

Lactate Kinetics as Predictors of Clinical Outcomes in Patients with Perforation Peritonitis

Harshit Mathur¹, Mathura Prasad Agrawal², Shalini T.V.³

¹Postgraduate Resident, Dept. of General Surgery, Pacific Institute of Medical Sciences, Udaipur, Rajasthan, India

²Professor and HOD, Dept. of General Surgery Pacific Institute of Medical Sciences, Udaipur, Rajasthan, India

³Postgraduate Resident, Dept. of General Surgery, Pacific Institute of Medical Sciences, Udaipur, Rajasthan, India

Received: 01-03-2026 / Revised: 15-04-2026 / Accepted: 21-05-2026

Corresponding author: Dr. Harshit Mathur

Conflict of interest: Nil

Abstract

Background: Perforation peritonitis is a common surgical emergency associated with significant morbidity and mortality despite advances in surgical and critical care management. Early identification of high-risk patients remains essential for improving outcomes. Serum lactate has emerged as an important biomarker of tissue hypoperfusion and severity of sepsis. Recent studies suggest that serial lactate measurements and lactate clearance may be superior to a single lactate value in predicting outcomes.

Aim: To evaluate the prognostic significance of serial serum lactate levels and lactate clearance in predicting morbidity and mortality among patients undergoing emergency laparotomy for perforation peritonitis.

Materials and Methods: This study was conducted in the Department of General Surgery at PIMS, Udaipur, over a period of 12 months from May 2025 to May 2026 with a sample size of 49 patients.

A prospective observational study was conducted in the Department of General Surgery, Pacific Institute of Medical Sciences, and Udaipur. Forty-nine patients diagnosed with perforation peritonitis and undergoing emergency laparotomy were included. Serum lactate levels were measured at admission, 6 hours, and 24 hours postoperatively. Lactate clearance was calculated using serial lactate values.

Patients were followed until discharge or death. A p-value <0.05 was considered statistically significant.

Results: A total of 49 patients were included, of whom 43 recovered and 6 succumbed. The overall mortality rate was 12.24%. Mean preoperative lactate levels were significantly higher among non-survivors compared with survivors (6.52 ± 0.92 mmol/L vs 4.10 ± 1.09 mmol/L; $p=0.00058$). Similarly, 6-hour postoperative lactate levels (7.47 ± 1.11 mmol/L vs 3.24 ± 1.20 mmol/L; $p=0.00007$) and 24-hour postoperative lactate levels (8.25 ± 1.22 mmol/L vs 2.60 ± 1.10 mmol/L; $p=0.00003$) were significantly elevated in non-survivors. Patients with persistently elevated lactate levels and poor lactate clearance had a significantly higher risk of mortality.

Conclusion: Serial serum lactate monitoring and lactate clearance are valuable prognostic indicators in patients with perforation peritonitis. Persistently elevated lactate levels are strongly associated with adverse outcomes and mortality. Routine monitoring of serial lactate values may aid in early risk stratification and guide aggressive resuscitative measures.

Keywords: Perforation Peritonitis, Serum Lactate, Lactate Clearance, Mortality, Morbidity, Emergency Laparotomy, Sepsis.

DOI: 10.25258/ijcpr.18.6.207

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

Introduction

Perforation peritonitis remains one of the most frequently encountered surgical emergencies worldwide and continues to pose a major challenge to surgeons. The condition results from perforation of a hollow viscus leading to contamination of the peritoneal cavity by gastrointestinal contents. Patients often present with severe sepsis, septic

shock, electrolyte disturbances, and multiple organ dysfunction syndrome.

Despite advancements in antimicrobial therapy, intensive care support, and operative techniques, mortality associated with perforation peritonitis remains substantial. Early identification of patients

at increased risk of adverse outcomes is therefore essential to improve survival.

The clinical course of perforation peritonitis is often unpredictable, with some patients responding favorably to surgical intervention and resuscitation, while others rapidly progress to septic shock and multiple organ dysfunction syndrome. Traditional prognostic indicators such as blood pressure, urine output, leukocyte count, and various scoring systems may not always accurately reflect ongoing tissue hypoperfusion. Consequently, there is increasing interest in biochemical markers that can provide early and objective assessment of disease severity. Serum lactate has gained prominence as one such marker due to its ease of measurement, rapid availability, and strong association with tissue hypoxia and systemic inflammation.

