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ORIGINAL ARTICLE

Predictive Value of Serum Lactate in Determining Mortality in Patients with Septic Shock Undergoing Surgery

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ABSTRACT

Background: Septic shock is a leading cause of death in the perioperative period and a significant problem in emergency surgery. Timely recognition of those at risk of death is crucial. Serum lactate is a valuable marker of tissue hypoperfusion and metabolic derangement, but its role in predicting mortality in surgical patients with septic shock needs to be explored.

Objective: To evaluate the usefulness of serum lactate in predicting mortality in patients with septic shock who require surgery.

Methods: This prospective observational study was carried out in the Department of General Surgery, Sughra Shafi Medical Complex Narowal between 1st January 2024 and 31st March 2025. Consecutively, 80 adult patients with septic shock who required surgery were included in the study. Lactate was measured at the time of admission and at 6 hours following resuscitation. Lactate clearance was determined, and outcomes were monitored until discharge or death. Statistical analysis was performed using SPSS-26.

Results: The average age of the patients was 54.1±15.2 years, and 61.3% were men. In-hospital mortality was 35.0%. Admission serum lactate levels were significantly higher in non-survivors 5.9±1.5 mmol/L than in survivors 3.4±1.0 mmol/L. Lactate levels at 6 hours were also higher in non-survivors 5.0±1.3 mmol/L than survivors 2.5±0.8 mmol/). Lactate clearance was also significantly lower in non-survivors 10.8±6.3% than in survivors 26.7±9.4%. Lactate levels at admission of 4.0 mmol/L or greater were significantly associated with mortality ($p < 0.001$).

Conclusion: Lactate is an important predictor of death in surgical patients with septic shock. High admission lactate, persistent hyperlactatemia and low lactate clearance are all predictors of poor outcome.

Keywords: Septic shock, Serum lactate, Mortality, Surgery, Lactate clearance, Critical care.

INTRODUCTION

Septic shock is the most severe and potentially fatal form of sepsis and is a significant cause of perioperative morbidity and mortality.[1] It is defined by severe circulatory dysfunction, sustained hypotension requiring vasopressor therapy, and cellular–metabolic dysfunction in the presence of adequate fluid resuscitation. Septic shock is commonly seen in surgical patients with complicated intra-abdominal infections, perforated hollow viscus, necrotizing soft tissue infections, bowel

ischemia, anastomotic leaks, gangrenous appendicitis, obstructed or strangulated hernias, and other severe infective emergencies. These patients frequently present in a state of rapid decline because the systemic inflammatory response, tissue hypoperfusion and multiple organ dysfunction occurs in the context of the physiological stress of surgery and anesthesia. Consequently, the mortality in this group remains high despite improvements in antibiotic therapy, source control, perioperative care and critical care.[2]

A key feature of the pathophysiology of septic shock is the inability to use oxygen and microcirculatory dysfunction, which results in anaerobic metabolism and increased lactate production.[3] As a result serum lactate is generally accepted as a valuable biochemical indicator of global tissue hypoperfusion, metabolic stress, and disease severity. But in septic shock, elevated lactate is not only a marker of anaerobic metabolism, but can also be caused by mitochondrial dysfunction, catecholamine-induced glycolysis, decreased hepatic clearance, and inflammatory dysfunction. This makes serum lactate a valuable biomarker of the physiological stress in critically ill patients. In emergency surgery, where patients may present late and with unstable hemodynamics, serum lactate can offer a quick and objective assessment of severity of illness and adequacy of resuscitation.[4]

