

Preoperative hypoalbuminemia as a prognosis indicator in patients with surgical sepsis and septic shock

ABSTRACT

Introduction: Sepsis and septic shock are among the leading causes of morbidity and mortality worldwide. Hypoalbuminemia is commonly observed preoperatively and may serve as a prognostic factor for predicting severity of sepsis and septic shock.

Methodology: A cross-sectional, prospective descriptive study was conducted on 122 surgical adult patients diagnosed with sepsis or septic shock according to the Sepsis-3 criteria. All patients were admitted to the intensive care unit from April 2023 to May 2024.

Results: A total of 46 patients (37.7%) were diagnosed with sepsis and 76 patients (62.3%) developed septic shock. The septic shock group had significantly longer hospital stays compared to the sepsis group (7 days vs. 4 days, respectively) and higher mortality rates (52.6% vs. 10.9%, respectively). Hypoalbuminemia was present in 89.3% of all patients, with 22.1% patients having severe hypoalbuminemia. There was a significant difference in mortality rates between patients with hypoalbuminemia and normal albumin level (40.4% vs. 7.7%, respectively). The mortality rate of severe hypoalbuminemia patients was also higher (48.1%) than non-severe hypoalbuminemia (37.8%) and normal albumin levels (7.7%). The adjusted odds ratio for post-operative in-hospital death comparing patients with hypoalbuminemia and patients with normal albumin level was 8.12 [1.02–64.73]. A preoperative hypoalbuminemia with cutoff of 29.8 g/L was the prognostic factor for mortality with an area under the receiver operating characteristic curve (AUROC) of 67.3%, sensitivity of 78.6%, and specificity of 56.6%.

Conclusions: Preoperative albumin level was the potential prognostic indicator for severity and should be considered in the risk stratification model for patients with surgical sepsis and septic shock.

Key words: Hypoalbuminemia, mortality rate, septic shock, sepsis

Introduction

Sepsis and septic shock are among the leading causes of death in developing countries. Despite significant advancements in diagnosis and treatment, the mortality rate of sepsis and septic shock remains high, with reported 30-day mortality

averaging around 34.7% and 90-day mortality approaching 38.5%.^[1] Early diagnosis and risk stratification is important for timely therapeutic interventions, playing a crucial role

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in reducing mortality rates, shortening hospital stays, and lowering treatment costs. Various scoring systems and markers are used to prognosticate the severity of patients with sepsis and septic shock, including the SOFA and APACHE II scores, *procalcitonin*, *lactate*, and *IL-6*.

Albumin is a serum protein that plays many vital roles in the human body. Serum albumin levels fluctuate across various physiologic states and significantly decrease during sepsis. In surgical septic patients, a study by Sun *et al.*^[2] demonstrated that a decrement of 1 g/L in serum albumin below the critical threshold of 23 g/L correlated with a 19.4% increase in mortality and a 28.7% increase in the incidence of multiorgan dysfunction. A study conducted by Phi Xuan An *et al.*^[3] revealed a significant correlation between serum albumin levels and 28-day mortality. Specifically, for each 10 g/L decrease in serum albumin concentration, the risk of mortality increased eightfold. Presently, there is a paucity of research examining sepsis, septic shock, and the prognostic utility of hypoalbuminemia perioperatively. Our study aims to evaluate the association between hypoalbuminemia and severity prognosis in patients with sepsis and septic shock who underwent surgery.

Methodology

Inclusion criteria

Patients over 18 years old diagnosed with sepsis or septic shock according to the definition and criteria of Sepsis-3^[4] at the Departments of Anesthesiology, Emergency Medicine and Critical Care, Hue University of Medicine and Pharmacy Hospital and Hue Central Hospital.

- Sepsis: Considered when there is an infection and multiorgan dysfunction (acute change in the SOFA score ≥ 2 points).
- Septic shock: Defined as a patient with sepsis who has been adequately fluid resuscitated, but (1) requires vasopressors to maintain mean arterial blood pressure ≥ 65 mmHg and (2) with serum lactate level > 2 mmol/L.

