



“ASSOCIATION OF SERIAL SERUM ALBUMIN TRENDS WITH CLINICAL OUTCOMES IN CRITICALLY ILL MEDICAL PATIENTS”

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ABSTRACT

Background: Serum albumin is a well-recognized indicator of nutritional status, systemic inflammation, endothelial integrity, and overall physiological reserve. In critically ill patients, hypoalbuminemia is common due to increased capillary leakage, reduced synthesis, and heightened catabolism. Serial serum albumin measurements may therefore serve as a simple, cost-effective prognostic marker, particularly in resource-limited intensive care settings.

Aim: To evaluate the prognostic significance of baseline and serial serum albumin levels in critically ill patients admitted to the MICU/ICCU of Himalaya Medical College, Patna.

Methods: This prospective observational study included 100 critically ill medical patients admitted between January and September 2025. Serum albumin levels were measured on admission (Day 0) and serially on Days 1, 3, 5, 7, and 10. Patients were categorized as survivors and non-survivors based on in-hospital mortality. Outcomes assessed included mortality, need for mechanical ventilation, duration of ventilation, and length of hospital stay. Statistical analysis was performed using Chi-square and Student's t-tests.

Results: Of the 100 patients, 64% were male and 72% survived. Hypoalbuminemia (<3.5 g/dL) at admission was significantly more common in non-survivors (92.9%) than in survivors (41.7%) ($p = 0.002$). Serial albumin levels showed a progressive rise in survivors but a continuous decline in non-survivors ($p < 0.001$ at all time points). Among patients requiring mechanical ventilation, 75% had admission hypoalbuminemia compared with 50% in the non-ventilated group ($p = 0.03$). Prolonged ventilation (>10 days) occurred exclusively in non-survivors (39.3%). Length of hospital stay did not significantly differ between survivors and non-survivors ($p = 0.41$).

Conclusion: Both admission hypoalbuminemia and declining serial serum albumin levels were strong predictors of mortality in critically ill patients. Low albumin levels also correlated significantly with the need for and duration of mechanical ventilation. Routine serial monitoring of serum albumin is an inexpensive, accessible, and valuable tool for early risk stratification and prognostication in ICU settings, especially in resource-limited environments.

Keywords: Serum albumin, hypoalbuminemia, critical illness, prognostic marker, mechanical ventilation, ICU mortality

INTRODUCTION

Critical illness represents a state of physiological instability in which patients are at imminent risk of organ failure requiring urgent life-support measures such as mechanical ventilation, inotropic support, or advanced monitoring.[1] Mortality in the intensive care unit (ICU) remains high, and timely identification of patients at increased risk of adverse outcomes is essential for optimizing resource allocation—particularly in settings such as India, where ICU facilities, staffing ratios, and financial resources are constrained. Within this context, the need for simple, inexpensive, and reproducible biomarkers that reflect disease severity and predict outcomes becomes especially important.

Several scoring systems—including APACHE, SAPS, SOFA, GCS, and MPM—have been widely used for prognostication in critically ill patients.[2] While these systems provide valuable risk-stratification data, they require numerous physiological and biochemical variables, making them time-intensive and sometimes impractical for frequent bedside assessment in resource-limited environments. Hence, the search for objective, low-cost markers that can be monitored serially has intensified.

Serum albumin has emerged as a promising prognostic biomarker across diverse clinical settings.[3] Beyond its traditional role in maintaining colloid osmotic pressure, albumin participates in antioxidant defense, immune modulation, drug binding, and maintenance of endothelial stability. Numerous studies have demonstrated that hypoalbuminemia is associated with increased morbidity, prolonged hospitalization, and higher mortality in hospitalized and critically ill patients.[4–8] Because serum albumin estimation is inexpensive, widely available, and rapidly measurable, it lends itself well to serial monitoring in critically ill patients.

