

ROLE OF SERIAL SERUM LACTATE LEVELS AS PROGNOSTIC PREDICTOR IN EMERGENCY LAPAROTOMY PATIENTS

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Abstract

Objective: The purpose of the research is to find out the role of serial serum lactate levels as prognostic predictor in emergency laparotomy patients

Study Design: Prospective Observational Comparative Study

Study Duration: 06 months from August 2024-Janurary 2025

Study Place: Department of General Surgery, CMH Lahore

Methods: A prospective observational research was carried out in the general surgery department following the ethical approval. Adult patients who were subjected to emergency laparotomy were sampled randomly. Lactate serum levels were taken at admission, 6 hours after surgery, 24 and 48 hours. Trends were calculated through the calculation of lactate clearance. In-hospital mortality was used as a primary outcome and postoperative complications, Statistical data analysis was done in SPSS 26 and p-value less than <.05 was considered significant.

Results: A total of 141 patients undergoing emergency laparotomy were analyzed, with a mean age of 52.6 ± 15.4 years and a male-to-female ratio of 1.6:1. Most patients were classified as ASA III-IV (68.1%). Overall survival was 78.0%, while mortality was 22.0%. Survivors showed a declining trend in serum lactate levels, whereas non-survivors had persistently elevated levels ($p < 0.001$). Higher admission lactate levels and failure of lactate clearance at 24 hours were significantly associated with increased mortality, prolonged ICU stay, and organ dysfunction.

Conclusion: Serial serum lactate monitoring is useful prognostic data in emergency laparotomy patients. High admission lactate and delayed postoperative lactate clearance is associated with high morbidity.

Introduction:

For life-threatening intra-abdominal conditions like perforation peritonitis, intestinal obstruction,

ischemic bowel, and intra-abdominal sepsis, emergency laparotomy is a common high-risk surgical procedure. Emergency laparotomy is still

linked to significant postoperative morbidity and mortality, especially in settings with limited resources, despite advancements in perioperative care, anesthesia, and critical care support. For surgeons and intensivists, early detection of patients at higher risk of unfavorable outcomes continues to be a crucial challenge.¹

The development of critical illness in emergency surgical patients is largely influenced by physiological abnormalities associated with tissue hypoperfusion and the systemic inflammatory response. Anaerobic metabolism's byproduct, serum lactate, has become a trustworthy indicator of both impaired oxygen utilization and global tissue hypoxia. In patients with sepsis, trauma, and shock, elevated serum lactate levels have been repeatedly linked to increased illness severity, organ dysfunction, and mortality. As a result, lactate measurement is now a crucial part of risk assessment in emergency and critical care settings. Even though a single serum lactate measurement offers useful prognostic information, it might not fully capture the dynamic physiological changes that critically ill patients experience. Serial serum lactate monitoring provides information about the patient's reaction to continuous tissue perfusion and resuscitation. It has been demonstrated that persistent hyperlactatemia or lactate clearance have a stronger correlation with outcomes than isolated lactate values, indicating that trends in lactate levels may be a better predictor.^{2,3}

Lactate kinetics may be greatly impacted by perioperative metabolic stress, sepsis, and hemodynamic instability in patients undergoing emergency laparotomy. However, little information is known about the prognostic value of serial serum lactate measurements in this particular patient population, especially in low- and middle-income nations. Determining the predictive value of serial lactate levels may help with early risk assessment, direct perioperative care, and enhance clinical judgment.⁴

Therefore, this study aims to evaluate the role of serial serum lactate levels as a prognostic predictor of postoperative outcomes in patients undergoing emergency laparotomy, with a focus on morbidity, mortality, and length of hospital stay.

Methodology:

The study involved a prospective observational study design, which was carried out in Department of General Surgery in tertiary care teaching hospital Lahore. The period of study was 06 months from August 2024-January 2025. Before the study was started, an ethical approval was taken by the Institutional Review Board. Informed consent was provided by all patients or their legally authorized attendants in situations when the former were not able to express their consent in writing. A sample size of 141 was calculated using WHO sample size calculator, keeping CI 95% and margin of error 5%.

Eligibility screening was done to all adult patients who had emergency laparotomy and participated in the study period. The patients who have passed the inclusion criteria were recruited through a consecutive sampling method. Emergency laparotomy was considered as any non- elective abdominal surgery undertaken under 24 hours of admission in hospital because of an acute intra-abdominal pathology.

Inclusion Criteria

1. Age ≥ 18 years
2. Experience of emergency laparotomy due to acute intra-abdominal events like perforation peritonitis, intestinal obstruction, ischemic bowel, abdominal sepsis, or intra-abdominal trauma.
3. The presence of serum lactate levels at the designated time points.
4. Informed consent by the patient or a legally appointed representative.

