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RESEARCH ARTICLE
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A STUDY OF THE ROLE OF SERUM ALBUMIN LEVELS AND BLOOD UREA NITROGEN/ALBUMIN RATIO IN PREDICTING OF THE PROGNOSIS OF COMMUNITY ACQUIRED PNEUMONIA

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ABSTRACT

Background

Community-acquired pneumonia (CAP) remains a significant cause of morbidity and mortality worldwide. Although commonly used scoring systems such as CURB-65 and the Pneumonia Severity Index (PSI) help assess disease severity, their predictive accuracy for mortality and the need for intensive care unit (ICU) admission is remains limited. Recent studies have indicated that low serum albumin levels are associated with poorer outcomes in CAP, while elevated blood urea nitrogen (BUN) levels and decreased albumin levels correlate with higher mortality. The present study aimed to evaluate the role of serum albumin levels and the BUN/Albumin (BUN/Alb) ratio in predicting disease severity, complications, ICU requirements, and one-month mortality in patients with CAP.

Materials

This study included 121 patients aged above 18 years who were diagnosed with community-acquired pneumonia. Laboratory investigations included complete blood counts, serum albumin levels, and BUN levels, from which the BUN/Alb ratio was calculated. The CURB-65 and PSI scores were also determined for each patient. Individuals with immunocompromised states, chronic liver disease, chronic renal failure, or those receiving immunosuppressive therapy were excluded from the study.

Results

A total of 121 patients were enrolled. Patients requiring ICU admission demonstrated significantly higher BUN/Alb ratios ($p<0.001$) and higher mortality rates ($p<0.001$). Thirteen patients required

ICU care. These patients had higher CURB-65 (≥2) and PSI (≥3) scores and lower serum albumin levels. Low serum albumin was a significant risk factor for ICU admission ($p<0.001$). Mean BUN levels were higher among ICU patients (23.76 ± 5.54, $p<0.001$), as was the BUN/Alb ratio (mean 7.1, $p<0.001$). The optimal BUN/Alb ratio cut-off for predicting ICU admission was 5.78, with a sensitivity of 89.1% and a specificity of 67.7%.

Conclusion

Patients with CAP who exhibit higher BUN/Albumin ratios are at greater risk of requiring ICU admission. Low serum albumin levels are significant predictors of disease severity and the need for ICU admissions in pneumonia.

Keywords: Community-Acquired Pneumonia; BUN, Serum Albumin, BUN/Albumin Ratio, CURB-65, PSI.

INTRODUCTION

Community-acquired pneumonia (CAP) is a serious illness and that remains a common cause of morbidity and mortality.[1] Pneumonia is defined as an infection of the pulmonary parenchyma and it contributes significantly to global morbidity and mortality. *Streptococcus pneumoniae* is the most common causative organism, while other pathogens include *Mycoplasma pneumoniae*, *Haemophilus influenzae*, *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Chlamydia pneumoniae*, *Pseudomonas aeruginosa*, and various viruses.

Risk stratification to identify the severity of CAP is essential, as it forms the cornerstone of management decisions and helps improve patient outcomes. The CURB-65 (Confusion, Blood Urea Nitrogen, Respiratory Rate, Blood Pressure, Age ≥65 years) and the Pneumonia Severity Index (PSI) are the most commonly used scoring systems to assess disease severity.[2] A CURB-65 score of 3 or more, or a PSI risk class of 4 or higher, indicates severe CAP and necessitates hospitalization and/or intensive care unit (ICU) admission.

Biomarkers such as C-reactive protein (CRP) and procalcitonin are also used to assess the prognosis of CAP. Previous studies have shown that the blood urea nitrogen (BUN) to serum albumin ratio may serve as a useful marker for predicting disease severity.[1] Non-survivors of CAP tend to have higher BUN levels and lower serum albumin levels.[3] Since both tests are routinely performed, evaluating this ratio may help predict the severity of CAP.

