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RESEARCH ARTICLE

Cetin et al: ICU mortality prediction in pneumonia

Advancing ICU mortality prediction in community-acquired pneumonia: Combining fibrinogen-to-albumin ratio, CT severity score, PSI, and CURB-65

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ABSTRACT

Community-acquired pneumonia (CAP) is a leading cause of ICU admissions, with significant morbidity and mortality. Traditional risk stratification tools such as CURB-65, the Pneumonia Severity Index (PSI), and CT severity scores (CT-SS) are widely used for prognosis but could be improved by incorporating novel biomarkers. This retrospective study evaluated the fibrinogen-to-albumin ratio (FAR) as an additional predictor of 30-day mortality in ICU patients with CAP. A total of 158 CAP patients admitted to a tertiary care ICU were included. Baseline data encompassed demographic, clinical, laboratory, and radiological parameters, including FAR, CURB-65, PSI, and CT-SS. Logistic regression and ROC curve analyses were conducted to assess mortality predictors. The 30-day mortality rate was 70.88% (112/158). Higher FAR, PSI, CURB-65, CT-SS, and lactate levels were independently associated with increased mortality ($p < 0.05$). FAR demonstrated strong discriminatory power (AUROC: 0.704) and significantly improved the predictive accuracy of established models. Adding FAR to PSI increased the area under the receiver operating characteristic (AUROC) from 0.705 to 0.791 ($p = 0.009$), while combining FAR, CT-SS, and PSI yielded the highest predictive accuracy (AUROC: 0.844, $p = 0.032$). These findings suggest that FAR, which reflects both inflammation and nutritional status, complements traditional risk assessment tools by providing a dynamic perspective. Integrating FAR into existing models enhances the identification of high-risk patients, enabling timely interventions and more efficient resource allocation in the ICU.

Keywords: Community-acquired pneumonia; CAP; fibrinogen-to-albumin ratio; FAR, CT severity score, CT-SS; Pneumonia Severity Index; PSI

INTRODUCTION

Community-acquired pneumonia (CAP) continues to be a significant contributor of morbidity and mortality worldwide, especially among critically illidividuals admitted to intensive care units (ICUs). The etiology of CAP differs by region, comorbidities, and antimicrobial resistance. Common bacterial pathogens include *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Mycoplasma pneumoniae*, *Legionella pneumophila*, and *Chlamydia pneumoniae*, while viral causes such as influenza, respiratory syncytial virus (RSV) and adenovirus are significant, particularly in immunocompromised patients and seasonal outbreaks. Despite advances in antimicrobial therapy, supportive care, and the implementation of various preventive strategies, CAP mortality remains unacceptably high, necessitating robust prognostic tools to guide early intervention and optimize resource allocation [1-3]. In this context, traditional prognostic indexes like pneumonia severity index (PSI), CURB-65, and imaging-based assessments are commonly employed to stratify mortality risk in CAP patients [4,5]. However, limited data exist on the impact of incorporating biochemical markers such as fibrinogen-to-albumin ratio (FAR) into these models, despite their potential to improve predictive accuracy.

The PSI and CURB-65 are two well-established risk stratifying tools recommended to complement clinical judgment in decision-making. Both scoring systems are well-defined as tools to predict short-term mortality in CAP patients [6]. PSI primarily aims to identify low-risk patients suitable for outpatient management, focusing on safely minimizing unnecessary hospitalizations. CURB-65 was initially developed to identify high-risk patients requiring more intensive care and was later adapted to stratify patients into three severity levels, guiding management with progressively increasing intensities of medical care [4,7]. PSI integrates multiple clinical variables such as age, comorbidities, and laboratory findings to estimate 30-day mortality risk, whereas CURB-65 is solely rely on altered mental status, urea levels, systolic blood pressure, respiratory rate, and older age. Imaging-based assessments, such as the computed tomography severity score (CT-SS), are increasingly used to evaluate the extent of lung involvement, particularly in COVID-19-related pneumonia, providing a visual measure of disease severity that has been shown to correlate with clinical outcomes. Combining such objective metrics with biochemical markers like FAR may hold the potential to further improve predictive accuracy.

The pathophysiology of CAP involves a complex interaction between inflammation, infection, and host response. Fibrinogen is an acute-phase reactant that increases during

systemic inflammation, contributes to the clotting process, and hence is part of the inflammatory cascade. High levels of fibrinogen have been associated with poor outcomes in several diseases characterized by inflammation, including stroke associated pneumonia, aortic aneurysm, and tumoral diseases [8-12]. Contrary to fibrinogen, serum albumin has been depicted as a marker of nutritional and inflammatory status; its concentration decreases in systemic inflammation and infection. Low albumin levels have been linked to adverse clinical outcomes, such as prolonged hospital stays, organ failure, and increased mortality [13]. The ratio of FAR is considered a composite marker representing the dual dimensions of inflammation and nutrition, allowing a more nuanced assessment of disease severity compared to either marker alone [14]. Hence, FAR, as an early serum biomarker, could aid in the early identification of CAP patients at high risk of in-hospital mortality. It may also improve prognostication and provide more informed decision-making regarding ICU management and treatment strategies.

The primary objective of this study is to develop a reliable forecasting model that accurately predicts whether the addition of FAR to PSI, CURB-65, and CT-SS will improve their predictive performance with regard to mortality in ICU patients with CAP. Secondary endpoints are the contribution of each component to the whole model and assessment of their utility in guiding clinical decision-making. These findings have critical implications for personalized patient care as it would provide the clinician with the opportunity to tailor interventions based on a more precise assessment of mortality risk.

MATERIALS AND METHODS

Study design, definition of CAP and exclusion criteria

All patients with CAP who were admitted to Internal Medicine ICU between September 2021 and December 2023 were retrospectively analyzed (n = 497). CAP was defined as the presence of a new infiltrate on chest radiography along with at least one of the following clinical signs: fever (≥38.0°C) or hypothermia (≤36.0°C); a new cough, with or without sputum production; pleuritic chest pain; shortness of breath; or abnormal breath sounds detected during auscultation., with no alternative diagnosis identified during follow-up. Patients who were younger than 18, pregnant women, those for whom treatment was implemented due to a change in diagnosis, patients diagnosed with pulmonary embolism, aspiration pneumonia and COVID-19 pneumonia, those who hospitalized in ICU<24 hours, those who had severe immunosuppression and trauma patients were excluded from the study. Moreover, patients were excluded if a computed tomography (CT) scan could not be performed due to patient instability, the presence of concurrent injuries, or contraindications to CT imaging. Patients who did not meet the exclusion criteria were considered eligible for inclusion in the study. A comprehensive flowchart illustrating the selection process of the study population, including patient recruitment and exclusion criteria, is presented in Figure 1.

