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Original Research Article

Serum Albumin as a Predictor of Short-Term Outcomes in Critically Ill Children Admitted to the Paediatric Intensive Care Unit: A Prospective Observational Study

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Abstract

Background: Hypoalbuminemia is frequently observed in critically ill children and may reflect systemic inflammation and physiological disturbances. Its usefulness in predicting short-term clinical outcomes remains uncertain.

Aim: To determine the prevalence of hypoalbuminemia and evaluate its association with illness severity and short-term outcomes among critically ill children admitted to the Paediatric Intensive Care Unit.

Materials and Methods: This prospective observational study included 368 critically ill children aged 1 month to 18 years admitted to the PICU of Indira Gandhi Institute of Child Health, Bengaluru. Serum albumin levels and PRISM III scores were assessed within 24 hours of admission. Patients were categorized into hypoalbuminemia and normoalbuminemia groups. Mechanical ventilation requirements, duration of ventilation, length of PICU stay, hospital stay and mortality were evaluated.

Results: Hypoalbuminemia was present in 156 children (42.4%). The mean PRISM III score was significantly higher in children with hypoalbuminemia than in those with normal albumin levels (9.10 ± 6.81 versus 7.11 ± 5.08; $p = 0.007$). Mechanical ventilation requirements (38.5% versus 40.5%; $p = 0.318$), PICU stay (7.3 ± 9.0 versus 6.7 ± 7.5 days; $p = 0.622$) and hospital stay (13.4 ± 12.0 versus 11.5 ± 11.8 days; $p = 0.554$) did not differ significantly between the hypoalbuminemia and normoalbuminemia groups. Mortality was numerically higher in the hypoalbuminemia group, but the difference was not statistically significant ($p = 0.456$). PRISM III scores were significantly associated with mechanical ventilation requirements and mortality (both $p < 0.001$).

Conclusion: Hypoalbuminemia was common among critically ill children and was associated with greater illness severity. However, admission serum albumin levels did not demonstrate significant associations with the measured short-term outcomes. PRISM III scores showed stronger associations with mechanical ventilation requirements and mortality.

Keywords: Serum Albumin; Hypoalbuminemia; Pediatric Intensive Care Unit; PRISM III; Mechanical Ventilation; Mortality.

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Introduction

Serum albumin is the most abundant plasma protein and plays an important role in maintaining colloid oncotic pressure, transporting endogenous substances and regulating inflammatory responses. In critically ill children, serum albumin concentrations frequently decrease because of systemic inflammation, increased capillary permeability, reduced hepatic synthesis and

accelerated protein breakdown. Hypoalbuminemia has been associated with greater illness severity, prolonged hospitalization and adverse clinical outcomes. Ari et al.[1] reported an association between admission serum albumin concentrations and clinical outcomes among children admitted to pediatric intensive care units (PICUs). Early identification of children at increased risk of clinical deterioration is an important aspect of pediatric critical care. Serum albumin is routinely measured, inexpensive and readily available, making it a potentially useful marker for initial risk assessment. Gowa et al.[2] investigated the relationship between serum albumin levels and prognosis in critically ill children, while Bekhit et al.[3] examined its usefulness in predicting outcomes among PICU patients. Both studies contributed evidence regarding the clinical relevance of hypoalbuminemia in pediatric critical illness.

The relationship between serum albumin and mortality may not be uniform across all critically ill children. Zhang et al.[4] described a U-shaped association between serum albumin concentrations and PICU mortality, suggesting that the interpretation of albumin levels requires consideration of the patient's underlying clinical condition. Tiwari et al.[5] also reported that hypoalbuminemia was common among critically ill children and was associated with greater disease severity and adverse outcomes.

The prognostic significance of hypoalbuminemia has been investigated in specific pediatric populations. James et al.[6] reported an association between low serum albumin levels and adverse outcomes in critically ill children with cancer. However, serum albumin may reflect the severity of the underlying illness rather than independently predict mortality. Established severity assessment tools, particularly the Pediatric Risk of Mortality III (PRISM III) score developed by Pollack et al.[7], provide a structured approach to evaluating physiological disturbances and estimating mortality risk. Although previous studies have demonstrated associations between hypoalbuminemia and adverse outcomes, its usefulness as an independent prognostic marker remains uncertain.

The present study was therefore conducted to determine the frequency of hypoalbuminemia among critically ill children and evaluate its association with PRISM III scores, mechanical ventilation, length of PICU stay, duration of hospitalization and short-term mortality.

Materials and Methods

Study Design and Setting: This prospective observational study was conducted in the Paediatric Intensive Care Unit of Indira Gandhi Institute of Child Health, Bengaluru, over 18 months after obtaining approval from the Institutional Ethics Committee. A total of 368 critically ill children aged between 1 month and 18 years were enrolled.

Inclusion and Exclusion Criteria: Children aged 1 month to 18 years admitted to the PICU whose parents or guardians provided informed consent were included. Assent was obtained from older children wherever applicable.