Evaluating serial lactate measurements and lactate clearance may therefore offer a practical and cost-effective approach to identifying high-risk patients with perforation peritonitis at an early stage. Serum lactate is produced during anaerobic metabolism and accumulates during states of tissue hypoxia and hypoperfusion. Lactate reflects the balance between production and clearance and serves as an indirect marker of global tissue perfusion.

Recent evidence suggests that serial lactate measurements provide more meaningful prognostic information than a single lactate determination. Lactate clearance, defined as the percentage reduction in lactate concentration over time, reflects the adequacy of resuscitation and restoration of tissue perfusion. Failure to achieve adequate lactate clearance has been associated with poor outcomes in various critical illnesses.

However, limited studies have specifically evaluated the prognostic utility of serial lactate monitoring in patients with perforation peritonitis undergoing emergency laparotomy. Therefore, the present study was undertaken to assess the role of serial serum lactate levels and lactate clearance in predicting morbidity and mortality among patients with perforation peritonitis.

Materials and Methods

This study was conducted in the Department of General Surgery at PIMS, Udaipur, over a period of 12 months from May 2025 to May 2026 with a sample size of 49 patients.

Study Design: Prospective observational study.

Inclusion Criteria

1. Patients aged 18 years and above.
2. Radiological and clinical diagnosis of perforation peritonitis.
3. Patients undergoing emergency exploratory laparotomy.
4. Patients willing to participate.

Exclusion Criteria

1. Age less than 18 years.
2. Pregnant women.
3. Chronic liver disease.
4. Metabolic disorders affecting lactate metabolism.
5. Trauma-related perforation.
6. Patients refusing consent.

Methodology

All patients underwent detailed clinical evaluation and routine laboratory investigations. Serum lactate estimation was performed at:

- Admission (Preoperative)
- 6 hours postoperatively
- 24 hours postoperatively

Lactate clearance was calculated using:

$$\text{Lactate Clearance (\%)} = \frac{[(\text{Initial Lactate} - \text{Subsequent Lactate}) / \text{Initial Lactate}] \times 100}$$

Patients were followed during their hospital stay and outcomes were categorized as:

- Recovered
- Succumbed

Statistical Analysis- Data were entered into Microsoft Excel and analyzed. Continuous variables were expressed as Mean $\pm$ SD. $p < 0.05$ was considered statistically significant.

Results

Table 1: Age Distribution:

Age Group (Years)	Number of Patients	Percentage (%)
18–30	4	8.16
31–40	11	22.45
41–50	8	16.33
51–60	9	18.37
>60	17	34.69
Total	49	100

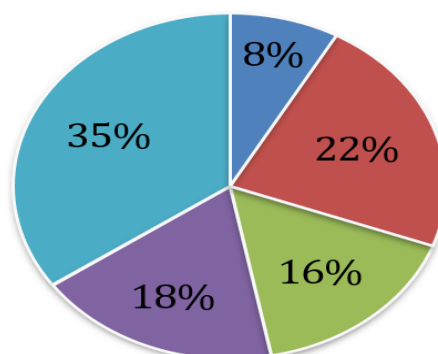
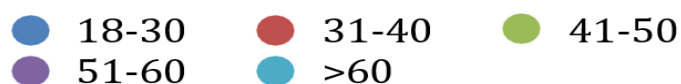


Figure 1: Age Distribution

Interpretation: The age of patients ranged from 22 to 78 years, with a mean age of 51.0 ± 16.25 years. The majority of patients belonged to the middle-aged and elderly population, indicating that perforation peritonitis is more commonly encountered in older individuals with associated comorbidities and delayed presentation.

Table 2: Outcome Distribution:

Outcome	No.	Percentage (%)
Recovered	43	87.76
Succumbed	6	12.24
Total	49	100

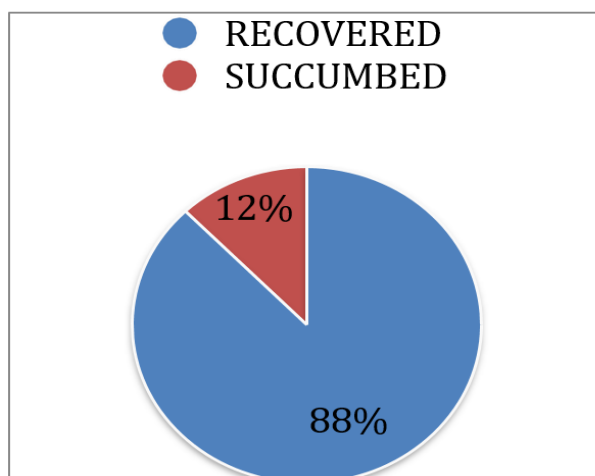


Figure 2:

Interpretation: Overall mortality in the present study was 12.24%, highlighting the continued burden of perforation peritonitis despite surgical intervention and intensive postoperative care.