Exclusion criteria

- Patients who refuse to participate in the study
- Patients who expired intraoperatively
- Patients with chronic conditions causing albumin loss: including decompensated cirrhosis, nephrotic syndrome, acute glomerulonephritis, systemic lupus erythematosus, malnutrition, and burns
- Patients who had received albumin supplementation before surgery
- Patients with sepsis and septic shock, who are diagnosed after surgery.

Study design: A cross-sectional descriptive study

Sample size

Using the formula to calculate sample size:

$$n = Z^2_{(1-\alpha/2)} \frac{p(1-p)}{d^2}$$

n : the minimum required number of patients

With a confidence level of 95%, $Z_{(1-\alpha/2)} = 1.96$

$P = 0.4$ is the proportion of patients with sepsis and septic shock admitted to the intensive care unit^[5]

$d = 0.1$ is the allowable margin of error

Substituting the values into the formula provided an n of 92

Study period and location

- Study period: April 2023 to May 2024.
- Study location: Departments of Anesthesiology, Emergency Medical and Critical Care, Hue University of Medicine and Pharmacy Hospital and Hue Central Hospital.

Data collection

Baseline demographic and medical history data of patients, including gender, age, vital signs, comorbidity diseases, clinical and laboratory characteristics were collected. Venous blood samples were collected from patients before operating room admission, and after intensive care unit admission. Serum albumin levels were measured at two time points: preoperatively and postoperatively (24 hours after surgery). Patients with missing serum albumin values were excluded from the analysis. Serum albumin was measured using standardized automated biochemical assays at our institution, and the same laboratory procedures were applied uniformly to all patients.

Statistical analysis

SPSS 20.0 statistical and MedCalc 22.017 software was used for data analysis. Enumeration data were presented as n (%) and the χ^2 test was used for comparison between groups. U test was used for ranked data. Measurement data with a normal distribution were presented as $\bar{X} \pm SD$ and unpaired t -test was used for comparison between groups, and those with a skewed distribution were presented as M (P25, P75) and the Mann-Whitney U test for comparison between two groups and Kruskal Wallis H test for comparison among multiple groups. The prognostic value for mortality of

albumin, lactate, procalcitonin, platelets, SOFA, and APACHE II score was analyzed using ROC curves. Differences with a *P* value of < 0.05 were considered statistically significant. Delong test was used for comparison ROC values.

Study flowchart: [Figure 1]

Results

In the study of 122 patients with sepsis and septic shock according to Sepsis-3 from April 2023 to May 2024, the following results were obtained:

General characteristics

Males accounted for 59.0% of the patients. The average age was 64.2 ± 16.9 years, with those over 60 years old being the largest sub-group, accounting for 64.8%. The proportion of patients with sepsis and septic shock was 37.7% and 62.3%. The most common bacteria isolated was *Escherichia coli* (42.9%), followed by *Klebsiella pneumoniae* (20.6%) [Table 1].

Clinical and laboratory characteristics

There was a significant difference in the SOFA and APACHE II scores between sepsis and septic shock groups. Regarding laboratory findings between the two groups, there was a significant difference in preoperative albumin levels. During postoperative intensive care treatment, laboratory values such as procalcitonin, lactate, pH, BE, HCO_3^- , and creatinine between the two groups (sepsis and septic shock) also showed significant differences. The mortality difference was also significant, being 10.9% and 52.6%, respectively [Table 2].

Relationship between hypoalbuminemia and mortality prognosis in sepsis and septic shock patients

Hypoalbuminemia was present in 89.3% of patients, with 22.1% patients having severe hypoalbuminemia. Mortality rates between patients with hypoalbuminemia and normal

albumin level were significantly different (40.4% vs. 7.7%, respectively). Among patients with albumin levels < 25 g/L, the mortality rate was 48.1%, which was higher compared to those with albumin levels of 25–34 g/L (37.8%) and albumin levels >34–55 g/L (7.7%) [Table 3].

The group of patients with preoperative hypoalbuminemia had the higher risk of mortality compared to the group with normal preoperative serum albumin levels (OR and 95% CI: 8.12 [1.02–64.73]), *P* < 0.05 [Table 4].