A declining albumin level during illness reflects a complex interplay of systemic inflammation, capillary leakage, reduced hepatic synthesis, and increased catabolism—processes that are amplified in critical illness. Prior reports suggest that each 10 g/L reduction in serum albumin is associated with dramatic increases in mortality, morbidity, ICU length of stay, and overall healthcare utilization.[9–10] Moreover, trends in serial albumin levels have been shown to correlate with ventilatory requirements, nutritional status, and recovery patterns.

Given these observations, evaluating the prognostic significance of serial serum albumin measurements could support early risk stratification and guide clinical decision-making in MICU/ICCU settings. The present study was therefore undertaken to determine whether baseline and serial serum albumin measurements can serve as reliable prognostic markers in critically ill patients admitted to the medical intensive care units of a tertiary care center.

MATERIALS AND METHODS

Study Design and Setting: This study was designed as a prospective, hospital-based observational study conducted in the Department of Medicine at Himalaya Medical College and Hospital, Patna. The study was carried out over a period of nine months, from January 2025 to September 2025, following approval from the Institutional Ethics Committee. All methods were performed in accordance with institutional guidelines and ethical standards.

Study Population: The study included critically ill patients admitted to the Medical Intensive Care Unit (MICU) and Intensive Coronary Care Unit (ICCU). Patients were enrolled consecutively after meeting the eligibility criteria. Written informed consent was obtained either from the patients or from legally authorized representatives in cases where patients were unable to consent.

Inclusion Criteria: Patients were eligible if they were: Critically ill adults admitted with medical (non-surgical) conditions requiring intensive monitoring or organ support. Subjects who were able to provide informed consent, or consent was given by a relative were enrolled in the current study.

Exclusion Criteria: To minimize confounding factors affecting serum albumin levels, patients with the following conditions were excluded: Chronic liver disease, Chronic kidney disease, Protein-losing enteropathy, Severe malnutrition, Pregnancy, Refusal to provide informed consent

Sample Size and Sampling Technique: A total of approximately 100 critically ill patients fulfilling the inclusion and exclusion criteria were recruited for the study. A purposive sampling technique was used to include all eligible patients admitted during the study period.

Data Collection and Study Procedure: Upon admission, detailed demographic information, medical history, and clinical examination findings were recorded. Baseline investigations were carried out according to hospital protocol. Serum albumin levels were measured serially on Day 0 (admission), and subsequently on Days 1, 3, 5, 7, and 10.

Patients were classified into two outcome groups—survivors and non-survivors—based on in-hospital mortality. Serial albumin trends were compared between these groups. Additional parameters assessed included the requirement for mechanical ventilation, duration of ventilation, and total duration of hospital stay.

Outcome Measures

Primary Outcome: The primary objective was to determine the association between serial serum albumin levels and in-hospital mortality among critically ill patients.

Secondary Outcomes: Secondary analyses examined:

- The relationship between serum albumin levels at admission (<3.5 g/dL or ≥ 3.5 g/dL) and the requirement for mechanical ventilation.
- The association of serial albumin trends with duration of mechanical ventilation.
- Differences in overall hospital stay between survivors and non-survivors.

Laboratory Methods: Serum albumin concentration was measured using standard automated biochemical assays available in the hospital's central laboratory. All samples were processed under consistent laboratory conditions to ensure accuracy and reliability.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 22 (IBM Corp., Armonk, NY). Continuous variables were expressed as mean, median, and standard deviation, while categorical variables were presented as proportions. Comparisons between groups were made using the Student's t-test for quantitative variables and the Chi-square test for categorical variables. A p-value of <0.05 was considered statistically significant.

RESULTS

Demographic information: In the present study we assessed the Gender-wise distribution among the study subjects. We observed that majority were males (59%), while 41% were females. In the present study we assessed the Age wise distribution among the study subjects. We observed that majority of the study subjects belonged to the age group of 36 to 45 years (33%), followed by 46 to 55 years (25%), and 56 to 65 years (22%)

Table 1: Demographic information

Demographic information		Number of subjects	Percentage
Gender-wise distribution	Males	64	64
	Females	36	36
Age wise distribution	Less than 25 years	4	4
	26 to 35 year	13	13
	36 to 45 years	29	29

