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Correlation Between Lactate, Albumin, Lactate/Albumin Ratio, and SOFA Score in Sepsis Patients

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ABSTRACT

Background & Objective: Sepsis is a condition with various body responses and often results in death from infection. Serum lactate levels, elevated during hypoxia, stress, and critical illness, can serve as a sensitive yet non-specific indicator of metabolic stress. Hypoalbuminemia may be present in sepsis and exacerbate its severity. Researchers propose the lactate/albumin ratio (LAR) as a marker associated with multi-organ failure, and the SOFA score assesses mortality in critically ill patients. This study aims to investigate the correlation between lactate, albumin, LAR, and the SOFA score in septic patients.

Materials & Methods: Thirty-five patients with sepsis were enrolled in this study. The LAR assessment and SOFA score were manually calculated; lactate and albumin levels were determined using a clinical chemistry analyzer. The Spearman test was employed to analyze the data, with a significance level of $p < 0.05$.

Results: The median levels of lactate, albumin, and LAR were 5.50 (1.90–10.40) mmol/L, 2.40 (0.90–3.70) g/dL, and 2.29 (0.53–7.46), respectively. The results of the Spearman correlation test between albumin levels and the SOFA score showed no correlation ($p = 0.643$ and $r = -0.081$). Lactate, LAR, and the SOFA score showed a significant correlation ($p = 0.002$ and $r = 0.498$, $p = 0.001$ and $r = 0.538$).

Conclusion: There is a potential relationship between lactate, and LAR parameters and organ dysfunction severity.

Keywords: Lactate, Albumin, LAR, SOFA Score

1. Introduction

A dysregulated host response to infection causes life-threatening organ dysfunction, which is known as sepsis (1). The global burden of sepsis is difficult to ascertain, although recent scientific publications estimate that in 2017 there were 48.9 million cases and 11 million sepsis-related deaths worldwide, accounting for nearly 20% of all global deaths (2). Another cohort study conducted in 2002 in 198 intensive care units (ICUs) in 24 countries in Europe showed that severe sepsis and septic shock accounted for 29.5% of intensive care diagnoses. Mortality in patients with severe sepsis in intensive care reached 32.2% and increased to 54.1% in septic shock. In Asia, a 2009 study in 150 intensive care units in 16 countries (including Indonesia) showed that severe sepsis and septic shock accounted for 10.9% of intensive care diagnoses with a mortality rate of 44.5%. A study at Cipto Mangunkusumo Hospital (RSCM) in Jakarta's intensive care unit found that severe sepsis and septic shock were present in 23 of 84 patients. The death rate during treatment was 47.8%, and the death rate in the early stages was 34.7% (3).

Early recognition, diagnosis, and resuscitation, whether performed in the emergency unit or the ward, are the keys to successful therapy of severe sepsis and septic shock in the intensive care unit (4). The Sequential Organ Failure Assessment (SOFA) score is commonly used in emergency rooms, internal medicine departments, surgery, and intensive care units (ICUs) to figure out how sick a patient is and what their prognosis is for having

multiple organ failure. The score can change over time to reflect changes in how the organs work. The Quick Sequential Organ Failure Assessment (qSOFA) is a score that can quickly analyze changes in a patient's condition by analyzing consciousness, systolic blood pressure, and heart rate (5).

Sepsis is understood as an unusual systemic reaction to what is sometimes a common infection and may represent a pattern of response by the immune system to injury. An immunosuppressive phase follows the hyper-inflammatory response, causing multiple organ dysfunction and making the patient vulnerable to nosocomial infections. Markers for diagnosing sepsis may allow early intervention and reduce the risk of death. At the moment, lactate is the most common way to tell if someone has sepsis. Other markers may help lactate work better, such as pro-inflammatory cytokines and chemokines; proteins like C-reactive protein and procalcitonin (PCT), which are made in response to infection and inflammation; and markers of neutrophil and monocyte activation. Researchers have also suggested C-Reactive Protein (CRP) and serum albumin levels as predictors of therapeutic response and outcome in sepsis. Procalcitonin and serum albumin levels have been associated with case fatality rates in sepsis (6).