Albumin had moderate prognostic value for mortality, with AUROC values of 67.3%. At an albumin cutoff of 29.8 g/L, sensitivity was 78.6% and specificity was 56.6%. Lactate, procalcitonin and SOFA also demonstrated moderate prognostic value for mortality, with AUROC values of 68.7% 70.0% and 73.9%, respectively. APACHE II scores showed strong prognostic value for mortality in sepsis and septic shock patients, with AUROC values of 74.7%, z-statistic = 2,139, *P* < 0.05. Although the AUROC of 67.3% shows only moderate discrimination, albumin alone is insufficient for definitive prognosis, and at the cutoff of 29.8 g/L, the sensitivity of

Table 1: General characteristics of the study population

Characteristics	Values	n(%)
Gender (n, %)	Male	72 (59.0%)
	Female	50 (41.0%)
Average age	64.2 ± 16.9	
Age distribution (years)	<30	7 (5.7%)
	30–45	10 (8.2%)
	46–60	26 (21.3%)
	>60	79 (64.8%)
Diagnosis classification	Sepsis	46 (37.7%)
	Septic shock	76 (62.3%)
Primary infection site	Gastrointestinal	111 (91.0%)
	Respiratory	1 (0.8%)
	Urinary tract	5 (4.1%)
	Skin	3 (2.5%)
	Obstetrics	1 (0.8%)
	Musculoskeletal	1 (0.8%)
Pathogen isolated	<i>Escherichia coli</i>	27 (42.9%)
	<i>Klebsiella pneumoniae</i>	13 (20.6%)
	<i>Enterobacter spp</i>	4 (6.3%)
	<i>Pseudomonas aeruginosa</i>	2 (3.2%)
	<i>Enterococcus spp</i>	10 (15.9%)
	<i>Streptococcus spp</i>	5 (7.9%)
	<i>Staphylococcus spp</i>	2 (3.2%)
Surgical intervention	Gastric perforation closure	37 (30.3%)
	Colonic/appendicitis perforation closure	37 (30.3%)
	Open common bile duct exploration	18 (14.8%)
	Surgical management of small bowel necrosis	18 (14.8%)
	Anatrophic nephrolithotomy	6 (4.9%)
	Other	6 (4.9%)

Values are presented as mean ± standard deviation or number(%)

