Original Article

Predictive Value of Neutrophil-to-Lymphocyte Ratio on Hospital Mortality of Patients with Community-Acquired Pneumonia

Md Khairul Islam[1], Zakir Hossain[2], Fahima Sharmin Hossain[3], Nur Alam[4], Abul Kalam Md. Sajedur Rahman[5], Md. Mamunur Rashid[6], Mohammad Zakaria Al Aziz[7], Md. Monir Uz Zaman[8]

Abstract

Background: The neutrophil-to-lymphocyte ratio (NLR), a cheap blood parameter, has shown promise as a predictor of adverse outcomes in severe infections. However, its utility in predicting mortality among patients with severe CAP in Bangladesh remains underexplored.

Objective: This study aimed to assess the predictive value of admission NLR for in-hospital mortality among patients with CAP admitted to a tertiary care hospital in Bangladesh.

Methods: This prospective, observational study was conducted from July 2023 to June 2024 at Dhaka Medical College Hospital. One hundred eight patients aged 18 years or older with a clinical and radiological diagnosis of CAP were included. Exclusion criteria were hospital-acquired pneumonia, pulmonary tuberculosis, malignancy, immunosuppression, and HIV infection. Baseline demographic, clinical, and laboratory data were collected. NLR was calculated from routine complete blood counts, and a predefined cutoff of 7.12 was used for stratification. In-hospital mortality was the primary outcome. Logistic regression and ROC curve analyses were performed to evaluate the predictive performance of NLR.

Results: The overall in-hospital mortality rate was 12.0%. Patients with an NLR ≥7.12 had a significantly higher mortality risk (OR: 1.63; 95% CI: (1.07–3.82); p = 0.040). Multivariate analysis identified NLR as an independent predictor of mortality (adjusted OR: 1.34; 95% CI: 1.02–1.75; p = 0.033), along with chronic kidney disease (adjusted OR: 5.63; 95% CI: 1.15–27.60; p = 0.033) and cardiac failure (adjusted OR: 36.87; 95% CI: 5.57–244.22; p < 0.001). ROC analysis demonstrated excellent predictive performance for NLR, with an area under the curve (AUC) of 0.905.

Conclusion: Elevated admission NLR is a significant independent predictor of in-hospital mortality in patients with CAP. Given its simplicity, cost-effectiveness, and widespread availability, NLR can be a valuable prognostic tool in resource-constrained settings, complementing traditional clinical scores like CURB-65.

Keywords: Community-acquired pneumonia, Neutrophil-to-lymphocyte ratio, Hospital mortality, Biomarkers, Bangladesh

1. Junior consultant, Department of Medicine, Dhaka Medical College Hospital, Dhaka.
2. Junior consultant, OSD, DG health
3. Indoor Medical Officer, Department of Obstetrics and Gynecology, Dhaka Medical College
4. Indoor Medical Officer, Department of Hepatology, Dhaka Medical College
5. Associate professor, Department of Medicine, Dhaka Medical College Hospital
6. Junior consultant Medicine, National Gastroliver institute and hospital
7. Associate professor, Department of Medicine, Dhaka Medical College Hospital
8. Professor of Medicine, Department of Medicine, Mugda Medical College

Corresponding author: Md. Khairul Islam, Junior consultant, Department of Medicine, Dhaka Medical College Hospital, Khairul0696207@gmail.com

Introduction

Despite profuse use of antibiotics, CAP continues to pose a substantial burden on healthcare systems, particularly in low- and middle-income countries like Bangladesh, due to its high incidence, complex management needs, and significant mortality.[1]

Several factors contribute to the mortality associated with CAP, including advanced age, comorbid conditions such as diabetes mellitus, chronic obstructive pulmonary disease, tuberculosis, and malignancies, as well as physiological parameters at presentation. A recent study from Bangladesh reported an in-hospital mortality rate of 6.9% among patients with CAP.[2] While commonly used biomarkers such as C-reactive protein (CRP) and procalcitonin are helpful, they

are often limited in availability, cost-effectiveness, and diagnostic precision in resource-constrained settings.[3,4]

In this context, the neutrophil-to-lymphocyte ratio (NLR) has emerged as a promising, readily accessible, inexpensive inflammatory biomarker. It reflects the dynamic interaction between the innate and adaptive immune responses, as neutrophilia and lymphocytopenia are frequently observed under pathological stress such as severe infections. Elevated NLR has demonstrated prognostic value across various clinical conditions, including cardiovascular diseases, malignancies, and infectious diseases such as pneumonia.[5,6]

Several studies have reported that elevated NLR at admission is associated with increased disease severity and mortality in CAP. For example, Yang et al. found significantly higher median NLR values in non-survivors compared to survivors (11.96 vs. 4.19), with an optimal cut-off of 7.12 yielding 82.6% sensitivity and 72.2% specificity in predicting mortality.[5] Nevertheless, evidence remains scarce from South Asian populations, where clinical and sociodemographic factors may differ.