Previous studies have demonstrated the use of LAR as a prognostic marker to independently predict sepsis mortality and severe heart failure (7). Studies have shown that the lactate/albumin ratio outperforms lactate as a marker in sepsis (8). In Jamie's study, there was a correlation between lactate levels and SOFA scores at 24 and 48 hours ($r = 0.303$, $p = 0.022$, and $r = 0.449$, $p = 0.000$, respectively). It was also said that the CNS, lungs, liver, and kidneys are some of the organs that aren't working properly and cause lactate levels to rise (9). It has been found that albumin infusion leads to higher levels of serum albumin and lower levels of IL-6, TNF-α, and SOFA (10). The ratio of lactate to albumin can be used to predict death from any cause in people who were admitted with acute pancreatitis within 28 days. It is a better predictor of outcome than arterial blood lactate or albumin serum alone (11). An experiment by Noer A. found that LAR on day 1 did not have any effect on the SOFA score ($r = 0.054$ and $p = 0.690$). However, an experiment by Erdogan found that the lactate/albumin ratio did have an effect on the SOFA score ($r = 0.272$, $P < 0.001$) (12, 13). There were still differences in the results of different studies that came before this one, so more research needs to be done to find out how albumin, serum lactate, and the lactate/albumin ratio are related to the SOFA score.

2. Materials and Methods

2.1 Study Design and Subject Recruitment

This study was an analytical observational study with a cross-sectional approach; the research subjects were patients over 18 years old diagnosed with sepsis in the integrated room and intensive care unit of Dr. Kariadi General Hospital in Semarang. We excluded patients with a history of blood disorders, kidney disorders, liver disorders, and nerve disorders from this study. The selection of research subjects was carried out by consecutive sampling.

The calculation of sample size for a correlation test involves determining the minimum number of subjects required to detect a significant correlation between two variables with a given level of confidence and statistical power. In this study, the test was designed with a significance level (α) of 0.05, corresponding to a Zα value of 1.96, and a power of 90%, which corresponds to a Zβ value of 1.28. We selected 35 patients treated in the ICU and inpatient wards who met the criteria for sepsis. Detailed clinical history was collected, and comprehensive physical and radiological examinations were performed. Laboratory examination of serum lactate and albumin was performed using the ADVIA 1800 clinical chemistry analyzer. Blood was collected in plain vacutainers for serum lactate and albumin. The LAR was calculated by dividing the serum lactate level by the serum albumin level.

2.2 Statistical Analysis

The data were analyzed statistically with the SPSS program. Descriptive analysis displays the frequency, mean (± standard deviation), or median (minimum-maximum) values of the variables. Data normality testing was carried out with Shapiro-Wilk. The correlation test used was the Spearman correlation test, with a p-value considered significant if it was < 0.05. Ethical clearance was obtained from the Institutional Committee for Medical and Health Research Ethics, Dr. Kariadi General Hospital, Semarang, Number 1476/EC/KEPK-RSDK/2023.

3. Result

This study included 35 sepsis patients, of whom 16 (45.7%) were male and 19 (54.3%) were female. The mean age was 53.22 years (53.22 ± 14.98). Table 1 displays the baseline characteristics of the study population. Based on the baseline characteristics of the people who were studied, 51.4% had a Glasgow Coma Scale (GCS) level of consciousness below 6, albumin levels were lower in most of them (94.3% had levels below 3.5 g/dL), and lactate levels were higher in 97.1% of them (> 2 mmol/L).

The normality test using the Shapiro-Wilk test found that the SOFA score variable was normally distributed, but the other parameters were not normal, so the next test was to test the relationship using the Spearman correlation test. The results of the Spearman correlation test on lactate levels against SOFA obtained a value of $p = 0.002$ and $r = 0.498$. On albumin against SOFA, it obtained a value of $p = 0.643$ and $r = -0.081$. The correlation between LAR and SOFA was 0.528, and the r value was 0.001 (Table 2). However, there is no correlation between albumin levels and SOFA scores. Here we include a scatter plot of the correlation between lactate levels, albumin, and the

lactate/albumin ratio, with SOFA scores below (Figure 1-3).

Table 1. Basic characteristics of the subjects studied.