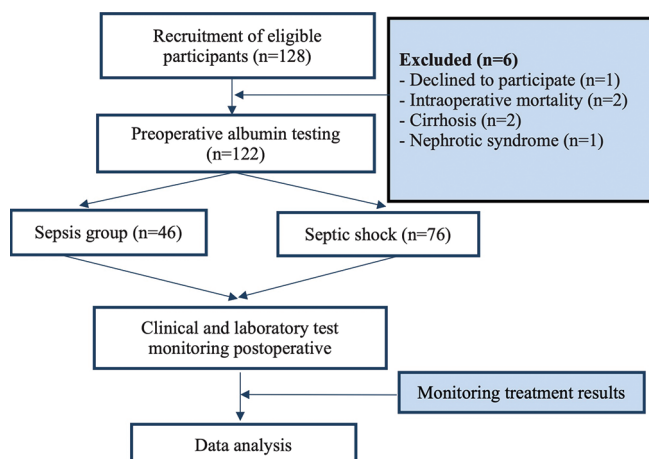


Figure 1: Study flowchart

Table 2: Clinical and laboratory characteristics

Group Characteristics	Total (n=122)	Sepsis (n=46)	Septic shock (n=76)	P
Average age	64.2 ± 16.9	58.2 ± 18.5	67.9 ± 14.9	<0.05 ^(a)
Mean HR (beats/min)	110.0 (100.0–142.5)	102.0 (90.0–120.0)	111.0 (95.0–172.5)	>0.05 ^(a)
Platelet (G/L)	225.0 (158.8–315.4)	254.0 (185.0–352.8)	215.0 (146.3–300.5)	
Procalcitonin (ng/mL)	14.2 (3.7–58.3)	8.0 (1.0–18.6)	27.2 (7.5–100.0)	<0.05 ^(b)
Lactate (mmol/L)	3.6 (2.2–5.2)	2.1 (1.4–3.1)	4.3 (3.2–6.4)	<0.05 ^(b)
Albumin (g/L)	28.0 ± 4.6	29.9 ± 4.9	26.0 ± 4.1	<0.05 ^(a)
Creatinine (μmol/L)	115.1 (74.0–182.1)	83.7 (62.8–134.7)	137.0 (83.5–196.0)	<0.05 ^(b)
pH	7.3 (7.2–7.4)	7.4 (7.3–7.4)	7.3 (7.2–7.4)	<0.05 ^(b)
BE (mmol/L)	−7.6 ± 6.3	−4.5 ± 6.0	−9.0 ± 5.9	<0.05 ^(a)
HCO ₃ [−] (mmol/L)	18.2 ± 5.4	20.4 ± 5.3	16.9 ± 5.1	<0.05 ^(a)
SOFA score	7.0 (4.0–8.0)	3.5 (2.0–6.0)	7.0 (6.0–9.8)	<0.05 ^(b)
APACHE II score	19.1 ± 6.0	16.4 ± 6.1	20.7 ± 5.3	<0.05 ^(a)
ICU duration (days)	5.0 (3.0–9.0)	4.0 (3.0–7.0)	7.0 (4.0–10.0)	<0.05 ^(b)
Mechanical ventilation	62 (50.8%)	12 (26.1%)	50 (65.8%)	<0.05 ^(c)
Dialysis therapy	35 (28.7%)	2 (4.3%)	33 (43.4%)	<0.05 ^(c)
Mortality	45 (36.9%)	5 (10.9%)	40 (52.6%)	<0.05 ^(c)

Values are presented as mean ± standard deviation, median(IQR) or number(%), (a) *t*-test, (b) Mann-Whitney *U* test, (c) χ^2 test

Table 3: Distribution of patient survival and mortality rate among various ranges of serum albumin levels

Albumin	<25 g/L	25–34 g/L	>34–55 g/L	P
Total (n=122)	27 (22.1%)	82 (67.2%)	13 (10.7%)	<0.05 ^(c)
Survivors (n=77)	14 (51.9%)	51 (62.2%)	12 (92.3%)	
Mortality (n=45)	13 (48.1%)	31 (37.8%)	1 (7.7%)	

(c) χ^2 test

56.6% and specificity of 78.6% imply a risk of false-negative and false-positive results. Nevertheless, albumin may serve as a supportive biomarker when combined with established clinical scores and biochemical markers. Combining albumin, Δ albumin, lactate, procalcitonin, SOFA and APACHE II scores further improves prognostic value for mortality, resulting in an AUROC of 82.2%, sensitivity of 64.3%, specificity of 86.8%, $P < 0.05$ [Figure 2] [Table 5].

Discussion

The average age of our study group was 64.2 ± 16.9 years, with the majority (64.8%) being over 60 years. This result aligns with Giang's study, in which the average age was reported as 58.27 ± 18.42 years.^[6] These results suggest that older age is associated with the higher risk of septic shock. Elderly patients often have comorbid chronic diseases, combined with lower immune systems, which may lead to a higher rate of septic shock, multiple organ failure, and increased mortality.

Globally, studies on patients with intra-abdominal infections worldwide have reported a septic shock rate ranging from 30% to 50%. For instance, Luo *et al.*^[7] reported a septic shock rate of 30.9%, while Park *et al.*^[8] found a rate of 47.0%. The

incidence of septic shock in our study is likely higher due to the characteristics of the healthcare system in Central Vietnam, where critically ill patients are concentrated in a single tertiary care hospital where we conducted our research.

In our study, pathogens were isolated in 63 cases. Gram-negative bacteria predominated (73.0%). Among these, with *Escherichia coli* being the most frequently identified pathogen (42.9%), followed by *Klebsiella pneumoniae* at 20.6%. These findings are in congruence with Tsai *et al.*^[9] study from 2014 to 2018 at 50 medical hospitals across nine countries, also showed that *Escherichia coli* was the most commonly isolated pathogens in patients with intra-abdominal infections (44.2%), followed by *Klebsiella pneumoniae* (22.7%) and *Pseudomonas aeruginosa* (8.7%). Similarly, Umemura *et al.*^[10] in Japan found that *Escherichia coli* was the most frequently isolated pathogen (21.5%), followed by *Klebsiella pneumoniae* (9.0%).