Data collection

Baseline data, including clinical, laboratory, and demographic features as well as the length of hospital stays were collected. In addition, information on comorbidities, source of ICU admission, laboratory parameters and CT scans were extracted. Cardiopulmonary parameters during the first 24 hours, interventions administered including antibiotics and mechanical ventilation, treatment protocols and intrahospital mortality at discharge were also retrieved from the hospital's electronic health records.

Laboratory analysis

Hemogram, biochemical parameters including serum glucose, total bilirubin, blood urea nitrogen, creatinine, initial serum lactate, fibrinogen, total protein, ALT, AST and lactate dehydrogenase were noted for each study subjects. Clinical examinations and initial laboratory tests were performed within twelve hours of ICU admission. All patients were monitored from the time of admission until their discharge from the hospital or death.

Screening tools to predict mortality

Clinical severity of patients were measured by four scoring systems; FAR, PSI, CURB-65 and CT-SS. FAR was calculated using the SPSS statistical software by dividing the fibrinogen concentration (mg/dL) by the albumin concentration (g/L). PSI was initially proposed by Fine et al. [15] and includes three demographic variables, five comorbidities, five physical examination variables, six laboratory tests an done radiographic findings namely pleural effusion. The normal range for the PSI is between 8 and 90 points. Scores between 91 and 130 indicate a moderate risk, while scores above 130 are associated with a high risk of mortality. CURB-65 score is a six-point score, with one point for each of: confusion; urea >7 mmol/l; respiratory rate ≥30/min; blood pressure (systolic or diastolic ≤60 mmHg); and age ≥65 years. The criteria, along with being over 65 years old, are collectively abbreviated as CURB-65. Each criterion is assigned one point if present. CT-SS was determined by assessing the degree of lobe involvement for each of the five lung lobes separately on a scale of 0–5 as suggested by Chang et al. [16]. A score of 0 identified no involvement, 1 identified less than 5%, 2 identified 5–25%, 3 identified 26–49%, 4 identified 50–75%, and 5 identified more than 75% involvement. The scores of all five lobes were summed, resulting in a total lung CT score ranging from 0 (no involvement) to 25 (maximum involvement).

Outcome measures and mortality

The primary outcome was the time to mortality within 30 days following ICU admission. For patients who were discharged from the hospital or completed critical care within 30 days but lacked hospital outcome data, it was presumed that they survived up to the 30-day mark.

Ethical statement

This study was approved by the Canakkale Onsekiz Mart University (Approval No: 2023/14-18) ethical committe. Due to the retrospective design of this study, the need for obtaining informed consent was waived.

Statistical analysis

Categorical variables were presented as frequencies and percentages (%), whereas mean and standard deviation (SD) were used to summarize continuous variables. The Shapiro-Wilk test was used to check for the normality of the continuous variables. The difference in proportions between groups was calculated by the Chi-Square or Fisher's exact tests, as appropriate. The t-test was applied for comparisons of continuous variables between two independent groups. Odds ratios (OR) together with 95% confidence intervals (CI) for

independent clinical parameters were derived from univariate and multivariate logistic regression models for predicting 30-day mortality. To examine the association between risk factor distributions and survival outcomes, multivariable Cox proportional hazards models were employed. Results were reported as hazard ratios (HR) with 95% confidence intervals (95% CI). Receiver operating characteristic (ROC) analysis was performed to calculate the area under the curve (AUROC) with 95% confidence intervals for study parameters in predicting 30-day mortality. Pairwise comparisons of AUROCs were performed using the DeLong test. All statistical analyses were carried out using SPSS version 19.0 for Windows (IBM Corp., Armonk, NY, USA) and R software version 3.6.2. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 497 CAP patients who were admitted to our ICU between September 2021 and December 2023 were initially enrolled in the study. 339 patients were excluded due to lack of inclusion criteria. Therefore, the final analysis was conducted on 158 patients (Fig. 1). Among the 158 patients in the study sample, 85 (53.8%) were men and 73 (46.2%) were female. The mean age of the patients was 75.03 (±SD 13.41) years (Table 1).

The baseline characteristics of the patients grouped by their survival status are provided in Table 2. Serum urea (84.4 ± 57.4 mg/dl vs. 109.2 ± 62.6 mg/dl, P = 0.010), ferritin (489.2 ± 577.5 ng/mL vs. 702.6 ± 642.9 ng/mL, P = 0.007), procalcitonin (8.7 ± 24.6 ng/ml vs. 12.6 ± 24.3 ng/ml, P <0.001), and lactate (1.8 ± 1.5 mmol/L vs. 2.8 ± 2.2 mmol/L, P =0.002) were statistically different between 30-day survivors and 30-day non-survivors. All of the scores were significantly higher in non-survivors than in survivors (PSI: 122.2 ± 35.2 vs. 140.2 ± 31.6, P =0.004; CURB-65: 2.2 ± 0.9 vs. 3.0 ± 0.8, P < 0.001; CT-SS: 7.4 ± 4.2 vs 10.7 ± 4.8, P < 0.001; FAR: 0.137 ± 0.061 vs 0.199 ± 0.098 P < 0.001).

In this study, we also analyzed predictors of mortality using univariable and multivariable logistic regression analyses (Table 3). Among the 158 ICU patients with CAP, the overall 30-day mortality rate was 70.9%. Higher FAR values, PSI, CURB-65, and CT severity scores were significantly associated with increased mortality ($p < 0.05$). Univariable analysis revealed that increases in PSI, CURB-65 and CT-SS score, FAR, urea, and lactate levels were significantly associated with higher mortality. Multivariable analysis further confirmed that FAR, CURB-65, CT-SS, and lactate remained independent predictors of mortality. Among these, FAR exhibited the strongest association (OR 74.14 (17.74–3097.59), p<0.001), highlighting its potential as a critical biomarker for assessing mortality risk in this patient population.