Children with protein-losing enteropathy, chronic liver disease, nephrotic syndrome, and chronic kidney disease or protein-energy malnutrition were excluded. Those who had received albumin, fresh frozen plasma or whole blood within four weeks before admission were also excluded.

Data Collection and Clinical Assessment: Demographic characteristics, clinical history, primary diagnosis and relevant examination findings were recorded at admission. Routine investigations included complete blood count, renal function tests, liver function tests, serum electrolytes and serum albumin. Serum albumin was measured within the first 24 hours of PICU admission using the bromcresol green colorimetric method on a Roche/Hitachi cobas analyzer.

Hypoalbuminemia was defined as a serum albumin concentration below 2.5 g/dL in children younger than 7 months and below 3.5 g/dL in children aged 7 months or older. Based on these values, patients were categorized into hypoalbuminemia and normoalbuminemia groups.

Assessment of Illness Severity and Outcomes: The PRISM III score was calculated using clinical and laboratory parameters recorded during the first 24 hours of admission.

Patients were followed throughout their PICU stay, and the requirement for mechanical ventilation, duration of ventilation, length of PICU stay, total hospital stay and mortality were recorded. Outcomes were compared between children with hypoalbuminemia and those with normal serum albumin concentrations.

Statistical Analysis: Data were analyzed using descriptive and appropriate inferential statistical methods. Continuous variables were summarized using measures of central tendency and dispersion, while categorical variables were expressed as frequencies and percentages. Comparisons were performed between the hypoalbuminemia and normoalbuminemia groups to assess associations with illness severity and short-term clinical outcomes. A p-value below 0.05 was considered statistically significant.

Results

A total of 368 critically ill children admitted to the Paediatric Intensive Care Unit (PICU) were included in the study. Of these, 190 (51.6%) were males and 178 (48.4%) were females. Most children belonged to the 1-month to 6-year age group (62.5%). Hypoalbuminemia was identified in 156 (42.4%) children, while 212 (57.6%) had normal serum albumin levels.

Table 1: Demographic Characteristics and Serum Albumin Status (n = 368)

Characteristics	Number (n)	Percentage (%)
Age distribution		
1 month–6 years	230	62.5
6–12 years	72	19.5
12–18 years	66	18.0
Sex distribution		
Male	190	51.6
Female	178	48.4
Serum albumin status		
Normoalbuminemia	212	57.6
Hypoalbuminemia	156	42.4

Children younger than six years constituted the largest proportion of PICU admissions. Hypoalbuminemia was observed in approximately two-fifths of the study population.

Table 2: Association between Serum Albumin Status and PRISM III Scores

PRISM III risk category	Normoalbuminemia (n = 212)	Hypoalbuminemia (n = 156)
Low risk (<10)	151 (71.2%)	94 (60.3%)
Moderate risk (10–20)	56 (26.4%)	49 (31.4%)
High risk (20–30)	5 (2.4%)	11 (7.1%)
Very high risk (>30)	0 (0.0%)	2 (1.3%)
Mean PRISM III score ± SD	**7.11 ± 5.08**	**9.10 ± 6.81**
p-value	**0.007**	

Children with hypoalbuminemia had significantly higher mean PRISM III scores than those with normal albumin concentrations (9.10 ± 6.81 versus 7.11 ± 5.08; p = 0.007). High-risk and very-high-risk categories were also more frequent in the hypoalbuminemia group, indicating an association between reduced serum albumin and greater illness severity.

Table 3: Comparison of Mechanical Ventilation and Length of Stay According to Serum Albumin Status

Clinical parameter	Normoalbuminemia (n = 212)	Hypoalbuminemia (n = 156)	p-value
Mechanical ventilation required, n (%)	86 (40.5%)	60 (38.5%)	0.318
Mechanical ventilation not required, n (%)	126 (59.5%)	96 (61.5%)	
Duration of mechanical ventilation (days), mean ± SD	8.07 ± 9.03	7.95 ± 10.88	0.657
Length of PICU stay (days), mean ± SD	6.7 ± 7.5	7.3 ± 9.0	0.622
Length of hospital stay (days), mean ± SD	11.5 ± 11.8	13.4 ± 12.0	0.554

Mechanical ventilation was required in 38.5% of children with hypoalbuminemia and 40.5% of those with normal albumin levels (p = 0.318). The mean duration of ventilation was comparable between the groups. Children with hypoalbuminemia had slightly longer PICU and hospital stays, but neither difference was statistically significant (p = 0.622 and p = 0.554, respectively).