Given the limitations of existing risk stratification tools and the high burden of CAP in Bangladesh, identifying a cost-effective and reliable prognostic marker is critical. NLR, derivable from routine complete blood count tests, offers a practical advantage. However, its predictive value for mortality in patients with severe CAP in this context remains underexplored. This study was therefore designed to assess the prognostic utility of NLR for predicting in-hospital mortality among patients with severe CAP admitted to a tertiary care hospital in Bangladesh.

Materials and Methods
Study Design and Setting
This prospective, longitudinal observational study was conducted in the Department of Medicine at Dhaka Medical College Hospital (DMCH), Bangladesh, over a 12-month period, from July 2023 to June 2024. The primary objective was to evaluate the predictive value of the neutrophil-to-lymphocyte ratio (NLR) on hospital mortality in patients diagnosed with severe CAP. Specific aims included:

1. Assessing the association between admission NLR and in-hospital mortality.

2. Comparing mean NLR between survivors and non-survivors.

3. Evaluating NLR's sensitivity, specificity, and predictive performance (AUC).

Participants
Eligible patients were consecutively enrolled from those admitted to the Medicine Department with a clinical and radiological diagnosis of community-acquired pneumonia (CAP), as defined by the Infectious Diseases Society of America (IDSA) criteria.[7] Inclusion criteria were age 18 years or older, confirmed CAP diagnosis, and provision of informed written consent by the patient or legal guardian. Patients with hospital- or ventilator-acquired pneumonia, co-existing pulmonary tuberculosis, malignancy, pulmonary embolism, HIV infection, immunosuppressed states such as chronic steroid use or post-transplant status, those receiving palliative care, or having other active infections unrelated to pneumonia were excluded from the study. The sample size was calculated using the Cochrane formula, assuming a 6.9% mortality rate for CAP[2], 95% confidence interval (Z = 1.96), and 5% margin of error, yielding a minimum required sample size of 98. Adjusting for a 10% expected loss to follow-up, the final sample size was set at 108.

Baseline Evaluation

All enrolled patients underwent assessment using the CURB-65 severity scoring system at admission. Important demographic and clinical data were recorded, including age, sex, and comorbid conditions. Laboratory tests included white blood cell (WBC) count, absolute neutrophil and lymphocyte counts, platelet count, and NLR calculation. Based on previous literature, a predefined NLR cutoff of 7.12 was used for stratification.[5]

Laboratory Methods and Quality Control
Patients were enrolled from all general medicine units of Dhaka Medical College Hospital. Blood samples were drawn within 6 hours of hospital admission, before the initiation of antibiotics or corticosteroids, and sent immediately to the hospital's hematology department.

The neutrophil-to-lymphocyte ratio (NLR) was calculated from automated complete blood count (CBC) results using a Sysmex XN-2000™ hematology analyzer, which uses flow cytometry and fluorescence-based detection for leukocyte differential counts. The analyzer is calibrated daily according to the manufacturer's guidelines, and internal quality control (IQC) procedures are routinely performed using control materials of known values.

All hematological measurements were conducted by trained laboratory technologists who were blinded to patient clinical outcomes. No manual blood film differential count was routinely performed unless flagged by the machine. However, all flagged samples underwent microscopic review by a senior hematologist, following the standard operating procedure (SOP) of the hospital laboratory.

To ensure consistency and reliability:

- A single NLR value per patient was taken from the first CBC done upon admission.
- Standardized protocols were followed for sample handling, processing, and data recording.

No inter-observer variability occurred, as NLR was calculated electronically from automated analyzer outputs, ensuring independence of the observer.

Follow-Up and Outcome Assessment
Patients were followed up throughout their hospital stay, with clinical assessments conducted on days 3, 7, and 10. Outcomes recorded included oxygen requirement, ICU referral, duration of hospitalization, and in-hospital mortality. Each participant was followed up until either hospital discharge or death.