Receiver operating characteristic curve (ROC) curve analysis was conducted to assess the ability of various laboratory parameters in conjunction with severity scores to predict mortality in ICU-admitted CAP patients. Among these, the best cut-off value for FAR to predict mortality was found to be ≥ 0.160 with a sensitivity of 62.5 (52.9–71.5)% and a specificity of 69.6 (54.3–82.3)%, while for PSI, the best cut-off value was ≥ 132 with a sensitivity of 60.7 (51.0–69.8)% and a specificity of 63.0 (47.6–76.8)%, for CURB-65 cut-off value was ≥ 3 with a sensitivity of 79.5 (70.8–86.5)% and a specificity of 63.0 (47.6–76.8)%. Furthermore, PCT (≥0.9) demonstrated the highest sensitivity (77.7%) with moderate specificity (56.5%), while CT-SS (≥8) showed good positive predictive value (79.8%) and

sensitivity (70.5%). CURB-65 (≥3) also exhibited a strong predictive performance with an AUROC of 0.718. These findings suggest that these parameters, can serve as useful tools in identifying high-risk patients at ICU admission. Detailed results for all parameters are presented in Table 4.

In the final step we analyzed the impact of FAR, PSI and CURB-65 on the discriminating accuracy of different mortality models and presented in table 5. Initially, a base model was created to identify patients at high mortality risk, considering factors such as advanced age, male gender, and elevated lactate levels. Pairwise analysis showed that adding FAR significantly improved the discrimination accuracy of base model (AUROC increased from 0.684 to 0.776, p = 0.015), Combining FAR to base model+CT-SS and base model+PSI also showed a significant higher accuracy in predicting mortality (DBA –0.057, P =0.037 and DBA:-0.086, p=0.009 respectively) (Figure 2). Thus, combining FAR to base model+PSI+CT-SS stunningly demonstrated a significant accuracy in predicting mortality (DBA:-0.055, p= 0.032). These findings highlight FAR's value in refining the predictive power of mortality models in ICU patients (Table 5).

Cumulative hazard functions for predicting mortality based on various clinical parameters in CAP patients admitted to the ICU were also analyzed. Higher FAR (≥0.160), PSI (≥132), CT-SS (≥8), and CURB-65 (≥3) were significantly associated with increased cumulative hazard over time ($p<0.001$ for all comparisons) (Figure 3).

DISCUSSION

In the present study, we investigated the potential benefit of integrating FAR with PSI, CURB-65, and CT-SS to create a more comprehensive prognostic model for ICU patients with CAP. By combining these three dimensions—biochemical, clinical, and imaging-based measures—we aimed to overcome the limitations of existing models and explore methods to enhance mortality prediction in high-risk populations. Our hypothesis was that the FAR, as a dynamic marker representing both inflammation and nutritional status, could complement the static characteristics of PSI and CURB-65 as well as the anatomical focus of the CT-SS to offer a more comprehensive assessment of patient risk.

Our findings revealed that FAR, CURB-65, and CT-SS are significantly associated with 30-day mortality, as demonstrated by crude and adjusted multivariable logistic regression analyses. Although PSI did not demonstrate a significant predictive capability as a standalone marker, it improved the prognostic ability of FAR across various prognostic models, as indicated in Table 5. Furthermore, FAR also significantly improved the prognostic ability of CT-SS across various prognostic models either with or without PSI. Adding FAR to the PSI increased the AUROC from 0.705 to 0.791 ($p = 0.009$), while combining FAR with CT-SS and PSI yielded the highest performance (AUROC: 0.844, $p = 0.032$). Our findings therefore highlight the importance of incorporating a validated laboratory tool into well-established risk stratification systems to enhance the assessment of severe critical deterioration risk in CAP patients admitted to the ICU.

The ratio of fibrinogen to albumin is a new type of biomarker for the balance between systemic inflammation and nutritional status. As a newly emerging index, FAR has garnered significant attention in recent years. Its utility lies in its ability to reflect inflammatory changes more precisely because it combines the increasing trend of fibrinogen and the decreasing trend of albumin during inflammation. This dynamic relationship makes FAR a reliable marker for detecting and monitoring the severity of inflammatory processes. Indeed, previous studies have already shown that FAR is useful as a prognostic marker for conditions such as sepsis, cardiovascular disease, and malignancies [17-20]. However, its role in forecasting outcomes in ICU patients with CAP remains an underexplored area.

In this study, we demonstrated that FAR is a valuable standalone marker and its integration into existing prognostic models markedly enhances their predictive accuracy. Furthermore, our ROC analysis demonstrated FAR's strong discriminatory power [AUROC: 0.704 (0.619–0.789)], comparable to established scores like PSI [AUROC: 0.634 (0.541–

0.726)] and CURB-65 [AUROC: 0.718 (0.628–0.809)]. Although there is no data in the literature regarding the effect of FAR on mortality prediction when combined with other scoring systems, several papers have stated the importance of FAR for mortality prediction in CAP patients. In a recent study by Luo et al. [21], a significant increase in FAR was observed in patients with CAP, where FAR demonstrated greater predictive accuracy for CAP severity compared to fibrinogen alone. Additionally, FAR correlated positively with high-sensitivity CRP and the CURB-65 score. These findings suggest that FAR could serve as a valuable marker for assessing the severity of CAP and might enhance existing prognostic tools.

This study also explored the individual and combined predictive value of distinct scoring systems in ICU patients with CAP. We evaluated the overall performance of the PSI, CURB-65, and CT-SS in their ability to predict 30-day mortality. We conducted ROC curve analysis to calculate the AUC for both PSI and CURB-65 as well as CT-SS to evaluate their ability to distinguish patients who will not survive one month after admission to ICU. For CAP patients, we determined that a CURB-65 score ≥ 3 and PSI ≥ 132 indicated a significant risk of death. Moreover, the AUCs for the PSI and CURB-65 to predict mortality in CAP patients were 0.634 (0.541–0.726) and 0.718 (0.628–0.809), respectively, which is comparable to previous studies by Gonzalez et al. [22] and Bradley et al. [23]

Additional studies have indicated that CURB-65 and PSI are effective tools for predicting mortality in CAP patients [24]. Both systems are well-known severity scores for predicting mortality secondary to CAP and are widely used to identify patients who can be managed as outpatients. The major strength of CURB-65 is its simplicity because it uses easily available clinical and laboratory parameters and is therefore accessible for quick decision-making. Moreover, CURB-65 provides unequivocal thresholds for the clinician to decide on ICU admission or more aggressive therapeutic intervention, like invasive ventilation or vasopressors. Notwithstanding its usefulness, CURB-65 focuses on physiological and demographic factors without taking into consideration comorbidities or radiological findings that might influence the outcomes in CAP [24-26].