Variable	Frequency	%	Mean ± SD	Median (Min-Max)
Age			53.22 ± 14.98	56 (19 – 79)
≤ 65 years	27	77.1		
> 65 years	8	22.9		
Gender				
Male	16	45.7		
Female	19	54.3		
GCS			6.69 ± 2.98	5 (3 – 14)
15	0	0.0		
13 – 14	2	5.7		
10 – 12	5	14.3		
6 – 9	10	28.6		
< 6	18	51.4		
Type of admission				
Medical	19	54.3		
Surgical	16	45.7		
ETT				
Yes	18	51.4		
No	17	48.6		
Leukocytes				
≤ 10.6 x 10^3/µL	10	28.6		
> 10.6 x 10^3/µL	25	71.4		
Lactate			5.57 ± 2.63	5.50 (1.90 – 10.40)
< 2 mmol/L	1	2.9		
> 2 mmol/L	34	97.1		
Albumin			2.43 ± 0.62	2.40 (0.90 – 3.70)
<3.5g/dL	33	94.3		
>3.5g/dL	2	5.7		
LAR			2.51 ± 1.47	2.29 (0.53 – 7.46)
SOFA score			9.09 ± 2.77	9 (4 – 16)

GCS: Glasgow Coma Scale, ETT: Endotracheal tube,

LAR: lactate/albumin ratio, SOFA: Sequential Organ Failure Assessment

Table 2. Spearman correlation test results between lactate, albumin, and LAR with SOFA scores

Parameters	SOFA score	
	p	r
Lactate	0.002	0.498
Albumin	0.643	- 0.081
LAR	0.001	0.538

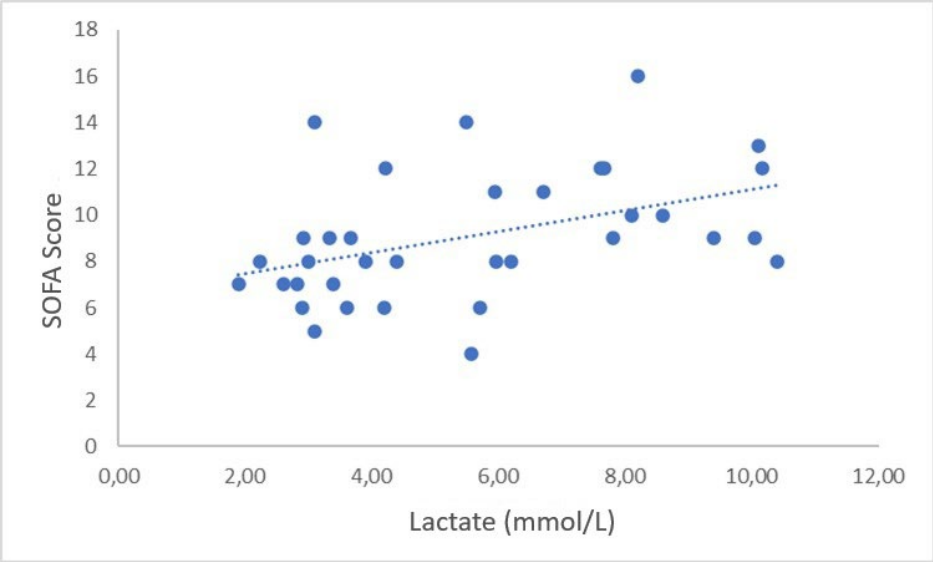

Figure 1. Scatter graph of the correlation between lactate and SOFA score (p=0.002, r=0.498) (**Designed by Authors, 2025**).