Exclusion Criteria

1. Patients were to be excluded in case of:
2. Elective or semi-elective abdominal surgery.
3. Known chronic hepatic failure or liver disease which may limit the ability to clear lactate.
4. Dialysis-treated end-stage renal disease.
5. Cytochrome diseases caused by known inborn errors in metabolism or in the mitochondrion.
6. Malignancy and extensive metastasis.
7. Pregnancy
8. Patients that died during the surgery.

9. Patients were transferred to a different hospital, having laparotomy already.

10. Instances of incomplete clinical information or deficient lactate.

Basic demographic information such as age, sex, comorbidities (diabetes mellitus, hypertension, ischemic heart disease), and presenting diagnosis were noted. Clinical parameters such as vital signs, state of hemodynamics, and laboratory tests were recorded before the operation. The American Society of Anesthesiologists (ASA) physical status was used to determine the severity of illness. Measurement of serum lactate was done using an arterial or venous blood sample, which was analyzed on a standard blood gas analyzer. The Lactate values were measured at the following time point:

Baseline (preoperative baseline) during admission.
As soon as after operation (within 6 hours after operation).

24 hours postoperatively

48 hours postoperatively

The percentage change between baseline lactate levels at later intervals was taken to be the lactate clearance.

In-hospital mortality was the major outcome. The secondary outcomes were postoperative complications (surgical site infection, sepsis, acute kidney injury, and ventilatory support), the length of stay, in the intensive care unit, and overall hospital stay.

Statistical Package of Social Sciences (SPSS) version 26 was used to analyze data. Continuous variables were reported as also the mean and standard deviation or median and interquartile range, whereas the categorical variables were reported as frequencies and percentages. The independent t-test or Mann Whitney U test which is used to compare the continuous variables and chi-square test used to compare the categorical

variables between the survivors and the non survivors. Trends of serial levels of serum lactate were assessed by repeated-measures analysis. A p-value less than 0.05 was taken as statistically significant.

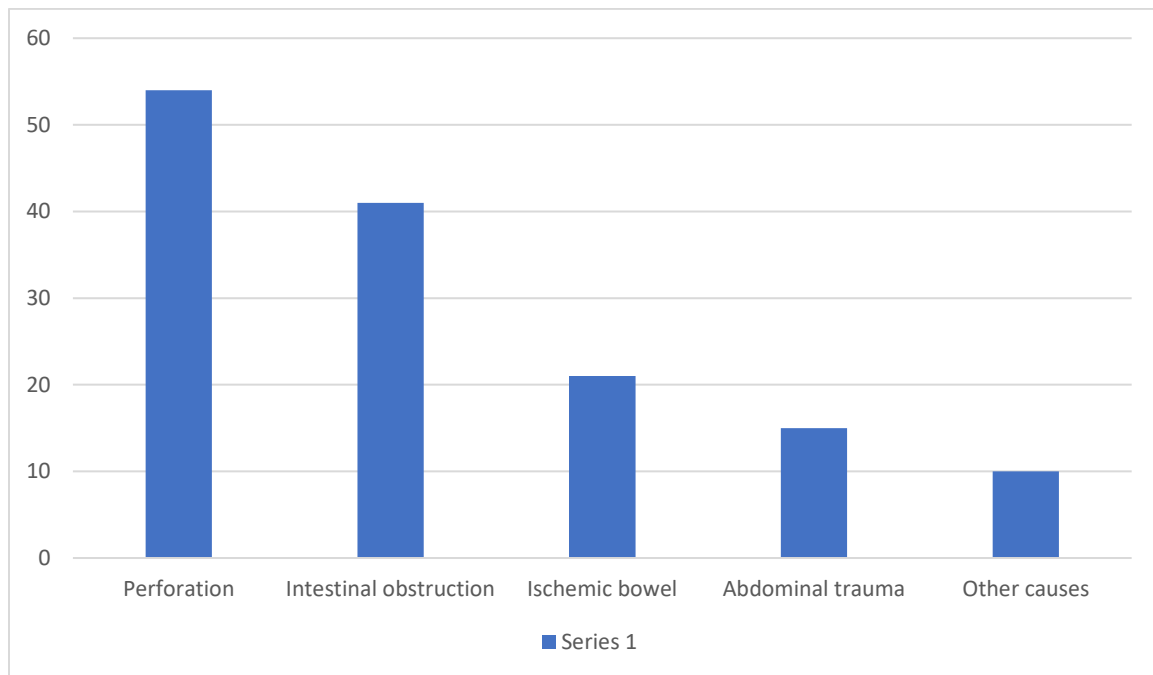
Results:

The final analysis included 141 patients who had emergency laparotomies. The study population's average age was 52.6 ± 15.4 years, with a range of 18 to 85 years. The male-to-female ratio was 1.6:1, with 86 males (61.0%) and 55 females (39.0%). Intestinal blockage (29.1%), ischemic bowel (14.9%), and perforation peritonitis (38.3%) were the most frequent reasons for emergency laparotomy. Significant preoperative physiological compromise was evident in the majority of patients (68.1%) who fell into ASA physical status III and IV. While persistently elevated or rising lactate levels were seen in non-survivors, mean serum lactate levels were highest at admission and showed a declining trend among survivors. At every postoperative time point, there was a statistically significant difference in serial lactate levels between survivors and non-survivors ($p < 0.001$).