Conversely, PSI is a more comprehensive score that integrates demographic information, comorbidities, vital signs, laboratory values, and radiological findings to yield a point-based score. The risk classes include five categories, with higher scores corresponding to greater mortality. Unlike CURB-65, which is primarily designed to identify patients at high risk for mortality, PSI was designed to identify patients at low risk for mortality and provides a better evaluation, especially regarding certain chronic diseases, such as chronic liver or renal disease [24]. However, PSI is complex, requiring more time to collect data and make

calculations; hence, it is not very practical in a resource-limited setting. Several studies have demonstrated that higher scores in PSI are related to an increased risk of complications like septic shock and multi-organ failure, thus signifying its predictive value [27,28].

The CT-SS complements CURB-65 and PSI by assessing the degree of pulmonary involvement with radiological imaging. CT-SS scores the extent of lobe involvement from 0 (no involvement) to a maximum of 25 (maximum involvement). Unlike CURB-65 and PSI, CT-SS quantifies the extent of lung involvement directly. This score provides critical insights into the extent of pneumonic infiltration in the lungs, with higher scores correlating with severe hypoxemia, heightened inflammatory burden, and increased mortality risk. Unfortunately, there is insufficient data regarding the use of CT-SS in CAP, and studies on this topic are predominantly related to COVID-19 pneumonia [29,30]. For this reason, we believe that this study holds significant value. Incorporating this score into our study gives us a visual and measurable parameter reflecting disease progression. In particular, we identified a CT-SS of ≥ 8 as a threshold for increased mortality risk with a specificity and sensitivity of 56.5 % and 70.5 %, respectively. Comparable to our study, Bardakci et al. [31] proposed a cut-off level of > 10 (specificity 79.7%, sensitivity 82.3 %) as the threshold for increased mortality risk in their COVID-19 pneumonia patients (AUROC: 0.708 [0.620–0.795]; sensitivity: 70.5 [61.2–78.8]; specificity: 56.5 [41.1–71.1]).

Although this study highlights the significance of utilizing risk stratification tools in combination with one another, the findings should be interpreted with an awareness of their limitations. Firstly, the retrospective design may introduce selection bias, and external validation in larger, more diverse cohorts is necessary to generalize these findings. Secondly, the dynamic nature of CAP progression warrants the exploration of temporal changes in FAR and other parameters to further refine predictive accuracy. Lastly, our study was conducted in a single tertiary care center; hence, the sample population was relatively small and might not represent the general population.

CONCLUSION

In conclusion, combining FAR with established clinical and radiological scores such as PSI, CURB-65, and CT-SS increases the accuracy of mortality prediction in ICU patients with CAP. The addition of laboratory markers such as FAR to existing models offers a more holistic approach toward risk stratification and helps in making timely decisions on resource allocation in the critical care setting.

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REFERENCES

1. Metlay JP, Waterer GW, Long AC, Anzueto A, Brozek J, Crothers K, et al. Diagnosis and Treatment of Adults with Community-acquired Pneumonia. An Official Clinical Practice Guideline of the American Thoracic Society and Infectious Diseases Society of America. Am J Respir Crit Care Med. 2019 Oct 1;200(7):e45-e67

2. Mandell LA, Wunderink RG, Anzueto A, Bartlett JG, Campbell GD, Dean NC, et al.. Infectious Diseases Society of America/American Thoracic Society consensus guidelines on the management of community-acquired pneumonia in adults. Clin Infect Dis. 2007 Mar 1;44 Suppl 2(Suppl 2):S27-72.

3. Guo Q, Li HY, Song WD, Li M, Chen XK, Liu H et al. Updating cut-off values of severity scoring systems for community-acquired pneumonia to orchestrate more predictive accuracy. Ann Med. 2023 Dec;55(1):2202414.

4. Barlas RS, Clark AB, Loke YK, Kwok CS, Angus DC, Uranga A, et al. Comparison of the prognostic performance of the CURB-65 and a modified version of the pneumonia severity index designed to identify high-risk patients using the International Community-Acquired Pneumonia Collaboration Cohort. Respir Med. 2022 Aug-Sep;200:106884

5. Nemoto M, Nakashima K, Noma S, Matsue Y, Yoshida K, Matsui H et al. Prognostic value of chest computed tomography in community-acquired pneumonia patients. ERJ Open Res 2020; 6: 00079-2020

6. Ramirez JA, File TM. How to assess survival prognosis in patients hospitalized for community-acquired pneumonia in 2024? Curr Opin Crit Care. 2024 Oct 1;30(5):399-405.

7. Mandell LA, Wunderink RG, Anzueto A, Bartlett JG, Campbell GD, Dean NC et al. Infectious Diseases Society of America; American Thoracic Society. Infectious Diseases Society of America/American Thoracic Society consensus guidelines on the management of

community-acquired pneumonia in adults. Clin Infect Dis. 2007 Mar 1;44 Suppl 2(Suppl 2):S27-72

8. Bender M, Haferkorn K, Tajmiri-Gondai S, Uhl E, Stein M. Fibrinogen to Albumin Ratio as Early Serum Biomarker for Prediction of Intra-Hospital Mortality in Neurosurgical Intensive Care Unit Patients with Spontaneous Intracerebral Hemorrhage. J Clin Med. 2022 Jul 20;11(14):4214.

9. Jomrich G, Yan W, Kollmann D, Kristo I, Winkler D, Puhr H et al. Elevated fibrinogen-albumin ratio is an adverse prognostic factor for patients with primarily resected gastroesophageal adenocarcinoma. J Cancer Res Clin Oncol. 2024 Oct 14;150(10):459

10. Xie Y, Xu X, Wang D, Zhou Y, Kang Y, Lai W et al. Fibrinogen-to-Albumin Ratio and Long-Term Mortality in Coronary Artery Disease Patients with Different Glucose Metabolism Status. Rev Cardiovasc Med. 2023 Nov 16;24(11):317.