Data Processing and Analysis
Confidentiality was maintained throughout the study, and data analyses were conducted using IBM SPSS version 26.0. Continuous variables were summarized as mean ± standard deviation (SD), while categorical variables were expressed as frequencies and percentages.

The Chi-square test was used for comparisons among categorical groups, and both bivariate and multivariate logistic regression analyses were conducted to identify mortality predictors and calculate odds ratios (ORs) with 95% confidence intervals (CIs).

A receiver operating characteristic (ROC) curve analysis was performed to assess the predictive value of the neutrophil-to-lymphocyte ratio (NLR). A p-value of less than 0.05 indicated statistical significance, suggesting genuine effects rather than random chance.

Ethical Considerations
Approval was obtained from the Ethical Review Committee at Dhaka Medical College. Written informed consent was obtained from each participant. The research adhered to the ethical principles outlined in the Declaration of Helsinki.

Operational Definitions
Community-Acquired Pneumonia (CAP): Defined as pneumonia acquired outside hospital or healthcare settings, confirmed by clinical features (e.g., cough, fever, dyspnea) and radiological findings consistent with pulmonary infiltrates.[7]

Results
The cohort comprised predominantly male patients (64.8%), with the majority aged between 41 and 60 years (63.8%), indicating a middle-aged population. A significant proportion were non-smokers (72.3%), while 27.8% had diabetes mellitus, 16.7% had chronic obstructive pulmonary disease (COPD), 15.7% had chronic kidney disease, 13.9% had ischemic heart disease, 11.1% had hypertension, and 9.3% had cardiac failure. (Table 1)

Table I

Demographic and Clinical Characteristics of the Study Participants (N = 108)

Characteristic	Category	n (%)
Gender	Male	60 (64.8)
	Female	48 (35.2)
Age Group (years)	18–40	14 (12.9)
	41–60	69 (63.8)
	≥61	25 (23.1)
Smoking Status	Smoker	30 (22.7)
	Non-smoker	78 (72.3)
Comorbidities	Diabetes Mellitus	30 (27.8)
	Chronic Kidney Disease	17 (15.7)
	Cardiac Failure	10 (9.3)
	Ischemic Heart Disease (IHD)	15 (13.9)
	Chronic Obstructive Pulmonary Disease (COPD)	18 (16.7)
	Hypertension (HTN)	12 (11.1)

Table 2. Distribution of Patients by NLR Levels and Hospital Outcomes (N = 108)

Variable	Category	n (%)
NLR Level	≥7.12 (High NLR)	72 (67.0)
	< 7.12 (Low NLR)	36 (33.0)
Hospital Outcome	Death	13 (12.0)
	Survived	95 (88.0)

Patients aged ≥61 years had a significantly higher mortality risk than those aged 18–40 years (OR: 7.79; 95% CI: 1.69–35.92; p = 0.000). Comorbidities such as diabetes mellitus (OR: 3.10; 95% CI: 1.29–7.44; p = 0.010), cardiac failure (OR: 13.80; 95% CI: 3.64–52.35; p = 0.000), ischemic heart disease (OR: 3.17; 95% CI: 1.34–7.51; p = 0.007), and chronic obstructive pulmonary disease (OR: 4.66; 95% CI: 1.99–10.93; p = 0.000) were significantly associated with increased in-hospital mortality. Chronic kidney disease was associated with a substantially lower mortality risk (OR: 0.16; 95% CI: 0.05–0.49; p = 0.001), indicating a potential need for further investigation. Gender and smoking status did not show a statistically significant association with mortality. Regarding the neutrophil-to-lymphocyte ratio (NLR), patients with NLR ≥7.12 had a higher odds of mortality (OR: 1.63; 95% CI: (1.07–3.82); p = 0.040), suggesting that elevated NLR may be a potential predictor of poor outcomes in severe CAP. (Table 3)