	46 to 55 years	26	26
	56 to 65 years	18	18
	More than 65 years	10	10

System involved: In the present study we assessed the System involved among the study subjects. We observed that Neurological system was involved among 28% study subjects, Cardiovascular system was involved among 24% study subjects, Respiratory system was involved among 20% study subjects, Abdominal system was involved among 11% study subjects, Other systems were involved among 17% study subjects,

Table 3: Clinical Parameters

Clinical Parameters		Number of subjects	Percentage
System involved	Neurological	28	28
	Cardiovascular	24	24
	Respiratory	20	20
	Abdominal	11	11
	Other	17	17
Outcomes	Survived	72	72
	Mortality	28	28

Outcomes: In the present study we assessed the Outcomes among the study subjects. We observed that 72% study subjects were survivors, while 28% mortality was observed in this current study.

Comparison of Demographic Characteristics, Admission Albumin Levels, and Ventilation Duration Between Survivors and Non-survivors: Table 3 presents the comparison of key demographic and clinical parameters between survivors (n=72) and non-survivors (n=28). Gender distribution showed a higher proportion of males in both groups; however, the difference was not statistically significant. Age distribution across various subgroups also did not differ significantly between survivors and non-survivors ($p>0.05$), indicating that age was not a major determinant of outcome in this cohort.

A strong association was observed between **serum albumin levels at admission** and survival outcomes. A markedly higher proportion of non-survivors (92.9%) had hypoalbuminemia (<3.5 g/dL) compared to survivors (41.7%), and this difference was statistically significant ($p=0.002$), suggesting that low albumin at admission is a predictor of poor prognosis.

Similarly, the **duration of mechanical ventilation** demonstrated a highly significant relationship with mortality ($p<0.0001$). The majority of survivors (95.8%) did not require ventilation, whereas prolonged ventilator dependence (>10 days) was seen exclusively among non-survivors (39.3%).

Table 3. Comparison of Demographic Characteristics, Admission Albumin Levels, and Ventilation Duration Between Survivors and Non-survivors

Parameters		Survivors (n=72)	Non-survivors (n=28)	Total	P-value
Gender	Male	44 (61.1%)	20 (71.4%)	64	>0.05
	Female	28 (38.9%)	8 (28.6%)	36	
Age	<25	3	1	4	>0.05
	26–35	10	3	13	
	36–45	22	7	29	
	46–55	18	8	26	
	56–65	12	6	18	

	>65	7	3	10	
Albumin Level	<3.5 g/dL	30 (41.7%)	26 (92.9%)	56	0.002
	≥3.5 g/dL	42 (58.3%)	2 (7.1%)	44	
Duration of Ventilation	Not required	69	7	76	<0.0001
	<5 days	3	4	7	
	5–10 days	1	6	7	
	>10 days	0	11	11	