11. Lin G, Hu M, Song J, Xu X, Liu H, Qiu L et al. High Fibrinogen to Albumin Ratio: A Novel Marker for Risk of Stroke-Associated Pneumonia? Front Neurol. 2022 Jan 13;12:747118.

12. Kuyumcu MS, Aydın O. Fibrinogen-to-albumin ratio may be a predictor for ascending aortic aneurysm. Rev Assoc Med Bras (1992). 2021 Jun;67(6):868-872

13. Thuemmler RJ, Pana TA, Carter B, Mahmood R, Bettencourt-Silva JH, Metcalf AK, et al. Serum Albumin and Post-Stroke Outcomes: Analysis of UK Regional Registry Data, Systematic Review, and Meta-Analysis. Nutrients. 2024 May 14;16(10):1486

14. Yang S, Pi J, Ma W, Gu W, Zhang H, Xu A et al. Prognostic value of the fibrinogen-to-albumin ratio (FAR) in patients with chronic heart failure across the different ejection fraction spectrum. Libyan J Med. 2024 Dec 31;19(1):2309757.

15. Fine MJ, Auble TE, Yealy DM, Hanusa BH, Weissfeld LA, Singer DE et al. A prediction rule to identify low-risk patients with community-acquired pneumonia. N Engl J Med. 1997 Jan 23;336(4):243-50.

16. Chang YC, Yu CJ, Chang SC, Galvin JR, Liu HM, Hsiao CH et al. Pulmonary sequelae in convalescent patients after severe acute respiratory syndrome: evaluation with thin-section CT. Radiology. 2005 Sep;236(3):1067-75.

17. La Vaccara V, Cammarata R, Coppola A, Farolfi T, Cascone C, Angeletti S et al. Data of postoperative complications related to fibrinogen-to-albumin ratio in pancreatic resections. Data Brief. 2022 Mar 18;42:108064

18. Dong G, Ma T, Xu Z, Zhang M, Hu Y, Yang J et al. Fibrinogen-to-Albumin Ratio in Neonatal Sepsis. Int J Gen Med. 2023 Oct 31;16:4965-4972

19. Huang R, Dai Q, Chang L, Wang Z, Chen J, Gu R et al. The association between fibrinogen-to-albumin ratio (FAR) and adverse prognosis in patients with acute decompensated heart failure at different glucose metabolic states. Cardiovasc Diabetol. 2022 Nov 12;21(1):241.

20. Li R, Song S, He X, Shi X, Sun Z, Li Z et al. Relationship Between Fibrinogen to Albumin Ratio and Prognosis of Gastrointestinal Stromal Tumors: A Retrospective Cohort Study. Cancer Manag Res. 2020 Sep 18;12:8643-8651.

21. Luo B, Sun M, Huo X, Wang Y. Two new inflammatory markers related to the CURB-65 score for disease severity in patients with community-acquired pneumonia: The hypersensitive C-reactive protein to albumin ratio and fibrinogen to albumin ratio. Open Life Sci. 2021 Jan 22;16(1):84-91.

22. Gonzalez C, Johnson T, Rolston K, Merriman K, Warneke C, Evans S. Predicting pneumonia mortality using CURB-65, PSI, and patient characteristics in patients presenting to

the emergency department of a comprehensive cancer center. Cancer Med. 2014 Aug;3(4):962-70

23. Bradley J, Sbaih N, Chandler TR, Furmanek S, Ramirez JA, Cavallazzi R. Pneumonia Severity Index and CURB-65 Score Are Good Predictors of Mortality in Hospitalized Patients With SARS-CoV-2 Community-Acquired Pneumonia. Chest. 2022 Apr;161(4):927-936.

24. Guo Q, Li HY, Song WD, Li M, Chen XK, Liu H et al. Updating cut-off values of severity scoring systems for community-acquired pneumonia to orchestrate more predictive accuracy. Ann Med. 2023 Dec;55(1):2202414.

25. Wen JN, Li N, Guo CX, Shen N, He B. Performance and comparison of assessment models to predict 30-day mortality in patients with hospital-acquired pneumonia. Chin Med J (Engl). 2020 Dec 3;133(24):2947-2952

26. Bahçecioğlu SN, Köktürk N, Baha A, Yapar D, Aksakal FNB, Gunduz C et al. A new scoring system to predict mortality in community-acquired pneumonia: CURB (S)-65. Eur Rev Med Pharmacol Sci. 2023 Jul;27(13):6293-6300.

27. Dremsizov T, Clermont G, Kellum JA, Kalassian KG, Fine MJ, Angus DC. Severe sepsis in community-acquired pneumonia: when does it happen, and do systemic inflammatory response syndrome criteria help predict course? Chest. 2006 Apr;129(4):968-78.

28. Ewig S, de Roux A, Bauer T, García E, Mensa J, Niederman M et al. Validation of predictive rules and indices of severity for community acquired pneumonia. Thorax. 2004 May;59(5):421-7.

29. Esper Treml R, Caldonazo T, Barlem Hohmann F, Lima da Rocha D, Filho PHA, Mori AL et al. Association of chest computed tomography severity score at ICU admission and respiratory outcomes in critically ill COVID-19 patients. PLoS One. 2024 May 2;19(5):e0299390.

30. Akdur G, Daş M, Bardakci O, Akman C, Sıddıkoğlu D, Akdur O et al. Prediction of mortality in COVID-19 through combing CT severity score with NEWS, qSOFA, or peripheral perfusion index. Am J Emerg Med. 2021 Dec;50:546-552.