Cardiac failure (CF) was the most significant predictor, with an adjusted odds ratio (OR) of 36.87 (95% CI: 5.57–244.22; p < 0.001), indicating a markedly increased risk of mortality in patients with CF. Chronic kidney disease (CKD) also emerged as a significant predictor (adjusted OR: 5.63; 95% CI: 1.15–27.60; p = 0.033), suggesting that patients with CKD had a higher likelihood of in-hospital death. Chronic obstructive pulmonary disease (COPD) was associated with an increased risk of mortality (adjusted OR: 4.37; 95% CI: 1.29–14.79; p = 0.018). Age was a significant continuous predictor, with each additional year increasing the odds of mortality by 6.6% (adjusted OR: 1.07; 95% CI: 1.01–1.12; p = 0.029). The neutrophil-to-lymphocyte ratio (NLR) was independently associated with mortality (adjusted OR: 1.34; 95% CI: 1.02–1.75; p = 0.033), indicating that higher NLR values were linked to increased risk of death. Other variables, including gender, smoking status, diabetes mellitus, white blood cell count, CURB-65 score, and individual counts of neutrophils and lymphocytes, did not show statistically significant associations with in-hospital mortality in this multivariate model. These findings underscore the importance of CF, CKD, COPD, age, and NLR as independent predictors of mortality in patients with CAP. (Table 4)

Table 3. Association of Independent Variables with In-Hospital Mortality (N = 108)

Variable	Survived (n)	Died (n)	Total	p-value	OR (95% CI)
Age 18–40	12	2	14		Reference
Age 41–60	64	5	69	0.000	1.20 (1.03–4.81)
Age ≥61	19	6	25		7.79 (1.69–35.92)
Male	62	8	70	0.665	1.20 (0.52–2.79)
Current smoker	60	9	69	0.156	1.86 (0.78–4.43)
Diabetes mellitus	25	5	30	0.010	3.10 (1.29–7.44)
Chronic kidney disease (CKD)	13	4	17	0.001	0.16 (0.05–0.49)
Cardiac failure (CF)	14	3	17	0.000	13.80(3.64–52.35)
Ischemic heart disease (IHD)	29	3	32	0.007	3.17 (1.34–7.51)
Chronic obstructive pulmonary disease (COPD)	30	9	39	0.000	4.66 (1.99–10.93)
Hypertension	3	1	4	0.499	1.97 (0.27–14.59)
NLR ≥7.12	64	8	72	0.040	1.63 (1.07–3.82)

Table 4. Multivariate Logistic Regression Analysis for In-Hospital Mortality (N = 108)

Variables	Adjusted OR	95% CI	p-value
CKD	5.634	(1.150-27.602)	0.033*
Age	1.066	(1.007-1.119)	0.029*
COPD	4.366	(1.289-14.792)	0.018*
CF	36.868	(5.566 -244.215)	0.000*
Female	1.664	(.296-10.281)	583
Current smoker	.760	(.117-4.944)	774
DM	2.099	(.462-9.545)	0.05
WBC	.997	(0.186-5.362)	0.998
CURB65	9.762	(0.0676-92.567)	0.037
Neutrophil	2.367	(0.570-4.387)	0.044
lymphocyte	0.087	(0.007-120.35)	0.997
NLR	1.337	(1.023 -1.745)	0.033*

The CURB-65 score demonstrated the highest discriminative ability, with an Area Under the Curve (AUC) of 0.959, indicating excellent predictive performance. The neutrophil-to-lymphocyte ratio (NLR) also demonstrated substantial prognostic value, with an AUC of 0.905, indicating that it is a reliable marker for mortality risk in severe CAP. These findings underscore the potential of NLR as a valuable adjunct to established clinical scoring systems, such as CURB-65, in stratifying mortality risk among patients with severe CAP. (Figure-1)
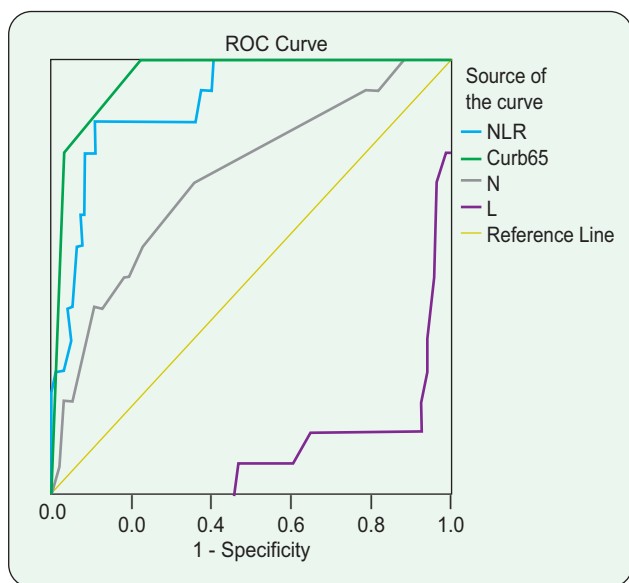

Figure 1: *ROC Curve for Prediction of In-Hospital Mortality*

Discussion

This prospective observational study evaluated the predictive value of the neutrophil-to-lymphocyte ratio (NLR) for in-hospital mortality among patients with severe community-acquired pneumonia (CAP) admitted to Dhaka Medical College Hospital. The findings demonstrate that an elevated NLR ($\geq$7.12) at admission is significantly associated with increased mortality, underscoring its potential as a prognostic biomarker in severe CAP.