110 patients (78.0%) out of 141 patients survived their hospital stay, while 31 patients (22.0%) passed away. Sepsis was the most frequent postoperative complication, occurring in 74 patients (52.5%). Patients who had consistently high lactate levels at 24 and 48 hours were much more likely to die, stay in the intensive care unit longer, and experience organ dysfunction. At admission, the mean serum lactate levels of non-survivors were significantly higher (5.1 ± 1.4 mmol/L) than those of survivors (3.2 ± 1.1 mmol/L, $p < 0.001$). Mortality was significantly correlated with lactate clearance failure at 24 hours ($p < 0.001$).

Variable	Frequency (%) / Mean $\pm$ SD
Age (years)	52.6 ± 15.4
Male	86 (61.0%)
Female	55 (39.0%)
ASA I-II	45 (31.9%)

ASA III-IV	96 (68.1%)
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Time of Measurement	Survivors (n = 110) Mean $\pm$ SD (mmol/L)	Non-Survivors (n = 31) Mean $\pm$ SD (mmol/L)
Admission	3.2 $\pm$ 1.1	5.1 $\pm$ 1.4
Immediate postoperative	2.8 $\pm$ 1.0	4.7 $\pm$ 1.3
24 hours	2.1 $\pm$ 0.9	4.3 $\pm$ 1.2
48 hours	1.6 $\pm$ 0.7	4.0 $\pm$ 1.1

Serial Serum Lactate Levels in Survivors vs Non-Survivors

Outcome	Frequency (%)
In-hospital mortality	31 (22.0%)
Any postoperative complication	74 (52.5%)
Sepsis	46 (32.6%)
Acute kidney injury	29 (20.6%)
Mechanical ventilation >48 h	34 (24.1%)
Mean ICU stay (days)	6.8 $\pm$ 3.9
Mean hospital stay (days)	12.4 $\pm$ 6.1

Postoperative Outcomes

Lactate Clearance at 24 h	Survivors (n=110)	Non-Survivors (n=31)
$\geq 20\%$ clearance	82 (74.5%)	6 (19.4%)
<20% or no clearance	28 (25.5%)	25 (80.6%)

Association of Lactate Clearance at 24 Hours with Mortality

Discussion:

Serial serum lactate levels and lactate clearance were highly correlated with postoperative mortality and morbidity in this prospective observational study of 141 patients undergoing emergency laparotomy. The successful patients showed a steady reduction in the levels of lactate over time, but, the non-survivors showed elevated levels of lactate long after the immediate postoperative period. The results highlight the importance of serial lactate monitoring as an efficient, dynamic prognostic tool in the emergency surgical population.

Our findings are in line with various past researchers that have emphasized the prognostic nature of the lactate dynamics in critically ill patients. As an example, a potential observational trial that assessed the outcomes of patients with perforation peritonitis and were taken to emergency laparotomy found that the level of lactate in the preoperative period, immediate postoperative period, and 24 hours is a predictive of 28-day mortality, and the higher the levels, the worse the outcome.

In the same line, serial lactate, on combination with severity data such as APACHE II, has been found to better predict postoperative mortality, which in turn validates the use of serially obtained lactate as a prognostic biomarker.⁵

The physiological explanation of these findings is the correlation between lactate production and tissue hypoperfusion or anaerobic metabolism. High lactates indicate insufficient oxygen supply versus the needs, and this can be a result of sepsis, hypovolemia, tissue necrosis, or shock, which is usually experienced by emergency laparotomy patients. Chronic hyperlactatemia is an indicator of chronic hypoxia of tissues or inability of resuscitative measures and, therefore, of imminent dysfunction of organs. This is consistent with the wider critical care literature, in which absolute lactate levels, as well as clearance of lactate rate, have been strongly linked with survival in the populations of sepsis, septic shock, and trauma.⁶ The results of our study are also reflected in research done in major abdominal emergency surgery not necessarily in the context of peritonitis. Higher levels of perioperative lactate

were linked to greater hospital stay and in-hospital mortality in a cohort of 93 emergency abdominal surgery patients and lactate at 12 h had the highest predictive value.⁷

This evidence also highlights that lactate is not just a sign of acute physiological disequilibrium but a predictor of more long-term clinical outcomes.

