 15 August 2023 **Accepted:** 6 September 2023 **Published:** 17 September 2023

INTRODUCTION

Community-acquired pneumonia (CAP) is a well-known reason of pediatric morbidity and mortality, although mortality rates differ between developed and developing countries. In 2015, an estimated 1 million children under age 5 died from CAP globally. Particularly in low- and middle-income countries, pneumonia continues to be the main cause of illness for young children outside of the newborn period (1). The reference standard for diagnosing CAP is the presence of a new infiltrate detected on chest radiography together with currently acquired breathing signs and symptoms (2–4), such as cough, phlegm, shortness of breath, fever, and abnormal auscultatory breath sounds (5). Children with pneumonia who do not cured well to treatment should be evaluated for potential suppurative parenchymal complications (6). According to the British Thoracic Society (7) guidelines, fever or discomfort that persists beyond 48 h after treatment initiation warrants reassessment of the child for possible complications. Pneumonia can lead to a series of purulent parenchymal complications (8), and the Pediatric Society of Infectious Diseases and the Infectious Diseases Society of America lists the following CAP-associated complications in children (9): pleural effusion or empyema, pneumothorax, lung abscess, bronchopleural fistula, and necrotizing pneumonia. Up to 53% of children who were hospitalized with pneumonia have been documented to have the above mentioned problems (10). Furthermore, pleural effusion, which cannot be treated with antibiotics and may necessitate surgical drainage or thoracoscopy (11). The most frequent complication of pediatric pneumonia is a parapneumonic effusion (PPE), which includes simple and complex effusions as well as empyema. Whenever a pleural effusion appears on a chest radiograph, ultrasonography (USG) is the preferred approach for measuring fluid volume (7), as the size of the effusion is important for determining the management. Small PPE (<10-mm thick) can usually be managed conservatively. Several clinical studies have been performed to validate the most suitable method for the drainage of complex effusions and empyema (12,13). Conservative management of PPE is mainly based on antibiotic therapy, chest tube thoracic drainage or video-assisted thoracoscopy only applied in the most severe or refractory cases (14,15). Moreover, the risk factors for prolonged hospital stay are uncertain (16), and the severity of the clinical manifestations of CAP varies widely (17). Finally, to address problematic cases, several biomarkers have been investigated and have been used in clinical practice in adults to reveal the etiology and severity of CAP and to provide further insights for the diagnosis and treatment of CAP (18,19). Despite several attempts to predict the severity and outcome, in most cases, the etiological diagnosis of pediatric CAP and evaluation of possible outcomes remain unresolved. Even when various tests were used alone, the use of biomarkers contributed little to the results of clinical and radiological signs and symptom assessment (8, 20). The Prognostic Nutritional Index (PNI) shows a patient's immunonutritional status and is a predictor of severity and mortality in patients with inflammatory diseases, gastrointestinal surgery, and cardiovascular disease (21–23). The PNI can be easily and quickly calculated using the results of routine blood tests (lymphocyte count and albumin level) and is a sign of inflammatory and nutritional status that is associated with poor prognosis for cancer, cardiovascular disease, pulmonary thromboembolism, and stroke (24–28). Some studies have predicted an association between the nutritional status and the severity of pneumonia in adults (29–30). For predicting the mortality of pneumonia patients, Shimoyama et al. demonstrated that the neutrophil-to-lymphocyte ratio was better to other inflammation-based prognostic scores, including PNI (31).

This study aimed to investigate primary the role of PNI and secondary to identify other inflammatory biomarkers for predicting the severity and length of hospital stay in pediatric patients with CAP with PPE through an analysis that included biochemical data.

MATERIALS AND METHODS

This retrospective chart review study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The local ethics committee for the study (no: 98, date: September 21, 2022) approved this study. Patients were included only after they provided written informed consent.

A total of 679 patients, ages 1-18 years, were enrolled in this retrospective single-center study who were hospitalized at a tertiary-level hospital in İstanbul, Turkey between January 1, 2012 and July 30, 2022 and had been diagnosed with lobar pneumonia (a lobar infiltrate on chest radiography with acute respiratory symptoms).