We observed that 67% of patients had NLR $\geq$7.12, with a 12% in-hospital mortality rate. The mean NLR was significantly higher in non-survivors (8.60 ± 2.70) compared to survivors, supporting the association between NLR and poor outcomes. These results align with prior studies linking elevated NLR to adverse prognosis in infectious diseases, including CAP.[8,9]

Multivariate logistic regression confirmed NLR as an independent predictor of mortality (adjusted OR: 1.337; 95% CI: 1.023–1.745; p = 0.033), even after adjusting for age, chronic kidney disease (CKD), chronic obstructive pulmonary disease (COPD), and cardiac failure (CF). This finding is consistent with: A 2022 meta-analysis (NLR >10: OR 3.21, 95% CI 2.15–4.80)[10]; Huang et al. (NLR $\geq$8.5: adjusted OR 2.89, 95% CI 1.76–4.74)[11]; and Cataudella et al. (NLR >7.0: HR 1.98, 95% CI 1.32–2.97).[12]

Among comorbidities, cardiac failure (adjusted OR = 36.868, p < 0.001), COPD (adjusted OR = 4.366, p = 0.018), CKD (adjusted OR = 5.634, p = 0.033), and age (adjusted OR = 1.066/ year, p = 0.029) were independently predictive of mortality. These associations corroborate existing literature.[15-17] Interestingly, CKD appeared protective in univariate analysis (OR 0.16; p = 0.001) but emerged as a significant risk factor in the multivariate model. This may be due to a discrepancy likely reflecting confounding; high-risk comorbidities, such as cardiac failure and COPD, were more prevalent in the non-CKD group. After adjusting, the independent contribution of CKD to mortality became apparent.

The prognostic utility of NLR. Further supported by the Receiver Operating Characteristic (ROC) curve analysis, an area under the curve (AUC) of 0.905 indicates excellent discriminative ability. Meanwhile, the CURB-65 score demonstrated a slightly higher AUC of 0.959. Adding NLR could enhance risk stratification, particularly in settings where comprehensive scoring systems are not feasible. Our findings align with recent studies of NLR's AUC values, which range from 0.82 to 0.91 for mortality prediction in pneumonia patients.[18] CURB-65 typically shows superior AUC (0.89-0.96) but requires more clinical parameters.[19]

Combined models (NLR + clinical scores) improve predictive power over either alone.[20]

A study by Ge et al. (2019)[21] reported a lower NLR AUC (0.81) compared to ours (0.905), possibly due to differences in populations, study design, or NLR cutoff values.

Limitations

The sample size was small, which may have resulted in a lack of representativeness. While excluding patients with tuberculosis, malignancy, or immunosuppression helped reduce potential confounders affecting NLR, it may limit the generalizability of our findings to the broader population of CAP patients with complex comorbid backgrounds. Although no patients were lost to follow-up during hospitalization, selection bias may still be present, as only admitted patients in a tertiary care hospital were included. Therefore, the findings may not be fully generalizable to primary care or outpatient patients.

Strengths

Despite these limitations, the prospective design and robust statistical analyses strengthen the validity of our findings. We showed the independent predictive value of NLR in CAP, which may be a helpful adjunct in clinical decision-making, especially in resource-limited settings.

Conclusion

The NLR could be useful in emergency and resource-limited settings due to its simplicity and cost-effectiveness.

References

1. Restrepo MI, Faverio P, Anzueto A. Long-term prognosis in community-acquired pneumonia. *Curr Opin Infect Dis.* 2013;26(2):151–8. https://doi.org/10.1097/QCO.0b013e32835ebc6d

2. Khan MA, Rahman S, Ahmed T, Chowdhury F, Sultana N. Community acquired pneumonia in Bangladesh: Sensitivity pattern, clinical courses and outcome of a cross-sectional population. *Asian J Med Health.* 2022;20(10):31-40.