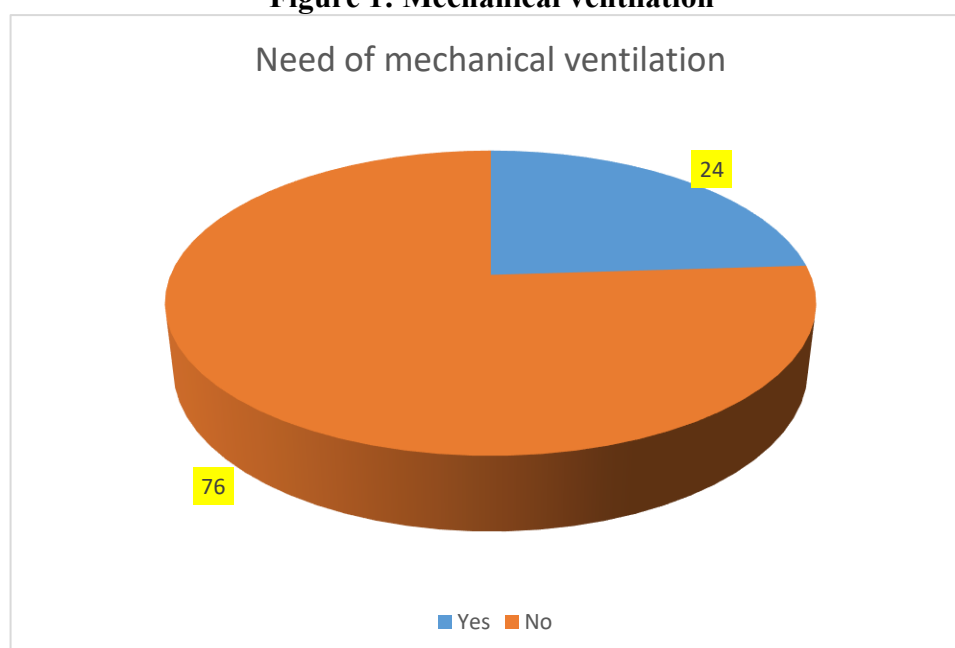
Serial Trend of Serum Albumin Levels Among Survivors and Non-survivors Over 10 Days of ICU Stay: Table 4 demonstrates the serial changes in mean serum albumin levels measured on Days 0, 1, 3, 5, 7, and 10 among survivors and non-survivors. At every time point, survivors maintained significantly higher albumin levels compared to non-survivors ($p < 0.001$ for all comparisons). Non-survivors showed a progressive decline from 3.10 ± 0.38 g/dL at admission to 2.20 ± 0.27 g/dL by Day 10, whereas survivors exhibited an initial fall followed by a gradual recovery, rising from 3.67 ± 0.45 g/dL to 3.26 ± 0.55 g/dL by Day 10.

Table 4. Serial Trend of Serum Albumin Levels Among Survivors and Non-survivors Over 10 Days of ICU Stay

Day	Survivors (Mean $\pm$ SD)	Non-survivors (Mean $\pm$ SD)	p-value
Day 0	3.67 ± 0.45	3.10 ± 0.38	<0.001
Day 1	3.30 ± 0.42	2.70 ± 0.33	<0.001
Day 3	2.98 ± 0.51	2.48 ± 0.29	<0.001
Day 5	3.05 ± 0.47	2.40 ± 0.32	<0.001
Day 7	3.14 ± 0.50	2.34 ± 0.30	<0.001
Day 10	3.26 ± 0.55	2.20 ± 0.27	<0.001

Mechanical ventilation: In the present study we assessed the need of mechanical ventilation among the critically ill study subjects. We observed that 24% study subjects required mechanical ventilation for their ventilatory support.

Figure 1: Mechanical ventilation



Comparison between Duration of mechanical ventilation and survival rate: Among the 24 patients requiring ventilation, 75% had hypoalbuminemia (<3.5 g/dL), compared with only 50% among those not requiring ventilatory support. Conversely, patients with normal or higher albumin levels (≥ 3.5 g/dL) were far less likely to require ventilation (25.0% vs. 50.0%). The association was statistically significant ($p = 0.03$), indicating that low albumin at admission is an important predictor of respiratory deterioration and subsequent ventilatory dependence (Table 5).

Table 5 : Comparison between Duration of mechanical ventilation and survival rate

Albumin Level	Ventilation Required (n=24)	No Ventilation (n=76)	Total
<3.5 g/dL	18 (75.0%)	38 (50.0%)	56
≥ 3.5 g/dL	6 (25.0%)	38 (50.0%)	44
P-value	0.03		

Comparison between duration of hospital stay among subjects: Table 6 compares the duration of hospitalization between survivors and non-survivors. Although differences did not reach statistical significance ($p = 0.41$), certain patterns were noted. Most survivors (40.3%) had hospital stays of 11–15 days, whereas non-survivors showed a relatively higher proportion of prolonged stays (>20 days), accounting for 25% of deaths. Additionally, fewer survivors required extended hospitalization beyond 20 days (11.1%).