Data were extracted from the patients' electronic health files in the hospital information system for analysis. Digital database searches were performed to identify baseline patient information, including age, sex, clinical characteristics, and laboratory test results that were obtained on the first day of admission. The body mass index (BMI) of all the patients was recorded as were the complete blood count and C-reactive protein (CRP) and albumin levels. The CRP/platelet (PLT) and CRP/albumin values were determined, and PNI was calculated as follows: PNI = 10×serum albumin (g/dL)+0.005×peripheral lymphocyte count (/mm3). The results of chest radiographs and thoracic USG were recorded. Lobar pneumonia was defined as having one or more of the recently acquired respiratory signs and symptoms: cough, expectoration, dyspnea, and a 38.0 °C degree core body temperature, abnormal breathing patterns and rales on auscultation, white blood cells count >10 or <4 × 10^9 L, and lobar infiltration on chest X-ray. Thoracic USG was performed in all patients. Based on the existence of, the cohort was divided into three groups: presence of only pneumonia, presence of PPE and PPE+ tube drainage. Patients with comorbidities, such as primary immunodeficiency, neuromuscular diseases, chronic lung and heart diseases, cystic fibrosis or active pulmonary tuberculosis, hospital-acquired pneumonia, non-infectious pleural effusion, and protein-energy malnutrition were excluded from the study as were those with low BMI, those who transferred to distant hospitals outside the research area, and those with missing data.

Statistical analysis

All statistical analyses in this study were performed using the Statistical Package for the NCSS (Number Cruncher Statistical System) 2007 (Utah, USA). In the evaluation of the data, in addition to descriptive statistical methods (mean, standard deviation, median, and interquartile range), the distribution of variables was examined using the Shapiro–Wilk normality test. One-way analysis of variance was used for intergroup comparisons of normally continuous variables, and Tukey's multiple comparison test was used for subgroup comparisons. The Kruskal–Wallis test was used for intergroup comparisons of non-normally distributed variables, the Dunn's multiple comparison test was used for subgroup comparisons, and the chi-square test was used for comparisons of qualitative data. For the differential diagnosis of PPE and PPE+tube drainage, the receiver operating curve (ROC) and respective areas under the curve (AUC) with 95% confidence intervals were calculated. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), likelihood ratio LR (+), and cut-off values of the variables were determined. Statistical significance was set at $p<0.05$.

RESULTS

In total, 679 patients with lobar pneumonia were enrolled in this study. All patients showed lobar infiltrates on chest radiography. According to the findings of thoracic USG, most of these patients had only pneumonia (69.21%). Of these, 209 had PPE (30.7%), of which 136, 39, and 23 had PPE <10, 10–20, and >20 mm, respectively, and 11 had massive PPE. In total, 177 participants with PPE (84.68%) were treated with appropriate antibiotics only, and thoracic tube drainage was applied to 32 (15.31%) patients due to massive effusion and empyema.

Table 1 displays the baseline characteristics and inflammatory biomarkers of the 679 patients upon admission. The p values of the Dunn's and Tukey Multiple comparison tests are presented in Tables 2 and 3.

A significant intergroup difference was observed in the monocyte and platelet counts of the lobar pneumonia, PPE, and PPE+tube drainage groups (p=0.022 and p=0.003, respectively), and the PPE+tube drainage group had significantly higher monocyte and platelet counts than those of the lobar pneumonia and PPE groups (monocyte: p=0.032 and p=0.008 and platelet: p=0.001 and p=0.023, respectively). The CRP and albumin levels of the lobar pneumonia, PPE, and PPE+tube drainage groups differed significantly (p=0.0001 for both) and were significantly higher and lower, respectively, in the PPE+tube drainage group than in the lobar pneumonia and PPE groups (p=0.0001 for both); the albumin levels of the PPE group were significantly lower than those of the lobar pneumonia group (p=0.0001).

A significant inter group difference was observed in the CRP/PLT and CRP/Alb values of the lobar pneumonia, PPE, and PPE+tube drainage groups (p=0.003 and p=0.0001, respectively); the CRP/PLT and CRP/Alb values in the PPE+tube drainage group were significantly higher than those of the lobar pneumonia and PPE groups (p=0.001 for both). The PNI of the lobar pneumonia, PPE, and PPE+tube drainage groups differed significantly (p=0.0001) and was significantly lower in the PPE+tube drainage group than in the lobar pneumonia and PPE groups (p=0.0001); the PNI of the PPE group was significantly lower than that of the lobar pneumonia group (p=0.0001). A significant intergroup difference was observed in the length of hospital stay values of the lobar pneumonia, PPE, and PPE+tube drainage groups (p=0.0001), and the PNI of the PPE+tube drainage group was

significantly higher than that of the lobar pneumonia and PPE groups (p=0.0001). Length of hospital stay values of the PPE group were significantly higher than those of the lobar pneumonia group (p=0.0001). Areas under the ROC curve of the lobar pneumonia and PPE groups are shown in Table 4 and Figure 1a.