Regarding the severity of the patients in the study, the mean SOFA score was 7, and the mean APACHE II score was 19.1. Recent studies on sepsis and septic shock have yielded similar results, such as Thinh's study,^[11] which reported mean SOFA and APACHE II scores of 9.7 and 18.3, respectively. The study by Shadvar *et al.*^[12] reported a mean SOFA score of 14.6. Lactate, a key indicator of tissue hypoperfusion and reduced oxygen delivery to tissues in septic shock, showed statistically significant differences between groups in our study, with values of 2.1 mmol/L and 4.3 mmol/L, respectively. This finding is like the study by Zhong *et al.*^[13] who reported that the serum lactate levels upon admission in patients with

sepsis and septic shock were 1.3 mmol/L and 4.3 mmol/L, respectively. In cases of infections due to surgical causes, we observed that procalcitonin levels were not markedly elevated. In this study, the levels in patients with sepsis and septic shock were 8.0 ng/mL and 27.2 ng/mL, respectively, with a significant difference between the two groups.

Despite advancements in diagnosis and treatment, mortality rates among patients with sepsis and septic shock remain high. In this study, the mortality rate was 36.9%, which is consistent with An's findings of 24.4% in surgical patients with sepsis and septic shock.^[3] Studies on patients with sepsis and septic shock due to internal medicine causes have shown higher mortality rates. For example, Thanh's

study recorded a 28-day mortality rate of 57.0%.^[5] Duyen *et al.*^[14] reported a mortality rate of 52.0%. The disparity in mortality rates between sepsis and septic shock patients due to surgical versus medical causes can be explained not only by the initial severity of the illness, diagnosis, and timing of treatment resuscitation and antibiotic administration but also by early infection control in surgical cases. Procedures like drainage, debridement, and lavage of the infected site reduce bacterial toxins burden, enhance antibiotic penetration into the infected area, decrease inflammation, and mitigate cellular dysfunction and tissue damage, leading to improved treatment outcomes. The average postoperative intensive care duration in this study was 5 days, with a statistically significant difference between the two groups of sepsis and septic shock patients, at 4 days and 7 days, respectively. The length of hospital stay depends on various factors, including the patient's condition, hospital resources, and the patient's financial situation.

The mean preoperative serum albumin concentration in patients was 28.0 ± 4.6 g/L. The prevalence of hypoalbuminemia, defined as albumin < 34 g/L among patients was notably high, at 89.3%. Among these, 22.1% of patients were classified as having severe hypoalbuminemia. There are several factors believed to influence hypoalbuminemia in patients with sepsis and septic shock, including nutritional status, advanced age, comorbidities, and the severity of the body's inflammatory response to infection, which can lead to disturbances in the distribution of albumin within and outside the vascular compartment. These confounders were not fully adjusted for in our study, representing an important limitation, and an opportunity for improvement in future studies. Moreover, our single-center cross-sectional design restricts generalizability, and causality cannot be inferred. Future prospective, multicenter studies with additional