The dynamic measure of lactate clearance was proved to be valid in numerous settings. Evidence in trauma participants, such as, demonstrates that early lactate clearance is an independent prognostic variable and the higher the clearance the lower the mortality.⁸

Furthermore, when measuring lactate in sepsis cohorts, reduced clearance of lactate during six to 24 h is linked to increased short-term mortality, which confirms the idea that the tendency of lactate variation offers greater prognostic information compared to an individual measure.⁹

In comparison with these studies, the trend is obvious: serial monitoring of lactate enhances risk stratification in comparison to baseline measurements. Similar to the above reports, lactate levels were considerably elevated among the non-survivors at all times of measurement and the lactate clearance was lower. This indicates that the introduction of serial lactate measurements into the pathways of postoperative care could assist clinicians to recognize high-risk patients and apply specific interventions to them, including the application of optimized fluid resuscitation, immediate vasopressor support, or the increase of intensive monitoring.^{10,11}

Notably, the prognostic significance of lactate in emergency abdominal surgery is not limited to emergency laparotomy of perforation peritonitis and is consistent with the literature on the general gastrointestinal surgical population. A recent multicenter observational study that involved 551 emergency gastrointestinal surgeries showed that intraoperative peak lactate levels were predictive of in-hospital mortality with a significantly greater value observed in non survivors than survivors (median 4.22 vs 1.80 mmol/L, $p < 0.001$). Logistic regression established intraoperative lactate to be a predictor of mortality indicating that lactate dynamics, even in the operating room, is indicative of the degree of underlying

physiological derangement and potentially a prime risk stratifier in the emergency room.^{12,13}

Other studies of abdominal surgery in an emergency also confirm these findings. Indicatively, high perioperative serum lactate (>4 mmol/L) was linked to significantly higher in-hospital mortality (86.7) and longer hospital stay than low serum lactate groups in a cohort of 93 patients (undergoing major emergency abdominal surgeries). It is noteworthy that the lactate values 12 hours after surgery had the greatest predictive value in mortality.¹⁴

All these findings combined strengthen the assumption that not only baseline but dynamic perioperative lactate patterns are clinically significant enough and capable of distinguishing high-risk patients. In addition to the elective or non-emergency setting, high lactate has always been an indicator of prognosis in various critically ill groups of patients. A massive retrospective study of adult emergency department patients revealed that high lactate levels (>2.6 mmol/L) at presentation were significantly correlated with an increased 30-day in-hospital mortality, which deems that higher levels of lactate are indicative of poor care even prior to surgery.¹⁵

Equally, traumatic systematic reviews reveal that increased ED lactate levels and inadequate lactate clearance are associated with increased mortality, age, and complications in heterogeneous emergency groups. These generalized findings indicate that the underlying pathophysiology is similar: the elevation of lactate indicates a condition of increased metabolism in the cell, which is surpassed by oxygen supply, irrespective of the initial insult.¹⁶

Mechanistically, the continued development of hyperlactatemia may be related to a set of factors, which include tissue hypoperfusion, mitochondrial damage, the release of inflammatory cytokines, and hepatic dysclearance especially in patients with sepsis or shock, which are frequent in emergency laparotomy. Another factor implicated in the accumulation of lactic acid is the adrenergic stimulation and enhanced glycolysis in stress leading to further lactic acid build-up regardless of tissue oxygenation. Failure to eliminate lactate with time is probably

indicative of continued circulatory or metabolic dysfunction, and reduced physiologic reserve, and spells doom.¹⁷

There are several clinical implications of our findings. Serial lactate can be used as an active method of risk stratification and to identify the patients who can be subjected to early aggressive resuscitation, hemodynamic optimization, and more intensive ICU supervision. When serial lactate is incorporated into the existing severity scores (e.g., ASA, SOFA, APACHE II) to improve predictive accuracy, one study has shown that serial lactate predicts better mortality when used together with APACHE II curves.¹⁸ Besides, the trending of lactate can assist in assessing the efficiency of resuscitative measures, policies fluid management, and vasopressor application.

Limitations:

The research took place in one center and the sample size is rather small which can restrict the applicability of the research. Serial measurements of lactate were collected at fixed intervals and might not be sensitive enough to detect high-frequency physiological changes. Lactate may have been affected by possible confounding variables like differences in resuscitation protocols, anesthetic care, and undetected liver malfunction.

Conclusion:

The present research indicates that serial serum lactate has become a useful prognostic means used in patients undergoing emergency laparotomy. High levels of admission lactate and more so continuing hyperlactatemia and inability to clear the lactate after surgery was closely linked to high morbidity rate, prolonged length of stay in intensive care and increased in-hospital mortality. The addition of serial serum lactate measurements to regular perioperative procedures can help identify high-risk patients in order to escalate care, optimize hemodynamic management, and more closely monitor the patient in the postoperative period. The findings of the study contribute to the increasing amount of evidence about the prognostic value of serial lactate monitoring in emergency surgical units.

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