31. Bardakci O, Daş M, Akdur G, Akman C, Siddikoğlu D, Şimşek G et al. Point-of-care Lung Ultrasound, Lung CT and NEWS to Predict Adverse Outcomes and Mortality in COVID-19 Associated Pneumonia. J Intensive Care Med. 2022 Dec;37(12):1614-1624

TABLES AND FIGURES WITH LEGENDS

Table 1: Clinical and laboratory profiles of ICU patients with community-acquired pneumonia

Variables	All Patients (n=158)
Demographics	
Age (years)	75.03 ± 13.41
Gender (Male, n/%)	85 (53.8)
ICU Admission Vitals	
Heart rate (/min)	102.4 ± 25.5
Respiratory rate (/min)	21.8 ± 6.0
SBP (mmHg)	113.6 ± 25.3
MAP (mmHg)	84.3 ± 17.1
Temperature (°C)	36.6 ± 0.5
Complete Blood Count	
WBC (x10³/uL)	14.5 ± 8.8
Hemoglobin (g/dL)	10.7 ± 2.1
Hematocrit (%)	32.8 ± 6.5
Platelet Count (x10³/uL)	246.6 ± 140.5
Biochemical Measurements	
Glucose (mg/dL)	171.5 ± 100.1
Urea (mg/dL)	101.9 ± 62.0
Creatinine (mg/dL)	2.04 ± 1.60
Total Bilirubin (mg/dL)	0.9 ± 1.2
Fibrinogen (g/dL)	0.49 ± 0.22
Albumin (g/dL)	2.87 ± 0.6
ALT (U/L)	81.1 ± 327.4
AST (U/L)	104.6 ± 317.7
LDH (U/L)	364.6 ± 307.0
CRP (mg/L)	169.1 ± 109.4
Sedimentation Rate (mm/h)	56.5 ± 31.9
Procalcitonin (ng/mL)	11.5 ± 24.4
Illness Acuity Assessment Tools	
PSI	134.9 ± 33.6
CT-SS	9.7 ± 4.9
CURB-65	2.8 ± 0.9
FAR	0.181 ± 0.092
Blood Gas Analysis	
pH	7.35 ± 0.13
HCO3 (mmol/L)	22.2 ± 6.5
Lactate (mmol/L)	2.5 ± 2.1

PSI, Pneumonia Severity Index; CT-SS, CT severity score; *FAR, fibrinogen/albumin Ratio; SBP, systolic blood pressure; MAP, mean arterial pressure*

Table 2. Prognostic factors and survival characteristics in ICU patients with community-acquired pneumonia

Variable	Alive (n=46)	Death (n=112)	P-Value
Demographics			
Age (years)	72.2 ± 17.3	76.2 ± 11.3	0.150
Gender (Male, %)	21 (24.7)	64 (75.3)	0.127
ICU Admission Vitals			
Heart rate (/min)	101.6 ± 24.1	102.7 ± 26.2	0.811
Respiratory rate (/min)	21.7 ± 6.4	21.8 ± 5.8	0.859
SBP (mmHg)	116.3 ± 20.9	112.5 ± 26.8	0.392
MAP, (mmHg)	85.8 ± 15.2	83.7 ± 17.8	0.474
Temperature (°C)	36.5 ± 0.6	36.6 ± 0.5	0.694
Complete Blood Count			
WBC, (x10³/uL)	14.0 ± 8.3	14.7 ± 9.0	0.633
Hemoglobin (g/dL)	10.8 ± 2.4	10.6 ± 2.0	0.462
Platelet Count (x10³/uL)	248.9 ± 122.0	245.6 ± 147.9	0.893
Biochemical Measurements			
Urea (mg/dL)	84.4 ± 57.4	109.2 ± 62.6	0.010
Creatinine (mg/dL)	1.9 ± 1.7	2.1 ± 1.6	0.561
ALT (U/L)	70.9 ± 228.7	85.2 ± 360.9	0.804
AST (U/L)	82.4 ± 260.9	113.6 ± 338.9	0.576
Ferritin	489.2 ± 577.5	702.6 ± 642.9	0.007
CRP (mg/L)	153.4 ± 100.6	175.6 ± 112.6	0.295
Procalcitonin (ng/mL)	8.7 ± 24.6	12.6 ± 24.3	<0.001
Illness Acuity Assessment Tools			
PSI	122.2 ± 35.2	140.2 ± 31.6	0.004
CT-SS	7.4 ± 4.2	10.7 ± 4.8	<0.001
CURB-65	2.2 ± 0.9	3.0 ± 0.8	<0.001
FAR	0.137 ± 0.061	0.199 ± 0.098	<0.001
Blood Gas Analysis			
pH	7.37 ± 0.11	7.33 ± 0.13	0.153
HCO3 (mmol/L)	22.4 ± 5.9	22.1 ± 6.8	0.353
Lactate (mmol/L)	1.8 ± 1.5	2.8 ± 2.2	0.002

PSI, Pneumonia Severity Index; CT-SS, CT severity score; *FAR, fibrinogen/albumin Ratio; SBP, systolic blood pressure; MAP, mean arterial pressure*

Table 3. Univariable and multivariable logistic regression analysis for the prediction of mortality in ICU patients with community-acquired pneumonia

	Death (n=112)			
	Univariable analysis		Multivariable analysis	
	Odds ratio (95% CI)	p value	Odds ratio (95% CI)	p value
Age	1.022 (0.997–1.048)	0.090	-	-
Gender M (ref)	1.587 (0.796–3.166)	0.190	-	-
PSI	1.017 (1.006–1.028)	0.003	-	-
CT Severity Score	1.178 (1.080–1.285)	<0.001	1.197 (1.084–1.321)	0.001
CURB-65	2.531 (1.649–3.887)	<0.001	2.230 (1.331–3.736)	0.002
Procalcitonin (ng/mL)	1.007 (0.991–1.024)	0.378	-	-
FAR	20.10 (9.57–4223.04)	<0.001	74.14 (17.74–3097.59)	<0.001
Urea (mg/dL)	1.007 (1.001–1.014)	0.025	-	-
Lactate (mmol/L)	1.425 (1.087–1.868)	0.010	1.370 (1.029–1.825)	0.031
Ferritin (ng/mL)	1.001 (1.000–1.001)	0.057	-	-

PSI, Pneumonia Severity Index; CT-SS, CT severity score; *FAR, fibrinogen/albumin ratio*

Table 4. Performance of FAR, PSI, CURB-65 and CT-SS in conjunction with selected laboratory parameters for predicting 30-days mortality.