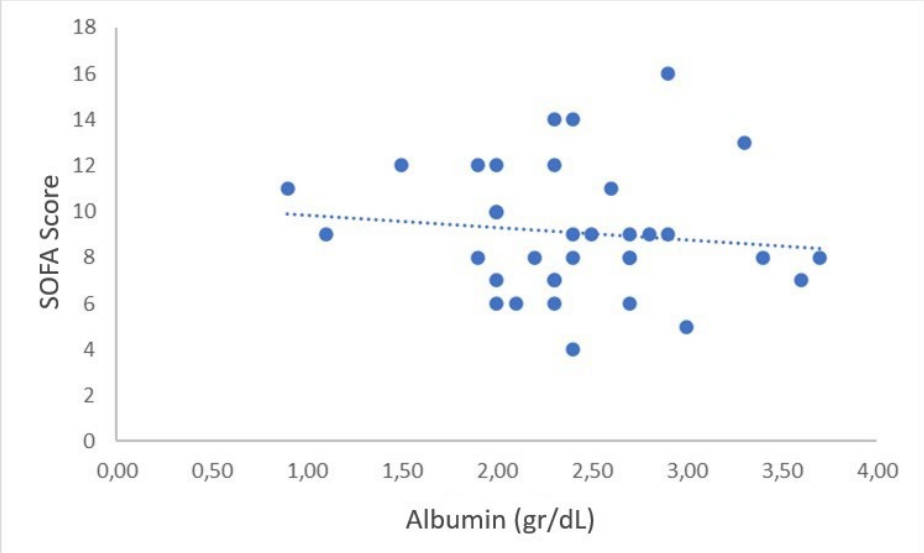

Figure 2. Scatter graph of the correlation between albumin and the SOFA score (p=0.643, r= -0.081) (**Designed by Authors, 2025**).

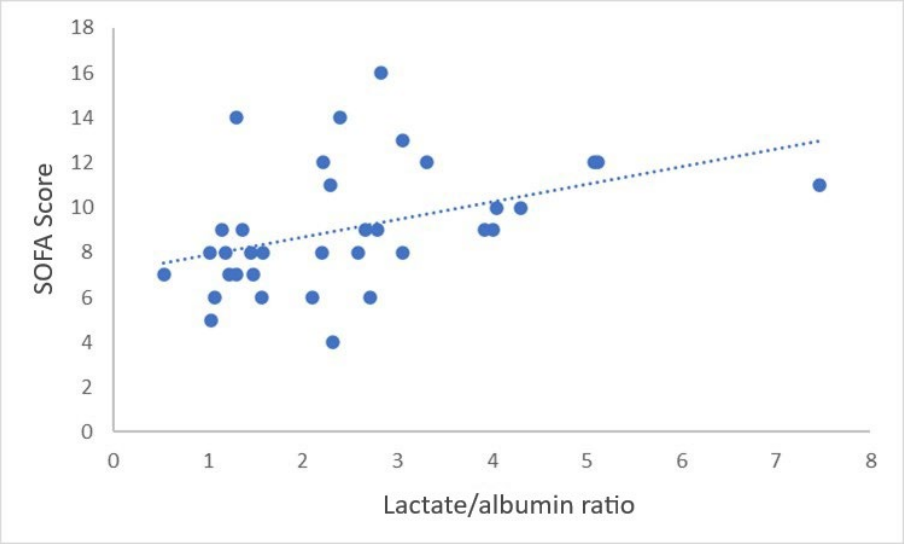

Figure 3. Scatter graph of the correlation between Lactate/albumin ratio and SOFA score (p=0.001, r=0.538). (**Designed by Authors, 2025**).

4. Discussions

The liver produces albumin, a negative acute phase protein. Decreased albumin levels are an indicator of inflammation that reflects the severity of inflammation that occurs. Albumin can function as an additional parameter for predicting mortality and prognosis in sepsis patients **(14)**. Changes in several nutritional markers, such as albumin and total protein, are associated with a higher risk of death in the short term in sepsis patients **(15)**. The study looked at 35 people with sepsis and found that their average serum albumin level was 2.43 ± 0.62 g/dL. The levels ranged from 0.90 to 3.70 g/dL. In healthy people, plasma albumin levels were 3.5 g/dL to 5 g/dL **(16)**. The study yielded results that indicated a decrease in the average albumin level. Albumin levels tend to decrease with acute phase reactions such as sepsis and trauma. Hypoalbuminemia in septic patients can be caused by a number of things, such as the liver not making as much albumin, the body not taking in as many amino acids, more plasma leakage, and more tissue breakdown **(6, 17)**. The peak decrease in albumin levels occurs in 2-4 days after inflammation and will decrease further with the resolution of the inflammatory process on the 4th to 7th day **(18)**. In this study, there was no correlation between albumin levels and the SOFA score; the SOFA score was stated to correlate with the severity and mortality of patients **(19)**.

Other research has found the same thing: albumin levels with the Spearman correlation test and the albumin value on the first day did not have a significant correlation with death due to sepsis ($r = 0.05$; $p = 0.703$). On the other hand, albumin on the fourth day did have a moderate correlation with death due to sepsis ($r = 0.4972$; $p = 0.001$) **(18)**. Utariani's study yielded results that did not align with the study's objectives. This is a relationship between albumin and the SOFA score, where the r value is 0.465 and $p = 0.01$. In this study, albumin levels were not measured on the same day the inflammation began, thus affecting the correlation between albumin and SOFA score in the sepsis subjects/patients studied **(10)**.