Table No 6: Comparison between duration of hospital stay among subjects

Hospital Stay Duration	Survivors	Non-survivors	Total
5–10 days	14	5	19
11–15 days	29	10	39
16–20 days	21	6	27
>20 days	8	7	15
P-value	0.41		

DISCUSSION

Serum albumin is well-established as an essential biochemical marker that reflects multiple physiological processes including nutritional reserve, systemic inflammatory load, microvascular permeability, oxidative stress, and overall metabolic capacity in critically ill patients. Its utility stems from its multifaceted biological roles—maintenance of oncotic pressure, buffering of biochemical reactions, transport of endogenous and exogenous molecules, and modulation of immune and antioxidant pathways.[11–13] In critically ill patients, these functions become significantly deranged, making serum albumin an easily measurable yet highly informative prognostic indicator. In the present prospective observational study conducted at Himalaya Medical College, Patna, we evaluated the prognostic value of serial serum albumin estimation in 100 critically ill medical patients and correlated albumin levels with mortality, ventilatory requirement, and hospitalization patterns.

Demographic Parameters and Survival

In our study population, males constituted 64% of the cohort, which aligns with trends in previous ICU studies, where a male predominance has been consistently reported due to higher burden of comorbidities, delayed healthcare-seeking behavior, and greater exposure to environmental and occupational risks.[11–13] Although non-survivors showed a slightly higher male representation (71.4%) compared with survivors (61.1%), the difference lacked statistical significance, indicating that gender alone did not influence mortality in this study. Similarly, age distribution between

survivors and non-survivors was not significantly different, suggesting that disease severity and biochemical parameters played a more important prognostic role.

These observations echo the findings of Mahajan et al.,[11] who also reported that demographic characteristics—including age and gender—did not independently predict ICU mortality. Saravanakumar et al.[14] made similar observations in sepsis patients, highlighting that while demographic factors contribute to baseline vulnerability, they are less predictive than dynamic physiological markers such as albumin, lactate, and organ dysfunction scores. Thus, our results reinforce the concept that static demographic data should be interpreted cautiously, whereas evolving biochemical derangements offer more reliable prognostic clues.

Admission Albumin Levels and Mortality

A striking finding of our study was the robust association between low admission albumin levels and mortality. Hypoalbuminemia (<3.5 g/dL) was present in 92.9% of non-survivors compared with 41.7% of survivors, a statistically significant difference ($p = 0.002$). This reinforces the well-documented relationship between early hypoalbuminemia and poor clinical outcomes, including increased mortality, prolonged ICU stay, and higher incidence of complications.[3,9,10,15]

Multiple studies corroborate this association. Mahajan et al.[11] demonstrated significantly lower admission albumin levels in non-survivors, while Pal et al.[16] reported that baseline hypoalbuminemia strongly predicted mortality and prolonged ICU stay. Similarly, Gosavi et al.[17] showed that early identification of low albumin levels can help stratify high-risk patients. Albumin decline on admission is believed to be influenced by capillary leak syndrome, systemic inflammatory burden, hepatic synthesis suppression, and increased fractional catabolism—pathophysiological processes commonly amplified in critical illness.[12,13] Therefore, early albumin measurement can be considered a frontline tool in ICU prognostication.

Serial Serum Albumin Trends and Predictive Value

Serial albumin estimation demonstrated even greater prognostic significance than single admission readings. Survivors exhibited an expected initial fall in albumin by Day 3 (mean 2.98 ± 0.51 g/dL), likely reflecting acute inflammation and fluid shifts, followed by a gradual rise, reaching 3.26 ± 0.55 g/dL by Day 10. This upward trend signifies clinical stabilization, reduction in inflammatory stress, and resumption of hepatic synthesis.

Conversely, non-survivors showed a continuous and progressive decline throughout their ICU stay, reaching as low as 2.20 ± 0.27 g/dL by Day 10. This persistent fall reflects ongoing systemic inflammation, worsening organ dysfunction, and catabolic stress. These findings are consistent with studies by Mahajan et al.[11] and McCluskey et al.,[18] both of whom emphasized that serial albumin decline correlates more strongly with mortality than admission values alone.