For the differential diagnosis of the presence of effusion, the area under the ROC curve was calculated; for albumin, the area under the ROC curve was 0.669 (95% CI 0.631–0.705). The cut-off value of the albumin variable was determined as ≤3.98 g/dL (sensitivity 49.43, specificity 79.36, PPV 47.30, NPV 80.70, and LR (+) 2.40); a patient with albumin level ≤3.98 g/dL had a 2.40 times higher risk for PPE than a patient with albumin level >3.98. The area under the PNI ROC curve was 0.671 (0.633–0.707, which is close to the desired value of 0.700). A PNI cut-off value of ≤40 for determining the presence of effusion had sensitivity of 50.57, specificity of 78.72, PPV 47.10, NPV 81.00, and LR (+) 2.38, whereby a patient with an albumin level ≤40 had a 2.38 times higher risk for PPE (Figure 1b). The areas under the ROC curve of the lobar pneumonia and PPE+tube drainage groups are shown in Table 5.

The area under the ROC curve was calculated for the differential diagnosis of the presence of PPE+tube drainage, and the area under the ROC curve for CRP was 0.749 (0.709–0.787); a CRP cut-off value of >84 mgdl showed sensitivity 72.73, specificity 69.79, PPV 24.50, NPV 97.30, and LR+ of 2.41 for the presence of effusion+tube drainage. The area under the ROC curve for CRP/albumin was 0.801 (0.763–0.835), and a cut-off value >21.89 showed sensitivity of 81.82, specificity of 72.13, PPV 27.10, NPV 93.30, and LR (+) of 2.94 for the presence of effusion+tube drainage. The area under the ROC curve for albumin was 0.917 (0.889–0.939), and a cut-off value of ≤3.79 had sensitivity of 85.85, specificity of 88.94, PPV 35.00, NPV 98.80, and LR (+) of 7.67 for the presence of effusion+tube drainage. The area under the PNI ROC curve was 0.921 (0.894–0.943, which is greater than the required value of 0.700), and a cut-off value of ≤38.01 showed sensitivity of 87.88, specificity of 88.30, PPV 34.50, NPV 99.00, and LR (+) of 7.51 for the presence of effusion+tube drainage (Figure 1c).

According to the ROC analysis, the monocyte and platelet counts had the lowest differential accuracy for predicting PPE+tube drainage, and the area under the ROC curve was 0.612 and 0.667, respectively.

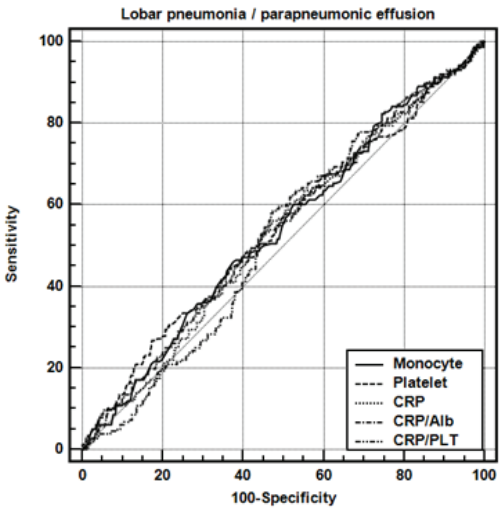

Figure 1a. ROC curves of various parameters on routine blood tests for predicting PPE on admission

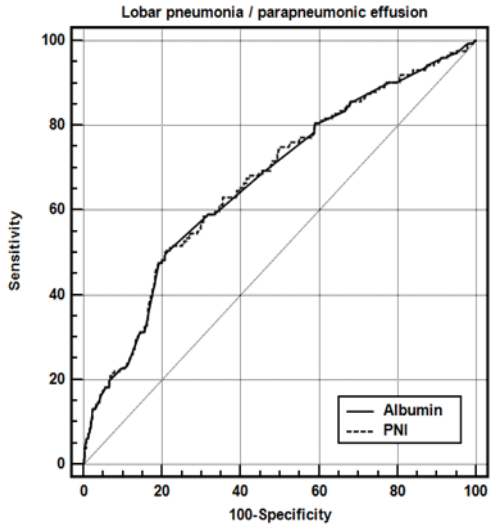

Figure 1b. ROC analysis of albumin and PNI to predict PPE

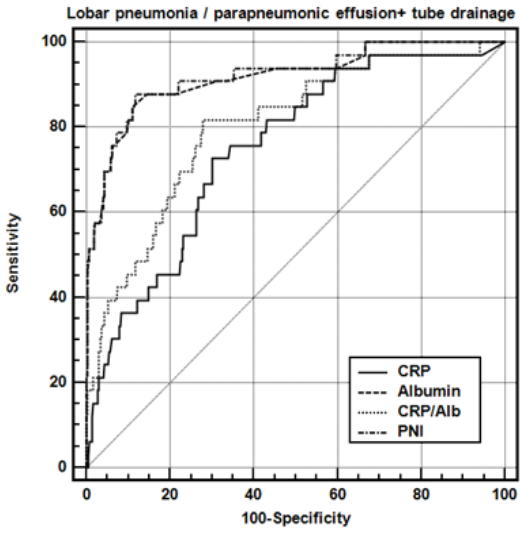

Figure 1c. ROC curves of various parameters on routine blood tests for predicting PPE + tube drainage on admission