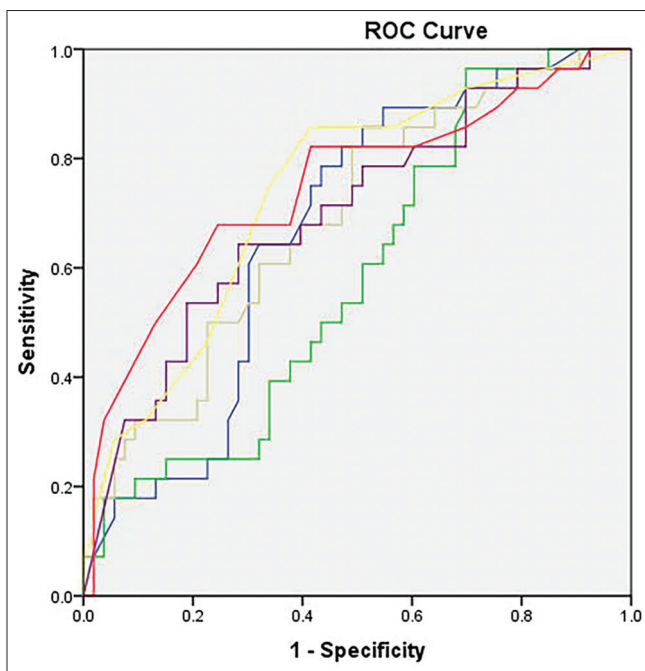


Figure 2: ROC curve for mortality prediction in patients

Table 4: Risk of mortality according to preoperative blood albumin levels

Characteristics	Values	Mortality (n, %)	Survivors (n, %)	95% CI	P
Albumin	<34 g/L	44 (40.4%)	65 (59.6%)	8.12 (1.02–64.73)	<0.05 ^(c)
	≥34–55 g/L	1 (7.7%)	12 (92.3%)		

(c) χ^2 test

Table 5: Prognostic value for mortality of albumin, Δ albumin, lactate, procalcitonin, platelets, SOFA, and APACHE II scores

Values Characteristics	AUC (%)	Cut - off	Sensitivity (%)	Specificity (%)	95% CI (%)	P
Albumin	67.3	29.8	78.6	56.6	0.55–0.79	<0.05
Δ Albumin	58.5	5.8	96.4	30.2	0.46–0.71	>0.05
Lactate	68.7	2.9	82.1	50.9	0.57–0.81	<0.05
Procalcitonin	70.0	22.5	64.3	71.7	0.58–0.82	<0.05
SOFA	73.9	5.5	85.7	58.5	0.63–0.85	<0.05
APACHE II	74.7	19.5	67.9	75.5	0.63–0.87	<0.05
Combined	82.2	#	64.3	86.8	0.73–0.92	<0.05

Table 6: Comparison albumin to lactate, procalcitonin, SOFA, and APACHE II scores with Delong test

Values Characteristic	Albumin (AUROC=67.3)	
	z-statistic	P
Lactat(AUROC=68.7)	0.413	0.680
Procalcitonin(AUROC=70.0)	0.810	0.418
SOFA(AUROC=73.9)	1.826	0.068
APACHE II(AUROC=74.7)	2.139	0.032

confounder adjustments are needed for external validation. Overall, a total of 45 in-hospital deaths (36.9%) occurred among all included patients, but there were 13/27 (48.1%) deaths among patients with severe hypoalbuminemia, 31/82 (37.8%) deaths among patients with non-severe hypoalbuminemia, and 1/13 (7.7%) deaths among patients with normal albumin level. The results of our study align with Petch-in *et al.*^[15] who reported a prevalence of severe hypoalbuminemia at 53.9%. Among the deceased patients, 40.7% had severe hypoalbuminemia, 19.5% had non-severe hypoalbuminemia, and 3.2% had normal serum albumin levels. The study was conducted by Thanh *et al.*^[5] found that patients with serum albumin levels between 20 and 23 g/L had the highest mortality rate at 81.8%, while those with serum albumin levels below 30 g/L had a mortality rate of 60.6%. The difference in 28-day mortality rates among the albumin groups was statistically significant. The study conducted by An *et al.*^[3] found that among patients with serum albumin levels less than 20 g/L, the mortality rate was 42.3%. In contrast, the mortality rate in patients with serum albumin levels between 20 and 30 g/L was 21.1%. Importantly, there were no fatalities reported in patients with serum albumin levels exceeding 30 g/L, the differences in mortality rates across the albumin groups were statistically significant.