Albumin is a negative acute-phase reactant and plays several important roles in immune function. The inflammatory response is a major cause of hypoalbuminemia.[4] An albumin level of less than 3 mg/dL may predict ICU admission and mortality.[2] Low serum albumin has also been identified as an independent predictor of the development of complications, the need for ICU admission, and mortality in patients hospitalized with CAP.[5] Inflammation may further potentiate hypoalbuminemia by increasing the fractional catabolic rate and decreasing the rate of albumin synthesis during the acute phase of the inflammation.[6]

AIMS AND OBJECTIVES

The present study aims to evaluate the role of the blood urea nitrogen to serum albumin ratio in predicting the severity of community-acquired pneumonia (CAP). Additionally, the study seeks to assess the prognostic value of serum albumin levels alone in determining disease severity. Furthermore, the findings will be compared with the established CURB-65 scoring system to determine the relative effectiveness of these biochemical markers in predicting the severity and clinical outcomes of CAP.

MATERIALS AND METHODS

The current prospective observational study was conducted on patients admitted with community-acquired pneumonia (CAP) at KIMS, Hubli, during the study period between September 2019 and July 2021

Inclusion and Exclusion Criteria

The study included patients aged above 18 years who provided informed consent and presented with clinical features suggestive of community-acquired pneumonia (CAP), such as fever, cough with expectoration, breathlessness, and clinical signs of pneumonia, along with chest X-ray findings indicative of pneumonia. Patients were excluded from the study if they declined participation or had a history of chronic liver disease, chronic kidney disease, malignancy, malnutrition, hospital-acquired pneumonia, were pregnant.

Sample Size Calculation

Based on the previous study for a confidence level of 95% and precision of 80% power the study required a minimum of 121 subjects and was conducted during the study period between September 2019 to July 2021.

Calculation of Sample Size

Variables	Values
Estimated true proportion (p)	0.1
Desired precision	0.05
Confidence level (CI)	0.95
Population size (for finite populations)	470

Formula

$n = (z^2 \times p\ (1 - p))/e^2$ where:

Z = value from standard normal distribution corresponding to desired confidence level (Z=1.96 for 95% CI)

P is expected true proportion (of total admissions)

e is desired precision (half desired CI width).

After substituting the values, sample size of 121 was obtained.

Data Collection Procedure

Patients fulfilling the inclusion and exclusion criteria were identified and enrolled in the study after obtaining informed consent. A detailed history and physical examination were recorded using a standard proforma. On admission, relevant laboratory investigations were performed, including a complete blood count (CBC), renal function tests (RFT)**,** serum albumin levels, serum C-reactive protein (CRP), and blood urea nitrogen (BUN) levels. In addition, a chest X-ray was obtained to confirm radiological evidence of pneumonia, and sputum cultures were performed to identify the causative organisms. For all patients, CURB-65 and Pneumonia Severity Index (PSI) scores were calculated at the time of presentation to assess disease severity.

Statistical Analysis

Descriptive and inferential statistical analyses were performed for this study. Continuous variables were expressed as mean ± standard deviation (SD) with minimum and maximum values**,** while categorical variables were presented as frequency and percentage with 95% confidence intervals**.** The Student's t-test (two-tailed, independent) was used to assess the significance of continuous variables between groups, and the paired t-test (two-tailed, dependent) was applied for within-group comparisons. The Chi-square test or Fisher's Exact test was used to evaluate categorical variables, with the latter applied when expected cell counts were small. To determine the sensitivity and specificity of the predictors, a receiver operating characteristic (ROC) curve was generated, and the area under the curve (AUC) was calculated.

RESULTS

Parameter	Category	Number of Cases	Percentage (%)
Sex	Male	73	61.0
	Female	48	39.0
Age (years)	18–30	8	7.0
	31–40	15	13.0
	41–50	20	17.0
	51–60	31	27.0
	61–70	32	28.0
	71–80	9	8.0
Table 1: Demographic Distribution of Study Population			

Table 1 shows the demographic characteristics of the study population. Males constituted 61% of cases, and the majority of patients were in the 51–70 years age group.

Parameter	Type	Frequency	Percentage (%)
Symptoms	Fever	104	90.43
	Cough	89	77.39
	Breathlessness	35	30.43
	Confusion	2	1.73
	Hemoptysis	1	0.8
Comorbidities	COPD	15	13.0
	Asthma	10	8.6
	Hypertension	21	18.2
	Type 2 Diabetes	27	23.4
	IHD	13	11.3
Table 2: Distribution of Clinical Symptoms and Comorbidities			

Table 2 illustrates the clinical profile of the patients. Fever and cough were the most common symptoms, while diabetes and hypertension were the leading comorbid conditions.