Abbrevations: CRP: C-reactive protein; Alb:Albumin; PLT: Platelet; PNI: Prognostic Nutritional Index ; PPE: Parapneumonic effusion; ROC: Receiver operating characteristic curve

Table 1. Baseline characteristics and biomarkers of the participants

	Lobar pneumonia n=470	PPE n=177	PPE+ chest tube pleural drainage n=32	*p*-value
Age (year) Mean±SD	5.11±3.22	5.5±3.29	5.99±3.92	0.170*
Male	237 (50.43%)	89 (50.28%)	18 (56.25%)	0.810**
Female	233 (49.57%)	88 (49.72%)	14 (43.75%)	
WBC (10^3/mm^3) Mean±SD	15.19±7.86	14.68±7.85	18.2±7.91	0.062*
Neutrophil (10^3/mm^3) Mean±SD	11.01±7.33	10.61±7.16	13.98±7.63	0.055*
Lymphocyte (10^3/mm^3) Median(min-max)	2.48(1.6–3.69)	2.5(1.58–3.42)	2.15(1.53–4.2)	0.725***
Monocyte (10^3/mm^3) Mean±SD	1.03±0.82	0.95±0.71	1.32±0.83	**0.022*****
Platelet (10^3/mm^3) Mean±SD	338.6±133.2	363.9±153.3	441.0±200.6	**0.003*****
CRP (mg/dL) Median(min-max)	41.8(15.5–103.2)	52(20.7–112)	114(64.4–211.0)	**0.0001*****
Albumin (g/dL) Mean±SD	4.18±0.35	3.94±0.44	3.13±0.74	**0.0001*****
CRP/PLT Median(min-max)	0.13(0.05–0.35)	0.15(0.06–0.31)	0.27(0.15–0.61)	**0.003*****
CRP/Alb Median(min-max)	9.7(3.6–24.7)	112.2(5.1–28.8)	35.1 (22.8–67.5)	**0.0001*****
PNI Mean±SD	41.8±3.5	39.4±4.4	31.3±7.4	**0.0001***
Hospitalization (day) Mean±SD	8.05±2.96	10.01±3.84	19.75±6.25	**0.0001***

***Abbreviations**:* WBC: White blood cells, CRP: C-reactive protein, Alb: Albumin, PNI: Prognostic Nutritional Index, PLT: Platelet, PPE: Parapneumonic effusion

**One-way ANOVA, **Chi square test, ***Kruskal–Wallis test.*

Bold values indicate statistical differences, and correlations were considered significant at p<0.05.

Table 2. Comparison of the study groups with regard to the laboratory parameters

Dunn's Multiple Comparison Test	Monocyte	PLT	CRP	Albumin	CRP/PLT	CRP/Alb
Lobar pneumonia-PPE	0.137	0.092	0.221	**0.0001**	0.599	0.071
Lobar pneumonia-PPE+tube drainage	**0.032**	**0.001**	**0.0001**	**0.0001**	**0.001**	**0.0001**
PPE/PPE+tube drainage	**0.008**	**0.023**	**0.0001**	**0.0001**	**0.001**	**0.0001**

Abbreviations: PPE: Parapneumonic effusion, PLT: Platelet, CRP: C-Reactive Protein, Alb: Albumin.
Bold values indicate statistical differences, and correlations were considered significant at p<0.05.

Table 3. Comparison of study groups in regard to the PNI and length of hospitalization

Tukey Multiple Comparison Test	PNI	Hospitalization (days)
Lobar pneumonia-PPE	**0.0001**	**0.0001**
Lobar pneumonia-PPE+tube drainage	**0.0001**	**0.0001**
PPE/PPE+tube drainage	**0.0001**	**0.0001**

Abbreviations*:* PPE: Parapneumonic effusion, PNI: Prognostic Nutritional Index.
Bold values indicate statistical differences, and correlations were considered significant at p<0.05

Table 4. Areas under the ROC curves of biochemical parameters on routine blood examination for predicting PPE

	AUC	SE	95% CI
Monocyte	0.538	0.025	0.499–0.577
Platelet	0.543	0.026	0.504–0.582
CRP	0.531	0.026	0.492–0.570
Albumin	0.669	0.022	0.631–0.705
CRP/Albumin	0.546	0.026	0.507–0.585
CRP/PLT	0.513	0.025	0.474–0.553
PNI	0.671	0.023	0.633–0.707

Abbreviations: PPE: Parapneumonic effusion, PLT: Platelet, CRP: C-reactive protein, PNI: Prognostic Nutritional Index, AUC: Area under the receiver operating curve, CI: Confidence interval, SE: Standard error.