	Cut-off	AUROC (95% CI)	Sensitivity % (95% CI)	Specifity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	Accuracy % (95% CI)
Procalcitonin (ng/mL)	≥ 0.9	0.711 (0.618–0.803)	77.7 (68.8–85.0)	56.5 (41.1–71.1)	81.3 (75.5–86.0)	51.0 (40.4–61.5)	71.5 (63.8–78.4)
FAR	≥ 0.160	0.704 (0.619–0.789)	62.5 (52.9–71.5)	69.6 (54.3–82.3)	83.3 (75.9–88.8)	43.2 (35.9–50.8)	64.6 (56.6–72.0)
Lactate (mmol/L)	≥ 1.6	0.660 (0.570–0.750)	67.0 (57.4–75.6)	52.2 (36.9–67.1)	78.0 (63.1–77.8)	39.3 (30.7–48.7)	62.7 (54.6–70.2)
PSI	≥ 132	0.634 (0.541–0.726)	60.7 (51.0–69.8)	63.0 (47.6–76.8)	80.0 (72.7–85.7)	39.7 (32.4–47.6)	61.4 (53.3–69.0)
CURB-65	≥ 3	0.718 (0.628–0.809)	79.5 (70.8–86.5)	63.0 (47.6–76.8)	84.0 (78.0–88.5)	55.6 (45.2–65.9)	74.7 (67.2–81.3)
CT-SS	≥ 8	0.708 (0.620–0.795)	70.5 (61.2–78.8)	56.5 (41.1–71.1)	79.8 (73.6–84.9)	44.1 (35.0–53.6)	66.5 (58.5–73.8)

PSI, Pneumonia Severity Index; CT-SS, CT severity score; *FAR, fibrinogen/albumin ratio*

Table 5. Impact of LAR, PSI, and CT-SS on the discrimination accuracy of different mortality models

	AUROC (95% CI)	AUROC (95% CI)	Pairwise analysis					
					95%CI			
Prognostic model	Without FAR	With FAR	DBA	SE	Lower	Upper	Z statistic	p
Base Model (Age, Sex, Lactate)	0.684 (0.597–0.771)	0.776 (0.698–0.855)	-0.092	0.287	-0.167	-0.018	-2.422	0.015
CT-SS	0.708 (0.620–0.795)	0.788 (0.713–0.863)	-0.080	0.284	-0.147	-0.014	-2.360	0.018
Base Model + CT-SS	0.780 (0.703–0.857)	0.838 (0.771–0.904)	-0.057	0.267	-0.111	-0.004	-2.091	0.037
PSI	0.634 (0.541–0.726)	0.750 (0.667–0.833)	-0.117	0.296	-0.194	-0.039	-2.956	0.003
Base Model + PSI	0.705 (0.619–0.791)	0.791 (0.714–0.867)	-0.086	0.284	-0.150	-0.022	-2.620	0.009
Base Model + CT-SS + PSI	0.788 (0.713–0.864)	0.844 (0.778–0.909)	-0.055	0.266	-0.105	-0.005	-2.146	0.032

PSI, Pneumonia Severity Index; CT-SS, CT severity score; *FAR, fibrinogen/albumin ratio*

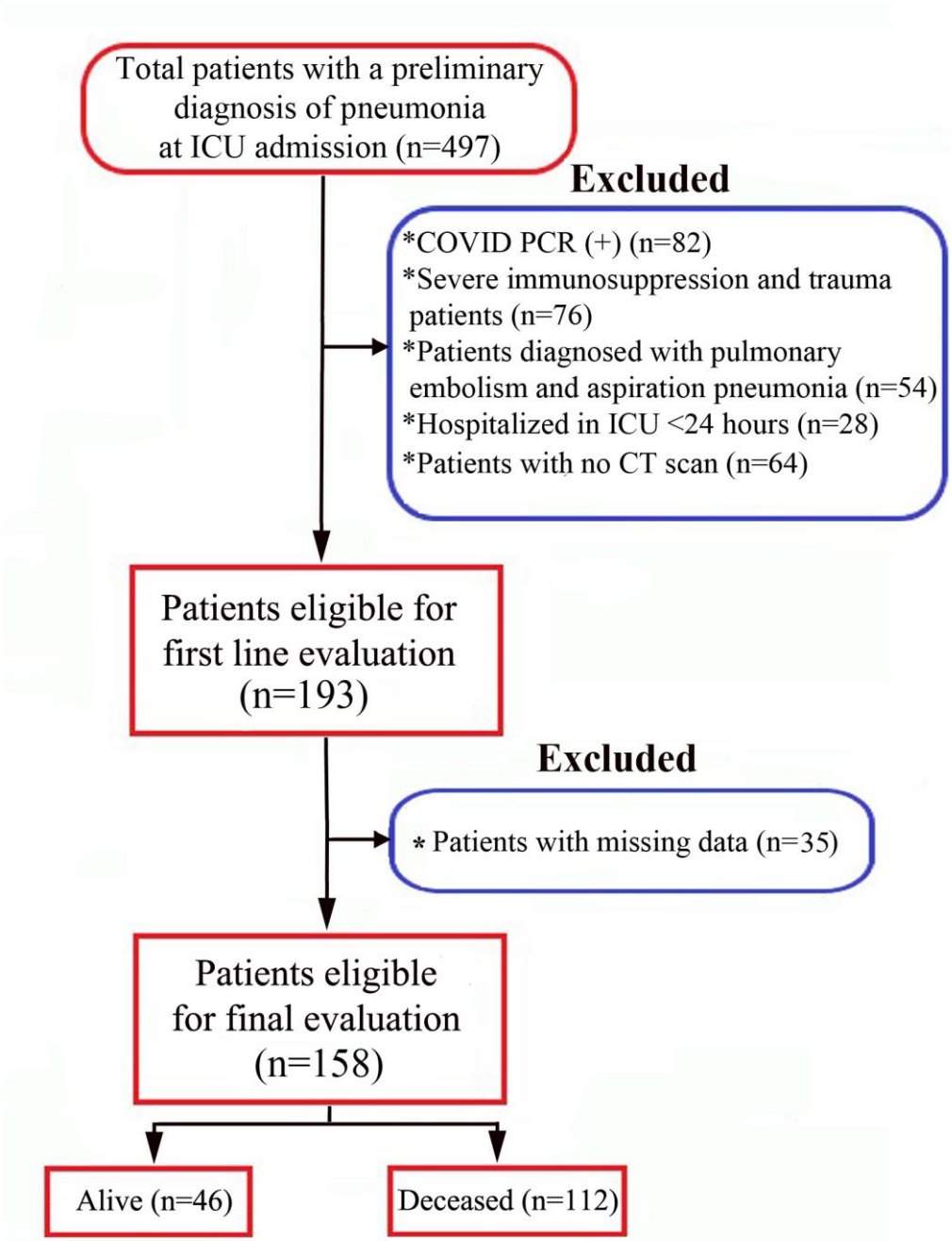

Figure 1. The study flowchart of patient selection.