Table 3: Comparison of Serial Lactate Levels

Parameter	Recovered Mean $\pm$ SD	Succumbed Mean $\pm$ SD	p-value
Preoperative Lactate	4.10 ± 1.09	6.52 ± 0.92	0.00058
6-hour Lactate	3.24 ± 1.20	7.47 ± 1.11	0.00007
24-hour Lactate	2.60 ± 1.10	8.25 ± 1.22	0.00003

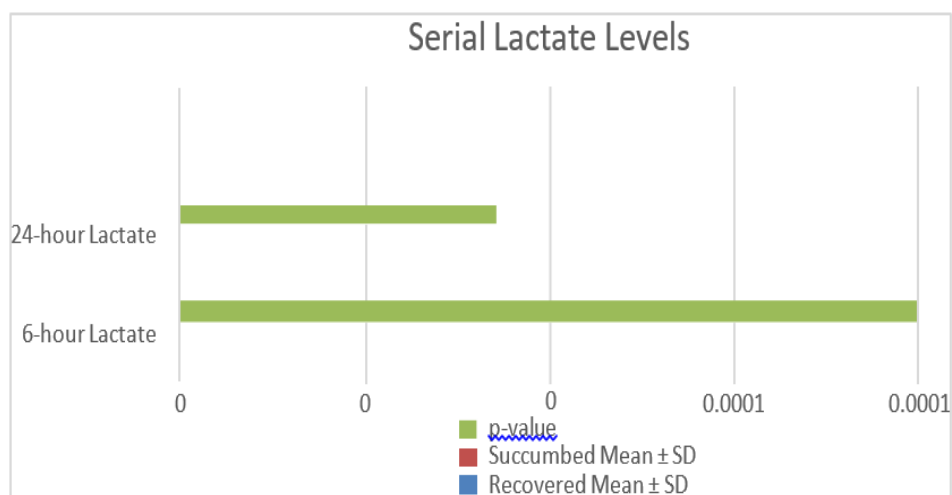


Figure 3:

Interpretation: A statistically significant difference was observed between survivors and non-survivors at all three time points.

Table 4: Lactate Clearance Analysis

Variable	Mean (%)
6-hour Lactate Clearance	19.76
24-hour Lactate Clearance	36.58

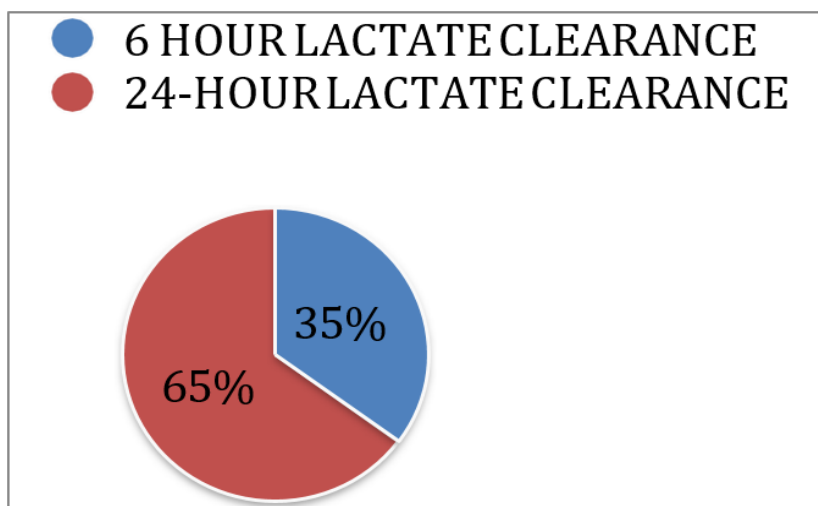


Figure 4: Percentage Reduction in Lactate

Lactate clearance was calculated to evaluate the effectiveness of resuscitation.

Interpretation: Patients with higher lactate clearance showed better clinical outcomes, whereas persistent hyperlactatemia and poor clearance were associated with mortality.