3. Cillóniz C, Torres A, Niederman MS, et al. Community-acquired pneumonia: Risk stratification and diagnostic strategies. *Curr Opin Pulm Med.* 2018;24(3):227–34. https://doi.org/10.1097/MCP.0000000000000478

4. Siempos II, Vardakas KZ, Kopterides P, Falagas ME. Adjunctive therapies for community-acquired pneumonia: A systematic review. *J Antimicrob Chemother.* 2008;62(4):661–8. https://doi.org/10.1093/jac/dkn283

5. 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;84:106504. https://doi.org/10.1016/j.intimp.2020.106504

6. Kuikel BK, Shah A, Shrestha M, Poudel RS. Prognostic role of neutrophil-to-lymphocyte ratio in community-acquired pneumonia: A prospective observational study. *Ann Med Surg.* 2022;76:103564. https://doi.org/10.1016/j.amsu.2022.103564

7. Infectious Diseases Society of America (IDSA). Clinical Practice Guidelines for the Management of Community-Acquired Pneumonia in Adults. *Clin Infect Dis.*

8. Lee JH, Park JY, Kim MJ, Lee HS, Kim JH, Lee YJ. Neutrophil to lymphocyte ratio at admission predicts the prognosis of patients with community-acquired pneumonia. *Korean J Intern Med.* 2016;31(6):1110–6.

9. Zahorec R. Neutrophil-to-lymphocyte ratio, past, present and future perspectives. Bratisl Lek Listy. 2021;122(7):474-488. doi: 10.4149/BLL_2021_078. PMID: 34161115.

10. Liu X, Shen Y, Wang H, et al. Prognostic significance of neutrophil-to-lymphocyte ratio in patients with sepsis: a systematic review and meta-analysis. J Intensive Care Med. 2021;36(5):497-507. https://doi.org/10.1177/0885066620917958

11. Huang Y, Liu A, Liang L, et al. Diagnostic value of blood parameters for community-acquired pneumonia. Int Immunopharmacol. 2018;64:10-15. https://doi.org/10.1016/j.intimp.2018.08.02

12. Cataudella E, Giraffa CM, Di Marca S, et al. Neutrophil-to-lymphocyte ratio: an emerging marker predicting prognosis in elderly adults with community-acquired pneumonia. J Am Geriatr Soc. 2017;65(8):1796-1801. https://doi.org/10.1111/jgs.148941

13. Güell E, Martín-Fernandez M, De la Torre MC, Palomera E, Serra M, Martinez R, et al. Impact of Lymphocyte and Neutrophil Counts on Mortality Risk in Severe Community-Acquired Pneumonia with or without Septic Shock. *J Clin Med.* 2019;8(5):754. https://doi.org/10.3390/jcm8050754

14. Yoon NB, Son C, Um SJ. Role of the neutrophil–lymphocyte count ratio in the differential diagnosis between pulmonary tuberculosis and bacterial community-acquired pneumonia. *Ann Lab Med.* 2013;33(2):105–10.

15. de Jager CP, van Wijk PT, Mathoera RB, de Jongh-Leuvenink J, van der Poll T, Wever PC. Lymphocytopenia and neutrophil-lymphocyte count ratio predict bacteremia better than conventional infection markers in an emergency care unit. *Crit Care.* 2010;14(5):R192.

16. Yoon NB, Son C, Um SJ. Role of the neutrophil-lymphocyte count ratio in the differential diagnosis between pulmonary

tuberculosis and bacterial community-acquired pneumonia. *Ann Lab Med*. 2013;33(2):105-110. https://doi.org/ 10.3343/alm.2013.33.2.105

17. Chalmers JD, Singanayagam A, Akram AR, et al. Severity assessment tools for predicting mortality in hospitalised patients with community-acquired pneumonia. *Thorax*. 2010;65(10):878-883. https://doi.org/10.1136/thx.2009.133280

18. Liu X, Shen Y, Li Z, et al. Prognostic significance of neutrophil-to-lymphocyte ratio in patients with sepsis: a prospective observational study. *Mediators Inflamm*. 2016;2016:8191254. https://doi.org/10.1155/2016/8191254

19. Ge YL, Zhang HF, Zhang Q, Zhu XY, Liu CH, Wang N, et al. Neutrophil-to-Lymphocyte Ratio in Adult Community-Acquired Pneumonia Patients Correlates with Unfavorable Clinical Outcomes. *Clin Lab*. 2019;65(5). doi: 10.7754/Clin.Lab.2018.181042. PMID: 31115235.