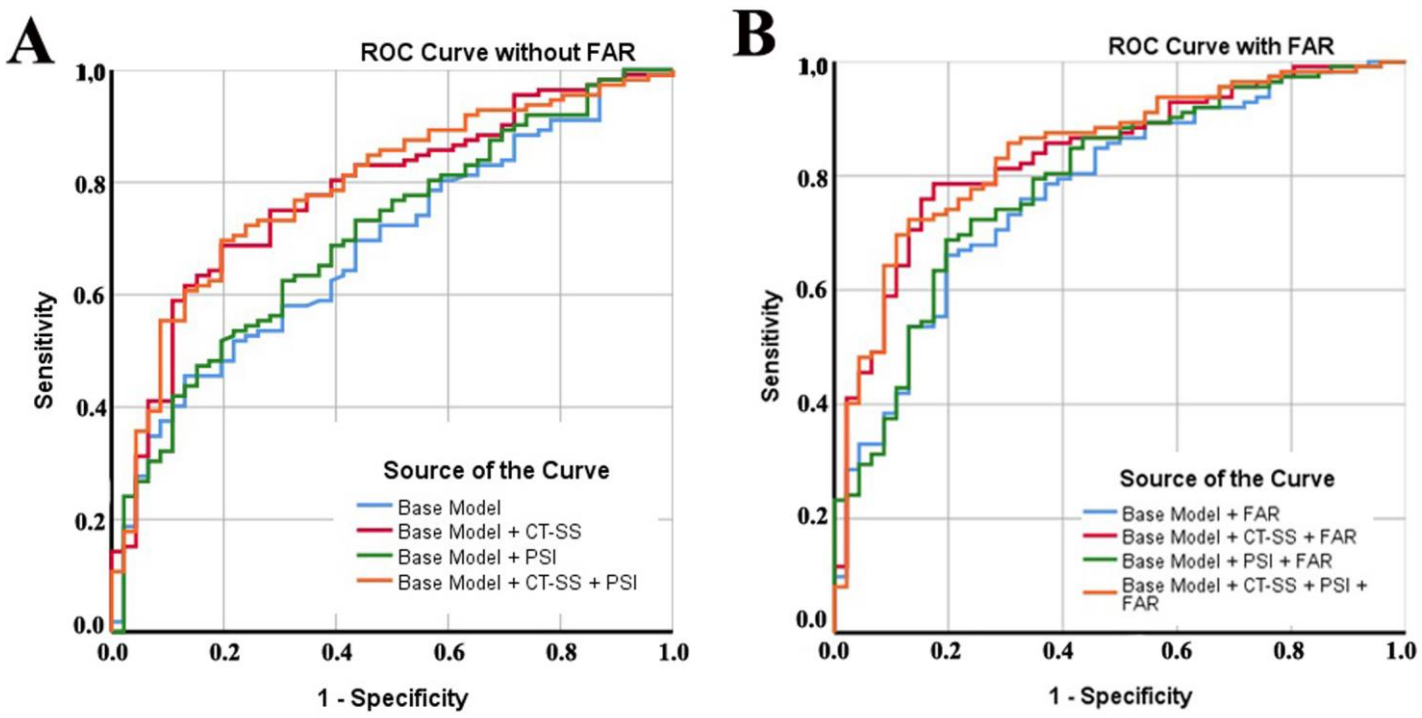

Figure 2. Comparison of ROC Curves based on various predictive models with and without fibrinogen-albumin ratio (FAR). (A) without FAR. (B): with FAR

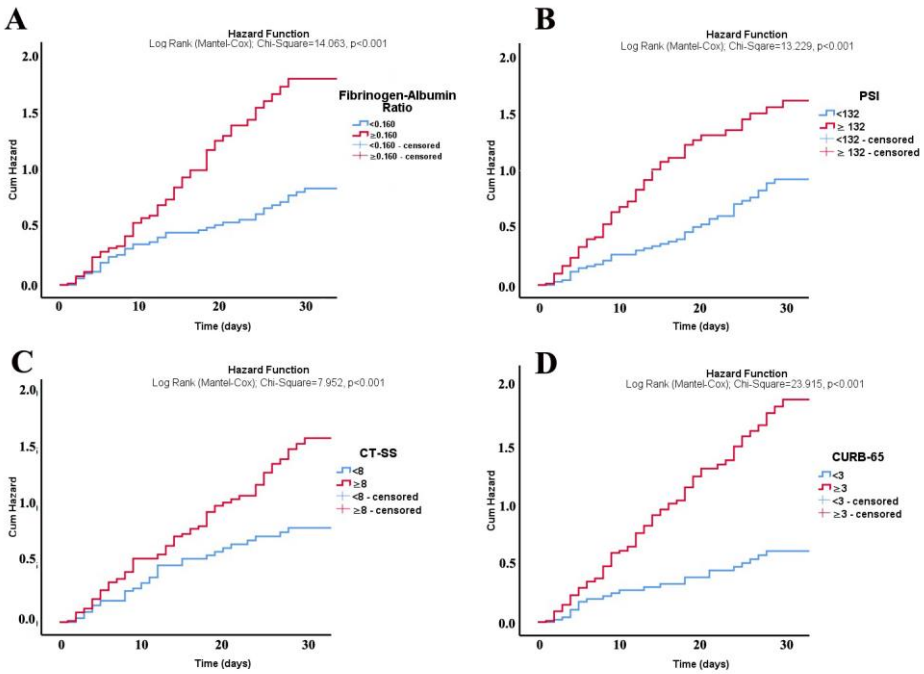

Figure 3. Cumulative hazard functions for prediction of mortality based on various clinical parameters in CAP patients admitted to ICU. (A) Fibrinogen-to-Albumin Ratio (<0.160 vs ≥0.160). (B) CT Severity Score (CT-SS) (<8 vs ≥8). (C) CURB-65 (<3 vs ≥3). (D) Pneumonia Severity Index (PSI) (<132 vs ≥132).