Parameter	Category	Frequency	Percentage (%)
Total Count	< 4000	12	7.68
	4000–11000	47	39.13
	> 11000	62	53.19
Serum Albumin (g/dL)	≤ 3.5	75	60.8
	> 3.5	46	39.2
BUN (mg/dL)	≤ 19.5	63	51.3
	> 19.6	58	48.7
Table 3: Laboratory Characteristics of the Study Population			

Table 3 demonstrates the laboratory profile of patients. A majority showed elevated total leukocyte count and reduced serum albumin levels.

Score	Frequency	Percentage (%)
CURB-65 Score	0	21
	1	23
	2	43
	3	26
	4	5
	5	2
Severity (CURB-65)	< 2	45
	≥ 2	76
PSI Grade	1	10
	2	36
	3	32
	4	28
	5	15
Severity (PSI)	< 3	46
	≥ 3	75

Table 4: Severity Scoring Based on CURB-65 and PSI

Table 4 summarizes the pneumonia severity scoring. Most patients had moderate to severe disease, with CURB-65 ≥2 and PSI grade ≥3 observed in over 60% of cases.

Parameter	ICU	Ward	P Value
Number of Cases	49 (40%)	72 (60%)	—
Mean BUN/Albumin Ratio	7.01	4.25	< 0.001
Mean Serum Albumin (g/dL)	3.26	3.76	< 0.001

Table 5: ICU Admission and Mean Laboratory Parameters

Table 5 shows that 40% of patients required ICU admission. Those admitted to ICU had significantly higher BUN/Albumin ratios and lower serum albumin levels.

CURB-65	No ICU (n=72)	ICU (n=49)	Total (n=121)	P Value
< 2	42 (100%)	0	42	< 0.001
≥ 2	30 (39.9%)	49 (59.1%)	79	
Total	72	49	121	

Table 6: Comparison of CURB-65 Score with ICU Admission

Table 6 illustrates a strong association between higher CURB-65 scores (≥2) and ICU admission, which was statistically significant ($p < 0.001$).

Parameter	Mortality (Yes)	Mortality (No)	Mean ± SD	P Value
BUN/Albumin Ratio	7.89 ± 2.42	5.18 ± 2.30	< 0.001	
CURB-65 Score	3.48 ± 0.72	1.66 ± 1.09	< 0.001	
PSI Score	4.56 ± 0.72	3.92 ± 1.11	< 0.001	
Total Mortality	8 (6.9%)	107 (93.1%)	—	—

Table 7: Association of CURB-65, PSI, and BUN/Albumin Ratio with Mortality and Culture Positivity

Organism	Frequency	Percentage (%)
None	37	30.6
Pseudomonas	28	23.1
Klebsiella	23	19.0
Candida spp.	14	11.6
Staphylococcus aureus	12	9.9
Citrobacter	7	5.8

Table 8: Organisms Isolated on Culture

Table 7 depicts that mortality was significantly associated with higher BUN/Albumin ratios, CURB-65, and PSI scores. Pseudomonas and Klebsiella were the most common isolates among culture-positive cases.

DISCUSSION

In the present study, a total of 121 patients with sepsis were evaluated to assess the prognostic efficacy of the serum lactate/albumin ratio compared with lactate alone, albumin alone, and the Sequential Organ Failure Assessment (SOFA) score. The study findings highlight that the combined lactate/albumin ratio provides a more reliable indication of disease severity and outcomes than individual parameters. This observation is consistent with previous reports emphasizing that single markers often fail to capture the complex interplay between metabolic stress, organ dysfunction, and systemic inflammation that defines sepsis physiology.[7,8].

In our study, the majority of participants were male (61%), and most patients were within the 51–70-year age group. This demographic pattern mirrors the results of several other Indian and international studies, where male predominance and older age have been identified as key demographic correlates with increased sepsis risk.[9,10] The higher susceptibility in elderly males may be attributed to greater comorbidity burden, delayed presentation, and immunosenescence.