Table 4: Short-Term Outcomes and Association of PRISM III Scores with Clinical Outcomes A. Final clinical outcomes according to serum albumin status

Clinical outcome	Normoalbuminemia (n = 212)	Hypoalbuminemia (n = 156)	p-value
Discharged	171 (80.6%)	125 (80.3%)	—
Death	22 (10.4%)	21 (13.7%)	0.456
Discharge against medical advice (DAMA)	15 (7.6%)	10 (6.4%)	—
Referred	3 (1.4%)	1 (0.6%)	—

Table 4: B. Association of PRISM III scores with clinical outcomes

Clinical outcome	Number (n)	Mean PRISM III score ± SD	p-value
Required mechanical ventilation	146	10.05 ± 6.80	**<0.001**
Did not require mechanical ventilation	222	6.58 ± 4.87	
Died	43	10.70 ± 7.89	**<0.001**
Survived	325	7.59 ± 5.56	

Mortality was numerically higher among children with hypoalbuminemia than among those with normal serum albumin levels, although the difference was not statistically significant ($p = 0.456$). PRISM III scores were significantly higher among children requiring mechanical ventilation ($p < 0.001$) and those who died during hospitalization ($p < 0.001$).

Discussion

The present study evaluated serum albumin levels and their association with short-term outcomes in 368 critically ill children admitted to the Paediatric Intensive Care Unit (PICU). Hypoalbuminemia was observed in 156 children (42.4%). Children with hypoalbuminemia had higher mean PRISM III scores than those with normal albumin levels (9.10 ± 6.81 versus 7.11 ± 5.08; $p = 0.007$). However, no statistically significant association was observed between hypoalbuminemia and mechanical ventilation, length of PICU stay, duration of hospitalization or mortality.

Serum albumin is a negative acute-phase reactant, and its concentration may decrease during critical illness because of systemic inflammation, increased vascular permeability and altered protein metabolism. Zhang et al.[8] examined the relationship between albumin administration and mortality in critically ill children with severe hypoalbuminemia. Although their study addressed a therapeutic intervention rather than the prognostic value of admission albumin, it reflected the continuing clinical interest in albumin abnormalities in pediatric intensive care.

The present study found that hypoalbuminemia was associated with greater illness severity, as reflected by significantly higher PRISM III scores. Hari Prasath and Anil Kumar[9] investigated the lactate-to-albumin ratio as an early predictor of mortality in critically ill children.

Similarly, Zuo et al.[10] examined the association between lactate-to-albumin ratio and all-cause mortality in pediatric intensive care patients. These studies suggested that combining serum albumin with other physiological markers may provide additional prognostic information compared with albumin measurement alone.

Yuan and Li[11] investigated the clinical significance of the lactate-to-albumin ratio in pediatric sepsis, while Chen et al.[12] examined the combined prognostic relevance of interleukin-6, serum albumin and acute kidney injury in pediatric COVID-19 patients. Mandal et al.[13] evaluated the C-reactive protein-to-albumin ratio and fluid overload in relation to mortality and PRISM III scores. These investigations indicated that albumin-related indices may reflect systemic inflammation and physiological disturbances in critically ill children. However, the findings of these studies cannot be directly compared with the present study because the patient populations and evaluated biomarkers differed.

In the present study, mechanical ventilation was required in 38.5% of children with hypoalbuminemia and 40.5% of those with normal albumin levels ($p = 0.318$). The mean duration of ventilation was also comparable between the groups (7.95 ± 10.88 versus 8.07 ± 9.03 days; $p = 0.657$). Uzunay et al.[14] examined albumin-corrected anion gap and lactate clearance as predictors of mortality in pediatric intensive care patients. Their findings supported the clinical relevance of combining biochemical parameters with measures of physiological disturbance.

Mortality was numerically higher among children with hypoalbuminemia than among those with normal serum albumin concentrations, but the difference was not statistically significant ($p = 0.456$). Horowitz and Tai[15] previously investigated hypoalbuminemia in critically ill children and reported its association with adverse clinical outcomes. The absence of a significant mortality association in the present study may have reflected differences in patient characteristics, underlying diagnoses, severity of illness and sample composition.

PRISM III scores demonstrated a stronger association with clinical outcomes than serum albumin status. Children requiring mechanical ventilation had significantly higher PRISM III scores than those who did not require ventilation (10.05 ± 6.80 versus 6.58 ± 4.87; $p < 0.001$). Similarly, children who died had higher scores than survivors (10.70 ± 7.89 versus 7.59 ± 5.56; $p < 0.001$). Pollack et al.[16] described the PRISM III Acute Physiology Score as a measure of physiological instability in pediatric intensive care patients. The original Pediatric Risk of Mortality scoring system developed by Pollack et al.[17] also established the importance of physiological variables in assessing illness severity and mortality risk.

The findings suggested that serum albumin was more closely associated with the severity of critical illness than with individual short-term outcomes. Its routine availability makes it a useful supplementary biochemical parameter, although it should not replace established clinical severity assessment tools. The single-center design and potential influence of underlying diseases, inflammatory status and nutritional factors limited the interpretation of the findings. The absence of a significant association with mortality also did not establish that albumin lacked independent prognostic value, as this would require appropriate multivariable analysis.

Conclusion

Hypoalbuminemia was observed in 42.4% of critically ill children and was significantly associated with higher PRISM III scores. However, it was not significantly associated with mechanical ventilation, duration of hospitalization or mortality. Serum albumin may serve as an additional marker of illness severity, while PRISM III remains more informative for short-term risk assessment.

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