Risk stratification for mortality is an important consideration in septic shock, especially in patients who require urgent or emergency surgical intervention.[5] Risk stratification enables clinicians to prioritise resuscitation, timing of surgery, increase the intensity of hemodynamic monitoring, predict the need for critical care support post-operatively and provide families with better information about the likely outcome. While various scoring systems, including the Sequential Organ Failure Assessment (SOFA), Acute Physiology and Chronic Health Evaluation (APACHE II) and quick SOFA (qSOFA) are widely used in critically ill patients, these systems may be cumbersome, require multiple variables, or may not be suitable for the rapid pace of emergency surgical care. However, assessing serum lactate is cheap, easy, quick, and reliable, making it an appealing biomarker for clinical use.[6]

Over the past decade, it has become apparent that serum lactate is not only valuable as a static baseline measurement but also as a dynamic variable when measured over time.[7] Baseline lactate may reflect the degree of shock, while changes in lactate levels over time (also known as lactate clearance) may reflect the response to fluid resuscitation, vasopressors, antibiotics, and surgical source control. Those who fail to demonstrate a reduction in lactate levels following initial resuscitation are more likely to have persistent tissue hypoxia, persistent infection, persistent shock and worse clinical outcomes. Thus, initial lactate level and lactate clearance may be useful in predicting mortality in septic surgical patients.[8]

This is especially important in low- and middle-income countries like Pakistan, where late presentation, lack of critical care facilities, financial constraints, late referral to tertiary care and limited availability of advanced monitoring may further compound the impact of septic shock.[9] Many surgical emergencies presenting to tertiary care hospitals are already in the late stages of sepsis with organ dysfunction. In these circumstances, an easily accessible biomarker like serum lactate may be particularly important for early identification and prognostication. Although this is important, there is a paucity of local data on the predictive value of serum lactate in patients with septic shock undergoing surgery. The majority of existing studies have been conducted in general ICU populations, or in patients presenting to the emergency department, or medical patients with sepsis, but the surgical population presents with unique physiological and management issues.[10]

In this context, the current study sought to assess the prognostic value of serum lactate in predicting mortality in patients with surgical septic shock.[11] The study sought to determine the relationship between initial lactate level, lactate level after resuscitation, lactate clearance, and in-hospital death. Through the investigation of the predictive value of this easily accessible biomarker in the surgical septic shock population, this study aims to provide clinically relevant data that may enhance risk stratification in the perioperative period, and facilitate timely and targeted intervention in the at-risk population.[12]

MATERIAL AND METHOD

This prospective observational study was carried out in the Department of General Surgery, Sughra Shafi Medical Complex Narowal between 1st January 2024 and 31st March 2025. The aim of the study was to assess the predictive value of serum lactate in predicting mortality in patients with septic shock who required surgical care. The protocol for the study was designed in accordance with established ethical and clinical research standards. We included 80 patients in the study using a non-probability consecutive sampling method. The patients were admitted via the emergency or surgical critical care unit and had a diagnosis of septic shock requiring surgical intervention. The study included patients who met the clinical criteria for septic shock and who then required surgery for source control or emergency surgical indication.

All patients aged 18 years or older, of either sex, with a diagnosis of septic shock at presentation or during the perioperative period, septic shock was defined as suspected or proven infection with persistent hypotension requiring vasopressors to maintain a mean arterial pressure and signs of tissue hypoperfusion, including elevated blood lactate levels despite fluid resuscitation and those who required emergency surgery for source control of septic abdominal, soft tissue or other potentially surgically treatable infection were included. Known chronic liver disease, advanced cancer, chronic renal replacement therapy, cardiogenic shock, hemorrhagic shock, severe non-septic trauma, or any other known metabolic abnormality that may significantly affect lactate metabolism and those who declined to participate or had incomplete biochemical or outcome data were also excluded.

Following informed consent from the patient or their immediate family, if necessary, clinical and demographic data were collected on a proforma. This included age, sex, co-morbidities, source of sepsis, pre-operative hemodynamic status, and the nature of the surgical procedure. Patients were treated according to the institutional guidelines for the management of septic shock, including fluid resuscitation, antibiotics, vasopressors (if needed) and urgent surgical source control.