Pal et al.[16] observed that patients demonstrating albumin recovery—particularly those achieving >3 g/dL by Day 5—had significantly lower mortality, further supporting the role of albumin kinetics as an indicator of physiological improvement. Pathophysiologically, progressive hypoalbuminemia reflects cytokine-driven suppression of synthesis, high oxidative stress, endothelial permeability, and dilutional factors—all of which are intensified in sepsis, shock, and multi-organ dysfunction.[12,13] Serial albumin trends therefore offer dynamic insight into disease trajectory and treatment response.

Albumin Levels and Requirement for Mechanical Ventilation

The association between low albumin and need for mechanical ventilation was also significant in our study. Among ventilated patients, 75% had hypoalbuminemia at admission compared with 50% in the non-ventilated group ($p = 0.03$). This corroborates observations by Banga et al.[19] and Gosavi et al.,[17] who reported that hypoalbuminemia increases the likelihood of respiratory muscle fatigue, difficulty in weaning, and dependence on ventilatory support.

Furthermore, ventilatory duration strongly predicted mortality in our cohort. While most survivors required only short-term ventilation or none at all, 39.3% of non-survivors required >10 days of

ventilatory support. This prolonged requirement underscores more severe disease, refractory systemic inflammation, and sustained hypoalbuminemia. Hypoalbuminemia contributes to poorer respiratory outcomes by reducing colloid osmotic pressure, leading to pulmonary edema, impairing gas exchange, weakening respiratory musculature due to catabolism, and increasing susceptibility to nosocomial infections.[12,20,21–23] These mechanisms substantially impede ventilatory recovery and contribute to higher mortality.

Hospital Stay Duration and Survival

In this study, although non-survivors tended to have longer hospital stays compared with survivors (25% vs. 11.1% staying >20 days), the difference was statistically insignificant ($p = 0.41$). This contrasts with findings from Gosavi et al.[17] and Dubois et al.,[15] who noted a strong correlation between hypoalbuminemia, complications, and prolonged hospitalization. The lack of statistical significance in our study may be due to sample size limitations or variability in discharge practices. Nonetheless, prolonged stay in non-survivors reflects a more complex clinical course involving multi-organ dysfunction, secondary infections, and persistent inflammation—processes closely associated with declining albumin levels.

The present study demonstrates that serum albumin—both at baseline and on serial monitoring—is a powerful prognostic marker in critically ill medical patients. While demographic factors such as age and gender were not predictive of outcomes, biochemical deterioration manifested through progressive hypoalbuminemia closely paralleled worsening clinical status and mortality. The strong association of hypoalbuminemia with mortality, ventilator requirement, and overall disease progression highlights its utility as an inexpensive, easily available, bedside biomarker.

In resource-limited settings, where access to advanced scoring systems or expensive biomarkers may be constrained, serial albumin monitoring offers a pragmatic and cost-effective tool to support risk stratification, guide clinical decision-making, and anticipate outcomes in critically ill patients.

STUDY LIMITATIONS: This study has some limitations. It is a single center, Observational study with small sample size. Therefore further studies with large sample size might be needed in a multicenter settings.

CONCLUSIONS: Serial serum albumin estimation proved to be a valuable prognostic marker in critically ill medical patients admitted to the MICU/ICCU. In this study, both low admission albumin levels and a continued decline in albumin during the ICU stay were strongly associated with higher mortality. Survivors demonstrated a recovery trend in albumin values over time, whereas non-survivors showed persistently low and progressively worsening levels. Hypoalbuminemia at admission also significantly correlated with the need for mechanical ventilation and prolonged ventilatory dependence, reinforcing its role as an early indicator of clinical deterioration.

Demographic factors such as age and gender did not significantly influence outcomes, highlighting the superior predictive value of biochemical markers over static patient characteristics. Although hospital stay duration differed between survivors and non-survivors, it did not independently predict mortality in this cohort.

Given its simplicity, low cost, and widespread availability, serial serum albumin monitoring can serve as an important adjunct in risk stratification, prognostication, and clinical decision-making in resource-limited intensive care settings. Integrating routine albumin trend analysis into ICU protocols may improve early identification of high-risk patients and guide timely, targeted interventions.

CONFLICT OF INTEREST: NONE TO DECLARE

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