Table 5. Areas under the ROC curves of various parameters for predicting PPE+tube drainage

	AUC	SE	95% CI
Monocyte	0.612	0.054	0.567–0.654
Platelet	0.667	0.053	0.624–0.708
CRP	0.749	0.050	0.709–0.787
Albumin	0.917	0.016	0.889–0.939
CRP/Alb	0.801	0.047	0.763–0.835
CRP/PLT	0.673	0.053	0.630–0.714
PNI	0.921	0.015	0.894–0.943

Abbreviations: PPE: Parapneumonic effusion, PLT: Platelet, CRP: C-reactive protein, Alb: Albumin, PNI: Prognostic Nutritional Index, AUC: Area under the receiver operating curve, CI: Confidence interval, SE: Standard error.

DISCUSSION

PPE, which includes simple and complex effusions and empyema, is the most frequent complication of pneumonia in childhood. This study found that as the severity of lobar pneumonia increased, the length of hospital stay increased, whereas the PNI scores decreased as lobar pneumonia progressed from common to severe types with empyema. The PNI score is an inverse independent factor that is associated with severe lobar pneumonitis with PPE. To our knowledge, this is the first research to show the clinical utility of analyzing the relationship between PNI and lobar pneumonia and pleural effusion outcomes.

Luis et al. reported that strong correlation exists between the severity of the PPE and its size. The majority of patients were just given antibiotics alone (32). In our study, we found that the hospitalization-day PNI of the PPE+tube drainage group was significantly higher than that of the lobar pneumonia and PPE groups; moreover, the hospitalization-day values of the PPE group were significantly higher than those of the lobar pneumonia group. Antibiotics alone were used to treat more than half of PPE patients in the USA, with an increase in this practice over the past ten years. Both the most interventionist and the most conservative institutions saw comparable results (33–35); Segerer et al. reported a median length of 17 days, and initial therapy was noninvasive in 45% and invasive 55% of the 645 patients in the study. In our study, tube drainage was required in 16.74% of PPE cases.

Albumin is a negative acute-phase reactant, and inflammatory cytokines inhibit albumin synthesis in the presence of inflammation. Therefore, albumin levels decrease when inflammation occurs (36). Severe inflammation is associated with hypoalbuminemia (37). Although our patients were not malnourished, the albumin levels were significantly lower in patients with severe PPE and tube drainage. Viasus et al. reported that within 24 hours of admission, the serum albumin level is a reliable indicator of the prognosis for CAP. Thus, when assessing the severity of a disease in patients with CAP, physicians should consider albumin levels (38). In our study, albumin levels were lower in patients who required tube drainage. The PNI is calculated from serum albumin levels and the total peripheral blood lymphocyte count and is commanly used as a marker of nutritional status and inflammation and to predict the prognosis of various diseases. However, the benefits of PNI in non-surgical and non-cancer patients have not been well established. It is yet unknown what causes the PNI to correlate with pneumonia severity. The PNI correlates nutritional status with a patient's immune response; is an objective numerical value that combines the peripheral blood lymphocyte count and albumin concentration and can be used to assess health, malnutrition, and immunological response (39). Therefore, the PNI is both an immunological index and a nutritional indicator. Low albumin levels and/or a reduced lymphocyte count, which are strongly correlated with the development of pneumonia, are indicated by a low PNI. Shang et al. found a relationship between a low PNI and the first occurrence of pneumonia in adult patients who were receiving peritoneal dialysis (40).

Yoshimasa Hachisu reported that the PNI might be an effective prognostic factor for nontuberculous bacterial lung diseases (41). Specific PNI cut-off values for all diseases have not yet been established. However, various studies on malignancies in the literature suggest that a low PNI is associated with a poor prognosis in various cancer types. Furthermore, the PNI is widely used to assess the immunonutritional status of cancer patients and is a useful prognostic marker for various malignancies such as adult colorectal cancer (42), non-small cell lung cancer (43), liver cancer (44), esophageal cancer (45), and osteosarcoma (46). Different cut-offs for the PNI have been reported for different diseases (47, 48); however, the optimal cut-offs and group classifications according to the PNI remain unclear. In this study, the PNI cut-off value for tube drainage was determined as ≤38.01. In recent years, The PNI has received significant attention lately because of how useful and important it is for clinical uses. The PNI has attracted significant attention because of its convenience and significance in clinical applications. According to the studies the PNI is clinically significant in adult patients with various disorders such coronavirus disease (27), cardiovascular disease (49), and sepsis. Tiewei et al. reported that the PNI decreased considerably with the severity of sepsis and was lower in infants with sepsis (50). In our study, the albumin level and PNI were superior to the other studied biomarkers for predicting the risk for tube drainage in patients with lobar pneumonia and PPE. Previous studies have not assessed associations between the PNI and CAP with PPE in children. Our results are instructive in this regard.