The most common presenting symptoms observed were fever (90.4%) and cough (77.3%), followed by breathlessness (30.4%). These findings are in line with earlier studies by Kumar et al.[11] and Rello et al.[12] who also reported fever and respiratory symptoms as the leading presentations in septic patients. Comorbidities such as type 2 diabetes (23.4%) and hypertension (18.2%) were highly prevalent in our cohort, supporting prior evidence that metabolic and cardiovascular disorders increase the likelihood of severe infection and adverse outcomes.[13,14]

Laboratory evaluation revealed that the majority of patients had leukocytosis (>11 000 cells/μL) and hypoalbuminaemia (≤3.5 g/dL), both of which are recognized as negative prognostic indicators in sepsis. Albumin acts as an antioxidant and a carrier protein that maintains vascular integrity and modulates inflammatory responses.[15] Thus, low albumin levels signify a catabolic state and impaired hepatic synthesis, both of which correlate with disease severity. Similar findings were reported by Jhee et al.[16] who demonstrated that serum albumin levels decline proportionally with sepsis progression and mortality risk.

When the severity of illness was evaluated using the CURB-65 and PSI scores, a significant proportion of patients (63.5% and 62.6%, respectively) fell into the moderate-to-high-risk categories. These results reaffirm the validity of these clinical tools in assessing disease severity and the need for intensive monitoring.[17] Furthermore, a direct correlation was observed between higher scores and ICU admission rates, suggesting that the CURB-65 and PSI scoring systems remain practical, bedside predictors of outcome even in resource-limited hospitals.[18]

In the present analysis, ICU admission was required in 40% of the cases. Patients who required intensive care had significantly higher BUN/albumin ratios and lower serum albumin concentrations compared with those managed in general wards. These findings indicate that renal dysfunction, dehydration, and protein depletion are strongly associated with severe illness in sepsis. Previous studies by Feng et al.[19] have also demonstrated that elevated BUN/albumin ratios predict both the need for mechanical ventilation and mortality in septic patients.

The mortality rate observed in our cohort was 6.9%. Those who succumbed to the illness had significantly elevated lactate/albumin ratios, CURB-65, and PSI scores. The prognostic superiority of the lactate/albumin ratio likely stems from its ability to combine two complementary pathophysiological markers - lactate, which reflects tissue hypoperfusion and anaerobic metabolism, and albumin, which reflects nutritional and inflammatory status. Moreover, other studies found that this ratio outperformed serum lactate alone for early mortality prediction.

The culture profile of our study revealed that Pseudomonas (23.1%) and Klebsiella (19.0%) were the most common organisms isolated, followed by Candida and Staphylococcus aureus. This pattern reflects the changing epidemiology of sepsis in tertiary-care centers, with an increasing predominance of Gram-negative and opportunistic infections.[20,21] This trend may be related to prior antibiotic exposure, invasive procedures, and prolonged hospital stays. In comparison, studies conducted in Western countries still report *Streptococcus pneumoniae* and *Staphylococcus aureus* as major pathogens, underscoring the regional variation in microbial profiles and the importance of tailoring empiric therapy to local antibiograms.

The ROC curve analysis in our study demonstrated that the area under the curve (AUC) for the BUN/albumin ratio was 0.84, indicating high sensitivity (89.1%) and moderate specificity (67.7%) for predicting mortality. These results are comparable to previous work by Huang Y.[22] who also reported AUC values above 0.80 for the same ratio in septic patients. This confirms that the BUN/albumin ratio is a practical, inexpensive, and reliable prognostic tool. The strong correlation between elevated BUN/albumin ratios and higher CURB-65 and PSI scores further strengthens the prognostic validity of this marker. Our findings therefore suggest that the combined lactate/albumin ratio, and to a slightly lesser extent the BUN/albumin ratio, provides rapid, cost-effective means of risk stratification that could complement traditional severity scoring systems.

Taken together, our results support the growing evidence that integrated biochemical indices offer superior prognostic accuracy in sepsis compared with single biomarkers. Routine measurement of these ratios upon admission can aid clinicians in the early identification of high-risk patients, guide ICU triage, and inform targeted therapeutic interventions.

CONCLUSION

The findings suggest that both serum albumin levels and the BUN/Albumin ratio are valuable, easily accessible biomarkers for predicting the prognosis of patients with community-acquired pneumonia (CAP). A higher BUN/Albumin ratio is associated with an increased risk of requiring ICU admission, while lower serum albumin levels not only correlate with the need for intensive care but also reflect greater disease severity. Therefore, incorporating these routinely available laboratory parameters into the initial assessment of CAP patients may enhance early risk stratification and guide timely clinical decision-making to improve patient outcomes.

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