Table 5: Percentage Reduction in Lactate

Interval	Lactate Clearance (%)
Preop to 6h	20.98
Preop to 24h	36.59
Interval	Lactate Clearance (%)
Preop to 6h	-14.57
Preop to 24h	-26.53

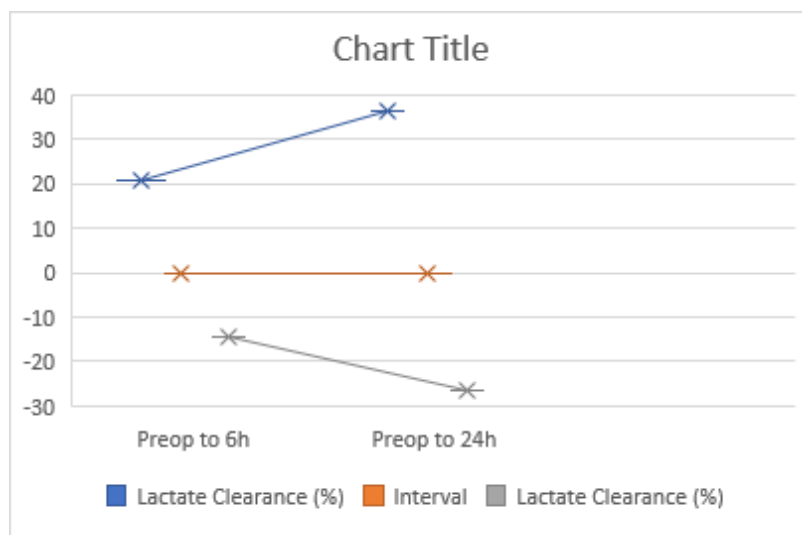


Figure 5:

Interpretation: Negative lactate clearance among non-survivors indicates worsening tissue hypoperfusion despite operative management.

Table 6: Mortality According To Admission Lactate Category

Lactate Level	Risk Category	Number of patients	Percentage (%)
<4 mmol/L	Low Risk	15	30.61
4–6 mmol/L	Intermediate Risk	30	61.22
>6 mmol/L	High Risk	4	8.16

Interpretation: Patients with admission lactate >6 mmol/L demonstrated the highest mortality risk.

The present study included 49 patients diagnosed with perforation peritonitis who underwent emergency exploratory laparotomy. The study population predominantly consisted of elderly patients, with more than one-third of the participants belonging to the age group above 60 years. The overall mortality rate was 12.24%, reflecting the serious nature of perforation peritonitis despite advances in perioperative management. Analysis of serial serum lactate levels demonstrated a clear distinction between survivors and non-survivors. Patients who recovered showed a progressive decline in serum lactate levels from admission through the postoperative period, whereas patients who succumbed exhibited persistently elevated and progressively increasing lactate values.

Furthermore, lactate clearance analysis revealed marked differences between the two groups. Survivors achieved a mean lactate clearance of 20.98% at 6 hours and 36.59% at 24 hours, indicating effective restoration of tissue perfusion following surgical source control and resuscitation. In contrast, non-survivors demonstrated negative lactate clearance values, suggesting continued lactate accumulation and ongoing tissue hypoxia. These findings indicate that dynamic assessment of lactate trends provides more clinically relevant information than a single lactate measurement. The

statistically significant differences observed at each time point reinforce the utility of serial lactate monitoring as a prognostic tool in perforation peritonitis.

Discussion

The present study demonstrates that serial serum lactate monitoring is a useful prognostic tool in patients with perforation peritonitis. Non-survivors exhibited significantly higher lactate levels at all measured time points compared with survivors.

The mean preoperative lactate level among non-survivors was 6.52 mmol/L compared with 4.10 mmol/L among survivors, indicating severe tissue hypoperfusion at presentation. Furthermore, survivors showed progressive reduction in lactate values over time, whereas non-survivors demonstrated persistent elevation.

These findings support the concept that lactate kinetics are superior to isolated lactate measurements in assessing response to resuscitation. Failure of lactate clearance reflects ongoing tissue hypoxia and persistent circulatory dysfunction.

Routine lactate monitoring may therefore assist surgeons in identifying high-risk patients requiring aggressive resuscitation, intensive monitoring, and early critical care support. Elevated lactate levels have long been recognized as markers of impaired tissue oxygen delivery and utilization. In perforation peritonitis, systemic inflammatory

response, sepsis, and septic shock contribute to microcirculatory dysfunction, resulting in increased lactate production.

An important observation of the present study was the superior prognostic value of serial lactate measurements and lactate clearance compared with isolated admission lactate levels. While elevated admission lactate identified patients at increased risk, persistent elevation at 6 and 24 hours was more strongly associated with mortality.

This suggests that the trend of lactate values over time is a better indicator of response to treatment and adequacy of resuscitation.