Limitations:

Our research had certain limitations. Firstly, this study is a limited-scale, retrospective investigation conducted at a single center. Its primary aim was to validate the results and make them applicable to a larger and more diverse group of participants. Second, due to the lack of anthropometric and dietary data, other classic nutritional index scores, such as the Nutrition Risk Screening 2002, Mini Nutrition Assessment Shortcut, and Nutrition Risk Index, could not be ascertained to determine the predictive power of the PNI for predicting illness severity in comparison with the above mentioned scores. Third, a healthy control group was not included. Fourth, the classification of the size of the effusion may be influenced by various factors, such as the technique used for patient positioning and the timing of the studies. Additionally, the volume of effusion and pleural thickness on diagnostic imaging may not be properly correlated (due to loculated effusion, patient age, or other factors). Fifth, PNI calculations were only made at admittance. Therefore, future studies that continuously monitor the PNI may yield more insightful results.

CONCLUSION

As an independent factor associated with the PPE severity, the PNI can serve as a simple, rapid, and valid outcome predictor to pediatric patients with pneumonia and PPE. The size of the effusion and complicated effusion/empyema and the PNI level were significantly correlated, which was defined by the radiological appearance on imaging studies. The amount of the effusion served as an independent predictor of how long a patient will be in the hospital and was closely related to the length of treatment.

Acknowledgement: We would like to thank the biostatistician Rana Konyalıoğlu for the assistance with the statistical analysis of this study.
Conflicts of interest: The authors declare that they have no potential conflict of interests pertaining to this article
Ethics committee approval:
This study adhered to the tenets of the Declaration of Helsinki, and was approved by the Ministry of Health of Turkey and the Ethics Committee of Zeynep Kamil Maternity and Children's Diseases Training and Research Hospital (Approval number: 98; Approval date: September 21, 2022). All parents or legal guardians written consented to their children's participation in the study.
Financial disclosure:
This work did not receive any financial support from private, public, or not-for-profit organizations/entities.
Peer-review: Externally peer-reviewed
Author contributions: Conceptualization; ÖE; Methodology; ÖE; Formal analysis and investigation; ES; Writing - original draft preparation; ÖE; Writing - review and editing; ÖE, ES; Supervision; ÖE; Software; ES

References

1. Marangu D, Zar HJ. Childhood pneumonia in low-and-middle-income countries: An update. Paediatr Respir Rev. 2019; 32:3-9.
2. Niederman MS, Mandell LA, Anzueto A, Bass JP, Broughton WA, Campbell GD, et al. Guidelines for the management of adults with community-acquired pneumonia. Diagnosis, assessment of severity, antimicrobial therapy, and prevention. Am J Respir Crit Care Med. 2001; 163:1730-54.
3. Mandell LA, Bartlett JG, Dowell SF, File TM Jr, Musher DM, Whitney C, et al. Update of practice guidelines for the management of community-acquired pneumonia in immunocompetent adults. Clin Infect Dis. 2003; 37:1405-33.
4. Dalhoff K. Worldwide guidelines for respiratory tract infections: community-acquired pneumonia. Int J Antimicrob Agents. 2001;18:39-44.
5. Hoare Z, Lim WS. Pneumonia: update on diagnosis and management. BMJ. 2006; 332:1077-9.
6. Masarweh K, Gur M, Toukan Y, Bar-Yoseph R, Kassis I, Gut G, et al. Factors associated with complicated pneumonia in children. Pediatr Pulmonol. 2021;56:2700-6.
7. Harris M, Clark J, Coote N, Fletcher P, Harnden A, McKean M, et al. British Thoracic Society Standards of Care Committee. British Thoracic Society guidelines for the management of community acquired pneumonia in children: update 2011. Thorax. 2011;66:2:ii1-23.
8. Tuğcu GD, Özsezen B, Türkyılmaz İ, Pehlivan Zorlu B, Eryılmaz Polat S, Özkaya Parlakay A, et al. Risk factors for complicated community-acquired pneumonia in children. Pediatr Int. 2022; 64:e15386.
9. Bradley JS, Byington CL, Shah SS, Averson B, Carter ER, Harrison C, et al. The management of community-acquired pneumonia in infants and children older than

3 months of age: clinical practice guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America. Clin. Inf. Dis. 2011; 53:e25-76.

10. Kurian J, Levin TL, Han BK, Taragin B, Weinsten S. Comparison of ultrasound and CT in the evaluation of pneumonia complicated by parapneumonic effusion in children. AJR Am J Roentgenol. 2009; 193:1648-54.