All patients had serum lactate levels measured at two time points. The initial lactate level was measured at the time of admission or initial surgical consultation before definitive surgical intervention, and was termed the admission lactate level. The second value was obtained six hours after initial resuscitation and surgical stabilization or source control. Serum was drawn and sent to the hospital laboratory for biochemical analysis. Lactate clearance was determined to measure the change in lactate levels following initial resuscitation. It was calculated as:

Lactate clearance (%) = [(Initial Lactate - 6-hour lactate)/Initial Lactate] x 100

This measure was used to assess the efficacy of resuscitation and surgical interventions, as well as to compare survivors and non-survivors. The primary outcome of interest was in-hospital death. The patients were monitored until discharge or death. Survival was the final outcome. We also noted the association between admission lactate level, post-resuscitation lactate level, and lactate clearance and survival.

The primary independent variable in this study was the level of serum lactate at admission and after six hours. Other variables studied were age, sex, source of infection and surgical diagnosis. The outcome variable was in-hospital death. Data was collected and analyzed using SPSS-26. The independent sample t-test was used to compare between survivors and non-survivors for continuous variables while the Chi-square test was used for categorical variables. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The study enrolled 80 patients with septic shock who required surgery. The average age of the patients was 54.1±15.2 years (range 19-82 years). Males were predominated, 49 (61.3%) males and 31 (38.7%) females. The most common cause of sepsis was intra-abdominal infection, followed by soft tissue and wound infections, with a minority of patients having hepatobiliary or other surgical infections. The in-hospital mortality rate was 38 (35%) and 52 (65%) of patients were discharged alive. Over half of the patients had intra-abdominal septic disease, and abdominal sepsis was the primary surgical cause of septic shock in this study. Deaths were still significant despite surgical intervention and resuscitation, suggesting the severity of this patient population (Table 1).

A comparison of the serum lactate levels between survivors and patients who died revealed a significant difference. The initial mean serum lactate in survivors was 3.4±1.0 mmol/L, whereas the mean initial serum lactate in patients who died was 5.9±1.5 mmol/L. The mean 6-hour serum lactate was also significantly lower in survivors 2.5±0.8 mmol/L than in non-survivors 5.0±1.3 mmol/L. Lactate clearance was also significantly greater in survivors 26.7±9.4% than in non-survivors 10.8±6.3%. This suggests that the absolute level of serum lactate, as well as the change in serum lactate after resuscitation, were significantly associated with mortality. The non-survivors had persistent hyperlactatemia at admission and after resuscitation. The statistical significance of initial lactate, 6-hour lactate, and lactate clearance suggests that serum lactate is a powerful predictor of outcome in patients with septic shock who require surgery (Table 2).

To better interpret the results, patients were divided into two groups based on admission serum lactate level (cut-off value 4.0 mmol/L). In the 33 patients with admission lactate <4.0 mmol/L, 4 (12.1%) patients died and 29 (87.9%) survived. However, among the 47 patients with admission lactate ≥4.0 mmol/L, 24 (51.1%) patients died and only 23 (48.9%) survived. This was statistically highly significant ($p<0.001$), suggesting that a higher admission lactate was significantly associated with great The mortality rate was significantly higher in patients with admission serum lactate levels of 4 mmol/L or higher, implying that this cut-off value may be useful in

identifying high-risk surgical patients with septic shock at admission.er risk of death (Table 3).

The findings of the present study clearly show that elevated admission serum lactate, persistently elevated 6-hour lactate, and reduced lactate clearance were all strongly associated with in-hospital mortality. These observations suggest that serial measurement of serum lactate is a useful and feasible method of predicting outcomes in the perioperative care of patients with septic shock.