The clinical implications of these findings are significant. Serial lactate monitoring is inexpensive, readily available, and easily incorporated into routine perioperative management. Patients demonstrating poor lactate clearance may benefit from closer hemodynamic monitoring, more aggressive resuscitation, intensive care admission, and early recognition of postoperative complications. Thus, serial serum lactate measurement has the potential to serve not only as a prognostic marker but also as a guide for therapeutic decision-making in patients with perforation peritonitis.

Conclusion

Perforation peritonitis continues to be a major surgical emergency associated with significant morbidity and mortality despite advances in operative techniques, antimicrobial therapy, and critical care management. Early identification of patients at increased risk of adverse outcomes remains crucial for optimizing treatment strategies and improving survival.

The present prospective observational study demonstrated a significant association between serial serum lactate levels, lactate clearance, and patient outcomes in perforation peritonitis. Patients who succumbed to the disease exhibited significantly higher serum lactate levels at admission, 6 hours, and 24 hours postoperatively compared to survivors. Furthermore, survivors showed progressive reduction in serum lactate levels with satisfactory lactate clearance, whereas non-survivors demonstrated persistently elevated lactate levels and negative lactate clearance values, indicating ongoing tissue hypoperfusion and inadequate physiological recovery.

In conclusion, serial serum lactate levels and lactate clearance are reliable prognostic markers in patients with perforation peritonitis. Routine assessment of lactate kinetics should be considered as an adjunct to clinical evaluation in order to improve outcome prediction and optimize patient management. Larger multicentric studies with

longer follow-up periods are recommended to further validate these findings and establish standardized lactate-based protocols in the management of perforation peritonitis.

"Serial lactate monitoring not only reflects the severity of illness in perforation peritonitis but also provides a dynamic assessment of response to treatment. Patients who clear lactate survive; those who fail to clear lactate warrant aggressive intervention and closer surveillance."

Limitations

- Single-center study.
- Relatively small sample size.
- Morbidity parameters such as ICU stay, wound infection, and organ dysfunction were not separately analyzed.
- Long-term follow-up was not performed.

References

1. Vincent JL, Quintairos e Silva A, Couto L Jr, Taccone FS. The value of blood lactate kinetics in critically ill patients: a systematic review. *Crit Care*. 2016; 20:257. doi:10.1186/s13054-016-1403-5.
2. Nguyen HB, Rivers EP, Knoblich BP, Jacobsen G, Muzzin A, Ressler JA, et al. Early lactate clearance is associated with improved outcome in severe sepsis and septic shock. *Crit Care Med*. 2004;32(8):1637-1642. doi: 10.1097/01.CCM.0000132904.35713.A7.
3. Bakker J, Gris P, Coffernils M, Kahn RJ, Vincent JL. Serial blood lactate levels can predict the development of multiple organ failure following septic shock. *Am J Surg*. 1996;171(2):221-226. doi:10.1016/S0002-9610(97)89552-9.
4. Mikkelsen ME, Miltiades AN, Gaieski DF, Goyal M, Fuchs BD, Shah CV, et al. Serum lactate is associated with mortality in severe sepsis independent of organ failure and shock. *Crit Care Med*. 2009;37(5):1670-1677.
5. Jansen TC, van Bommel J, Schoonderbeek FJ, Sleeswijk Visser SJ, van der Klooster JM, Lima AP, et al. Early lactate-guided therapy in intensive care unit patients: a multicenter, open-label, randomized controlled trial. *Am J Respir Crit Care Med*. 2010;182(6):752-761.
6. Singer M, Deutschman CS, Seymour CW, Shankar-Hari M, Annane D, Bauer M, et al. The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3). *JAMA*. 2016;315(8):801-810.
7. Rhodes A, Evans LE, Alhazzani W, Levy MM, Antonelli M, Ferrer R, et al. Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock 2016. *Intensive Care Med*. 2017;43(3):304-377.

8. Garcia-Alvarez M, Marik P, Bellomo R. Sepsis-associated hyperlactatemia. Crit Care. 2014;18(5):503.
9. Kruse O, Grunnet N, Barfod C. Blood lactate as a predictor for in-hospital mortality in patients admitted acutely to hospital: a systematic review. Scand J Trauma Resusc Emerg Med. 2011; 19:74.
10. Nichol AD, Egi M, Pettila V, Bellomo R, French C, Hart G, et al. Relative hyperlactatemia and hospital mortality in critically ill patients: a retrospective multicentre study. Crit Care. 2010;14: R25.