11. McCauley L, Dean N. Pneumonia and empyema: causal, casual or unknown. J Thorac Dis. 2015; 7:992-8.

12. Redden MD, Chin TY, van Driel ML. Surgical versus non-surgical management for pleural empyema. Cochrane Database Syst Rev. 2017; 17;3:CD010651.

13. Pacilli M, Nataraja RM. Management of paediatric empyema by video-assisted thoracoscopic surgery (VATS) versus chest drain with fibrinolysis: Systematic review and meta-analysis. Paediatr Respir Rev. 2019; 30:42-48.

14. Epaud R, Aubertin G, Larroquet M, Pointe HD, Helardot P, Clevent A, et al. Conservative use of chest-tube insertion in children with pleural effusion. Pediatr Surg Int. 2006; 22:357-62.

15. Bataev SM, Zurbaev NT, Molotov RS, Ignatiev RO, Afaunov MV, Fedorov AK, et al. The first experience of the use of hydro-surgical technologies in the treatment of children with pulmatic-pleural complications of destructive pneumonia. Khirurgiia (Mosk). 2019;7:15-23.

16. Breuer O, Picard E, Benabu N, Erlichman I, Reiter J, Tsabari R, et al. Predictors of prolonged hospitalizations in pediatric complicated pneumonia. Chest. 2018; 153:172-80.

17. Esposito S, Cohen R, Domingo JD, Pecurariu OF, Greenberg D, Heininger U, et al. Antibiotic therapy for pediatric community-acquired pneumonia: do we know when, what and for how long to treat. Pediatr Infect Dis J. 2012; 31:e78-85.

18. Lippi G, Meschi T, Cervellin G. Inflammatory biomarkers for the diagnosis, monitoring and follow-up of community-acquired pneumonia: clinical evidence and perspectives. Eur J Intern Med. 2011; 22:460-5.

19. Seligman R, Ramos-Lima LF, Oliveira Vdo A, Sanvicente C, Pacheco EF, Dalla Rosa K, et al. Biomarkers in community-acquired pneumonia: a state-of-the-art review. Clinics. 2012; 67:1321-5.

20. Principi N, Esposito S. Biomarkers in pediatric community-acquired pneumonia. Int J Mol Sci. 2017; 18:E447.

21. Kang N, Gu H, Ni Y, Wei X, Zheng S. Prognostic and clinicopathological significance of the Prognostic Nutritional Index in patients with gastrointestinal stromal tumours undergoing surgery: a meta-analysis. BMJ Open. 2022; 1;12:e064577

22. Beck MA, Levander OA. Host nutritional status and its effect on a viral pathogen. J Infect Dis. 2000; 182 Suppl 1:S93-6.

23. Keskin HA, Kurtul A, Esenboğa K, Çiçek MC, Katırcıoğlu SF. Prognostic nutritional index predicts in-hospital mortality in patients with acute Stanford type A aortic dissection. Perfusion. 2021; 36:710-6.

24. Schwegler I, von Holzen A, Gutzwiller JP, Schlumpf R, Mühlebach S, Stanga Z. Nutritional risk is a clinical predictor of postoperative mortality and morbidity in surgery for colorectal cancer. Br J Surg. 2010; 97:92-7.

25. Wada H, Dohi T, Miyauchi K, Jun S, Endo H, Doi S, et al. Relationship between the prognostic nutritional index and long-term clinical outcomes in patients with stable coronary artery disease. J Cardiol. 2018; 72:155-61.

26. Hayıroğlu Mİ, Keskin M, Keskin T, Uzun AO, Altay S, Kaya A, et al. A novel independent survival predictor in pulmonary embolism: Prognostic Nutritional Index. Clin Appl Thromb Hemost. 2018; 24:633-9.

27. Xiang W, Chen X, Ye W, Li J, Zhang X, Xie D. Prognostic Nutritional Index for predicting 3-month outcomes in ischemic stroke patients undergoing thrombolysis. Front Neurol. 2020; 11:599.

28. Wang R, He M, Yin W, Lia X, Whang B, Jin X, et al. The Prognostic Nutritional Index is associated with mortality of COVID-19 patients in Wuhan, China. J Clin Lab Anal. 2020; 34:e23566.

29. Wei L, Xie H, Li J, Li R, Chen W, Huang L, et al. The prognostic value of geriatric nutritional risk index in elderly patients with severe community-acquired pneumonia: A retrospective study. Medicine. 2020; 99:e22217.

30. Yanagita Y, Arizono S, Tawara Y, Domagari M, Machiguchi H, Yokomura K, et al. The severity of nutrition and pneumonia predicts survival in patients with aspiration pneumonia: A retrospective observational study. Clin Respir J. 2022; 16:522-32.

31. Shimoyama Y, Umegaki O, Inoue S, Agui T, Kadono N, Minami T, et al. The neutrophil to lymphocyte ratio is superior to other inflammation-based prognostic scores in predicting the mortality of patients with pneumonia. Acta Med Okayama. 2018; 72:591-3.