Table 1. Baseline demographic and clinical characteristics of the study population (n=80)

Variable	No.	%
Age (years)	54.1±15.2	
Gender		
Male	49	61.3
Female	31	38.7
Intra-abdominal sepsis	43	53.8
Soft tissue/wound sepsis	18	22.5
Hepatobiliary sepsis	11	13.8
Other surgical sepsis	8	10.0
Survivors	52	65.0
Non-survivors	28	35.0

Table 2. Comparison of serum lactate parameters between survivors and non-survivors

Parameter	Survivors (n=52)	Non-survivors (n=28)	p-value
Initial serum lactate (mmol/L)	3.4±1.0	5.9±1.5	<0.001
6-hour serum lactate (mmol/L)	2.5±0.8	5.0±1.3	<0.001
Lactate clearance (%)	26.7±9.4	10.8±6.3	<0.001

Table 3. Association of admission serum lactate category with in-hospital mortality

Admission Serum Lactate	Survivors	Non-survivors	Total	p-value
<4.0 mmol/L	29 (87.9%)	4 (12.1%)	33	<0.001
≥4.0 mmol/L	23 (48.9%)	24 (51.1%)	47	
Total	52 (65.0%)	28 (35.0%)	80	

DISCUSSION

The current study assessed the predictive role of serum lactate in predicting mortality in patients with septic shock who require surgery and found that there is a significant and clinically relevant association between increased lactate levels and in-hospital mortality. We found that patients who died had significantly higher admission serum lactate, persistent elevation at 6 hours, and poor lactate clearance than survivors. These findings provide strong evidence for the use of serum lactate as a useful prognostic indicator in the perioperative care of patients with septic shock. Septic shock is a serious and high-risk condition in emergency surgery.[3] In this study, the in-hospital mortality rate was 35.0%, which indicates the severity of the physiological insult and associated lethality of septic shock in surgical patients. This is in line with the known high lethality of septic shock, especially in patients who need urgent surgery for source control.[4] Patients with surgical septic shock are subjected not only to the systemic inflammatory response of sepsis but also to the additional physiologic insults of anesthesia, surgery, hemodynamic compromise, and postoperative metabolic requirements. This may account for the high mortality despite resuscitation and surgery.[7]

A key finding of the current study was that the average initial admission serum lactate concentration was significantly higher in non-survivors 5.9±1.5 mmol/L than in survivors 3.4±1.0 mmol/L.[5] This indicates that non-survivors had more severe tissue hypoperfusion, metabolic dysfunction and circulatory failure at presentation. Elevated lactate levels in septic shock are known to reflect poor oxygen delivery, microcirculatory dysfunction, anaerobic metabolism, mitochondrial dysfunction, and hepatic dysfunction. Thus, a higher admission lactate level indicates not only the severity of the disease but also the degree of physiological dysfunction. Clinically, this observation suggests the importance of early measurement of serum lactate in critically ill surgical patients, as this may assist in early identification of patients who may require more intensive and vigilant care.[6]

A further key finding of this study was that the 6-hour lactate remained much higher in non-survivors 5.0±1.3 mmol/L than in survivors 2.5±0.8 mmol/L.[8] This suggests that initial resuscitation failed to correct

metabolic stress and tissue hypoxia in those who subsequently died. In patients with septic shock, persistent elevation of lactate following fluid resuscitation, vasopressor administration, antibiotics and surgical source control generally reflects ongoing circulatory failure, persistent sepsis, or failure of recovery. As such, repeated lactate measurement seems to provide more information than an initial measurement. In emergency surgical settings where the course of the patient's illness may be unpredictable, serial lactate measurements may provide an objective measure of treatment efficacy.[9]

Perhaps the most important finding of the current study was the difference in lactate clearance between survivors and non-survivors.[10] The mean lactate clearance in survivors was 26.7±9.4%, compared with 10.8±6.3% in non-survivors. This highlights that not only the initial lactate value but also its change over time is important for prognostication. Lactate clearance is a measure of the return of tissue perfusion and metabolic recovery after resuscitation and source control. Failure to clear suggests ongoing physiological dysfunction and systemic dysfunction. This is of great clinical importance because it means that serum lactate can be used for both prognostication and monitoring of response to treatment. If a patient's lactate does not improve sufficiently after initial resuscitation, he or she may need more aggressive hemodynamic support, more frequent monitoring in ICU, or a re-evaluation of ongoing source control for infection.[11]