Our study identified an optimal preoperative albumin cut-off of 29.8 g/L for predicting mortality, with a sensitivity of 84.1% and a specificity of 42.9%. Comparatively, An *et al.*^[3] study reported that at the cutoff value of 20.75 g/L, serum albumin had the best predictive value for mortality, with a sensitivity of 76.1% and a specificity of 56.5%. The study by Sun *et al.*^[2] indicated that for each 1 g/L decrease in serum albumin levels below the cutoff threshold of 23 g/L, there was a corresponding increase of 19.4% in mortality and a 28.4% increase in the incidence of multiple organ failure. The differences among studies regarding the optimal cutoff for serum albumin levels in predicting mortality for patients with sepsis and septic shock can be attributed to several factors, including variations in the severity of the patients studied, differences in the timing of infection onset, as well as variations in surgical interventions and postoperative resuscitation treatments. Our study indicates that the group of patients with preoperative hypoalbuminemia had a

higher risk of mortality compared to the group with normal preoperative serum albumin levels (OR and 95% CI: 8.12 [1.02–64.73]), $P < 0.05$. The study conducted by Thanh *et al.*^[5] also found that patients with serum albumin levels < 25 g/L had a higher mortality rate compared to those with serum albumin levels ≥ 25 g/L, $P < 0.05$. Sun *et al.*^[2] showed that patients with sepsis and septic shock and serum albumin levels below 20 g/L (particularly those with albumin levels < 15 g/L) had worse outcomes. In contrast, patients with serum albumin levels between 21 and 25 g/L had a prognosis like those with albumin levels exceeding 26 g/L. Our study found that preoperative serum albumin levels, Δ albumin had average prognostic values for mortality, with AUROC values of 67.3% and 58.5%, respectively. In comparison, Yin *et al.*^[16] reported that serum albumin had a significant prognostic value for 28-day mortality, with AUROC of 72.4%.

We evaluated the prognostic value of various factors, including lactate, procalcitonin, SOFA score, and APACHE II score, after surgery. These parameters exhibited moderate-to-good prognostic values for mortality like serum albumin concentration, with AUROC values of 68.7%, 70.0%, 73.9%, and 74.7%, respectively [Table 6]. Lee *et al.*^[17] found that the initial lactate level had a lower prognostic value for mortality compared to lactate levels measured at 24 and 48 hours post-admission. The study by Thinh *et al.*^[11] on the changes and prognostic value of serum procalcitonin in patients with sepsis and septic shock following abdominal surgery reported that procalcitonin levels at the postoperative time point did not show a statistically significant difference between deceased and surviving patients. In contrast, procalcitonin levels at other time points studied (24 hours, 48 hours, 5 days, and 7 days) were significantly higher in patients who did not survive compared to those who did. Several studies have indicated that the SOFA and APACHE II scores provide moderate-to-good prognostic value for mortality, as these scoring systems are based on the synthesis of various clinical and laboratory parameters quantified from organ function. Consequently, they more accurately reflect the severity and prognosis of patients. The study by Sadaka *et al.*^[18] reported that the APACHE II score has a good predictive capability for mortality, with AUROC of 80.0%. The study by Khwannimit found that the SOFA score has a good prognostic capability for mortality, with AUROC of 83.9%.^[19] When combining six factors consisting of albumin, Δ albumin, lactate, procalcitonin, SOFA score, and APACHE II score, the prognostic value for mortality improves, yielding an AUROC of 82.2%, with a sensitivity of 64.3% and specificity of 86.8%, $P < 0.05$. The study by Zhao *et al.*^[20] found that SOFA, SOFA + APACHE II, Lactate + Lactate 24-hour + Procalcitonin + SOFA + APACHE II could predict mortality in septic shock patients, and AUROC was

76.9%, 78.7%, 80.0%, respectively. This reinforces the role of hypoalbuminemia as a component of multimodal risk assessment, not a stand-alone predictor.

Conclusions

Septic shock patients exhibited prolonged hospital stays and elevated mortality rates compared to sepsis patients. Statistically significant differences were observed in preoperative levels of albumin, postoperative procalcitonin, lactate, arterial blood gas, creatinine parameters, as well as SOFA and APACHE II scores when comparing sepsis and septic shock groups.

Serum albumin may contribute to risk stratification in surgical sepsis and septic shock. Combining albumin, Δ albumin, lactate, procalcitonin, and severity scores such as SOFA and APACHE II may further enhance the prognostic accuracy for severity and mortality in clinical practice.

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of Hue University of Medicine and Pharmacy, Hue University.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analyzed during this study are included in this article. Further enquiries can be directed to the corresponding author.

Authors' contributions

All authors read and approved the final manuscript.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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