32. Moral L, Toral T, Clavijo A, Caballero M, Canals F, Fornies MJ, et al. Population-based cohort of children with parapneumonic effusion and empyema managed with low rates of pleural drainage. Front Pediatr. 2021; 9:621943.

33. Goldin AB, Parimi C, LaRiviere C, Garrison MM, Larison CL, Sawin RS. Outcomes associated with type of intervention and timing in complex pediatric empyema. Am J Surg. 2012; 203:665-73.

34. Dorman RM, Vali K, Rothstein DH. Trends in treatment of infectious parapneumonic effusions in U.S. children's hospitals, 2004-2014. J Pediatr Surg. 2016; 51:885-90.

35. Segerer FJ, Seeger K, Maier A, Hagemann C, Schoen C, van der Linden H, et al. Therapy of 645 children with parapneumonic effusion and empyema-A German nationwide surveillance study. Pediatr Pulmonol. 2017; 52:540-7.

36. Skevaki C, Fragkou PC, Cheng C, Xie M, Renz H. Laboratory characteristics of patients infected with the novel SARS-CoV-2 virus. J Infect. 2020; 81:205-12.

37. Soeters PB, Wolfe RR, Shenkin A. Hypoalbuminemia:

Pathogenesis and clinical significance. JPEN J Parenter Enteral Nutr. 2019; 43:181-93.

38. Viasus D, Garcia-Vidal C, Simonetti A, Manresa F, Dorca J, Gudiol F, et al. Prognostic value of serum albumin levels in hospitalized adults with community-acquired pneumonia. J Infect. 2013; 66:415-23.

39. Zhang H, Tao Y, Wang Z, Lu J. Evaluation of nutritional status and prognostic impact assessed by the prognostic nutritional index in children with chronic kidney disease. Medicine (Baltimore). 2019; 98:e16713.

40. Shang S, Huang Y, Zhan X, Peng F, Wang X, Wen Y, et al. The relationship between the prognostic nutritional index and new-onset pneumonia in peritoneal dialysis patients. Int Urol Nephrol. 2022; 54;3017-24.

41. Hachisu Y, Murata K, Takei K, Tsuchiya T, Tsurumaki H, Koga Y, et al.. Prognostic nutritional index as a predictor of mortality in nontuberculous mycobacterial lung disease. J Thorac Dis. 2020; 12:3101-9.

42. Mohri Y, Inoue Y, Tanaka K, Hiro J, Uchida K, Kusunoki M, et al. Prognostic nutritional index predicts postoperative outcome in colorectal cancer. World J Surg. 2013; 37:2688-92.

43. Mori S, Usami N, Fukumoto K, Mizuno T, Kuroda H, Sakakura N, et al. The significance of the Prognostic Nutritional Index in patients with completely resected non-small cell lung cancer. PLoS One. 2015; 10:e0136897.

44. Caputo F, Dadduzio V, Tovoli F, Bertolini G, Cabibo G, Germa K, et al. The role of PNI to predict survival in advanced hepatocellular carcinoma treated with Sorafenib. PLoS One. 2020; 15:e0232449.

45. Dai Y, Fu X, Li T, Yao Q, Su L, Su H, et al. Long-term impact of prognostic nutritional index in cervical esophageal squamous cell carcinoma patients undergoing definitive radiotherapy. Ann Transl Med. 2019; 7:175.

46. Huang X, Hu H, Zhang W, Shao Z. Prognostic value of prognostic nutritional index and systemic immune-inflammation index in patients with osteosarcoma. J Cell Physiol. 2019; 234:18408-14.

47. Moon SW, Lee EH, Choi JS, Leem AY, Lee SH, Kim SY, et al. Impact of prognostic nutritional index on outcomes in patients with Mycobacterium avium complex pulmonary disease. PLoS One. 2020; 15:e0232714.

48. Lee JY, Kim HI, Kim YN, Hong JH, Alshomimi S, An JY, et al. Clinical significance of the Prognostic Nutritional Index for predicting short- and long-term surgical outcomes after gastrectomy: A retrospective analysis of 7781 gastric cancer patients. Medicine. 2016; 95:e3539.

49. Hayashi J, Uchida T, Ri S, Hamasaki A, Kuroda Y, Yamashita A, et al. Clinical significance of the prognostic nutritional index in patients undergoing cardiovascular surgery. Gen Thorac Cardiovasc Surg. 2020; 68:774-9.

50. Li T, Qi M, Dong G, Li X, Xu Z, Wei Y, et al. Clinical value of Prognostic Nutritional Index in prediction of the presence and severity of neonatal sepsis. J Inflamm Res. 2021;14:7181-90.