Sepsis is a major cause of death in acute hospitals and commonly causes multi-organ dysfunction secondary to infection. Septic shock is defined as hypotension that does not recover despite adequate fluid replacement in the guidelines issued by the Surviving Sepsis Campaign (SSC) **(20)**. Up until now, it was thought that septic shock had three parts: low blood pressure in the arteries throughout the body, low blood flow to tissues that causes organs to stop working, and high levels of lactate in the blood **(21)**. In this study, the average serum lactate level ranged from 5.57 ± 2.63 mmol/L; a lactate level exceeding 2 mmol/L was considered elevated **(22)**. According to this study, there was a moderately positive relationship between lactate levels and SOFA score. This is different from previous studies that did not find a relationship between lactate levels and SOFA score at hour 0 of care but did discover one at hours 12 and 24 of care. Sepsis will cause changes in the metabolic and hormonal systems to maintain body homeostasis. Intensive and prolonged stress responses will be associated with increased morbidity and mortality. In critically ill patients, failure of compensatory mechanisms triggers an imbalance that disrupts the body's homeostasis. The initial metabolic response is characterized by tissue hypoperfusion and a decrease in overall metabolic activity and lasts 12-24 hours and peaks around 3-5 days **(9)**. The findings of this study agree with those of Liu et al., who found that lactate levels and SOFA scores were related in a positive way ($r = 0.430$, $p < 0.001$) **(23)**.

Blood lactate levels are important parameters of tissue perfusion and infection, widely used in clinical medicine. Cellular ischemia and hypoxia can make lactate levels rise significantly and lead to metabolic problems by lowering the effective tissue circulation volume even more. Hypoalbuminemia is common in patients with sepsis,

further worsening the disease and increasing mortality. Based on the above, we consider that the lactate/albumin ratio can be a practical measure to assess the severity of the disease in patients with sepsis (24).

In laboratory findings, organ dysfunction and inflammatory parameters were significantly increased in patients with LAR > 0.60. The lactate/albumin ratio on the day the patient was admitted to the ICU was also linked to the SOFA score ($r = 0.335$, $p < 0.001$), which is in line with the study's findings ($p = 0.001$ and $r = 0.538$) (25). The correlation between the lactate/albumin ratio was strong in Kabra's study ($r = 0.76$ and $p = <0.001$), which is also true for this study (26). There was a positive correlation between the lactate/albumin ratio and the SOFA score in another study by Erdogan ($r = 0.272$, $p < 0.001$). However, there was no correlation between the lactate/albumin ratio and the SOFA score on Day 1 in the study by Noer A ($r = 0.054$ and $p = 0.690$) (11, 12).

According to earlier research, the lactate/albumin ratio as a whole is a more accurate predictor of mortality in sepsis and critically ill patients than either serum lactate or serum albumin alone. One limitation of this study is that albumin levels and SOFA scores were not always measured the same way when patients were admitted or before treatment. This could explain the discrepancy between correlation test results and albumin with SOFA scores when compared to earlier studies.

5. Conclusion

While lactate and the lactate/albumin ratio showed a moderately positive correlation with SOFA score, albumin and SOFA score did not correlate in this study. There is a potential relationship between lactate, and LAR parameters and organ dysfunction severity.

6. Declarations

6.1 Acknowledgments

Not applicable.

6.2 Ethical Considerations

Ethical clearance was obtained from the Institutional Committee for Medical and Health Research Ethics, Dr. Kariadi General Hospital, Semarang, No: 1476/EC/KEPK-RSDK/2023.

6.3 Authors' Contributions

V.P and DR: Responsible for conceptualization, methodology, formal analysis, investigation, writing original draft preparation. A.J contributed to review and editing, visualization, and supervision. All authors reviewed, edited, and approved the final version of the manuscript.

6.4 Conflict of Interest

The authors declare that they have no conflict of interest.

6.5 Fund or Financial Support

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6.6 Using Artificial Intelligence Tools (AI Tools)

The authors were not utilized AI Tools.

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