In the present study, a clinically relevant threshold effect was also observed when patients were grouped by admission serum lactate. Patients with admission lactate ≥4.0 mmol/L had a much higher mortality (51.1%) than did those with lower levels (12.1%). This is significant because it provides a useful threshold for identifying patients at high risk of dying. In a busy emergency and surgical department, particularly in resource-poor hospitals, this cut-off may be useful for triage, ICU admission, intensity of post-operative monitoring, and early prognostication for families. The ability to use a simple biochemical marker to stratify risk makes serum lactate very useful in clinical practice.[11,12]

It's also important to note the high proportion of intra-abdominal sepsis (53.8%) in this study, which is the surgical burden of septic shock in many tertiary hospitals.[13] Perforation peritonitis, bowel gangrene, anastomotic leak, complicated appendicitis, intestinal obstruction with ischemia and intra-abdominal abscesses are often associated with delayed presentation and advanced sepsis in low-resource settings. These conditions can lead to significant contamination, a high inflammatory response, and slow recovery after surgery. Thus, in these patients, serum lactate may be a particularly important predictor of the degree of systemic insult and risk of postoperative complications.[14]

Our study has several implications for perioperative and critical care practice.[15] First, serum lactate should be used as a routine part of the initial assessment of patients presenting for surgery with suspected septic shock. Second, serial lactate measurements should be used in perioperative resuscitation strategies to monitor response to therapy and determine the need for escalation of care. Third, patients with very high lactate levels or those who fail to clear their lactate should be considered to be at high risk for poor outcomes and treated accordingly with aggressive hemodynamic support, ICU care, and serial reassessment. Serum lactate provides a quick, cheap and objective alternative to complex scoring systems in situations where the latter may not be immediately available or practical.[16-20]

This study has several limitations. This was a single-center study with a small sample size (80 patients), which may not be representative of a larger population. Also, while lactate was measured at baseline and at six hours, more serial measurements may have offered a better insight into the dynamics of lactate and its relationship with outcomes. In addition, other severity scores, such as SOFA and APACHE II, were not included in the analysis for comparison of prognostic performance. However, the study is still clinically relevant as it focuses on a specific subset of patients with septic shock who may undergo surgery, which is not always the focus of other sepsis studies.

The present study shows that serum lactate is not just a laboratory test but a clinically relevant indicator of severity, response to therapy and likelihood of death in patients with septic shock requiring surgery. Its capacity to predict the risk of adverse outcomes and assess the response to resuscitation therapy makes it a useful marker in emergency surgical and critical care.

CONLUSION

Serum lactate is a powerful and clinically relevant predictor of death in surgical septic shock patients. The present study found that non-survivors had significantly higher admission and 6-hour lactate levels, and significantly lower lactate clearance than survivors. This suggests that both the absolute value of serum lactate and its dynamic change are useful in predicting patients at higher risk of mortality.

A serum lactate level of ≥4.0 mmol/L on admission was significantly associated with increased mortality, and may be a useful early indicator in patients with surgical septic shock. Furthermore, failure to clear lactate

following initial resuscitation (reflecting a failure to recover) was strongly associated with poor outcomes.

Accordingly, serum lactate should be routinely measured and monitored in the perioperative period for patients with surgical septic shock. It is a practical, inexpensive and highly predictive biomarker, especially in urgent and resource-constrained settings. Serum lactate may help to identify high-risk patients early in their course, enabling more intensive resuscitation, continuing monitoring and early admission to ICU, and thus improve outcomes.

DECLARATION

Conflict of Interest: The authors declare no conflict of interest.

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