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Role of Lactate as a Marker for Predicting Early Surgical Intervention in a Case of Acute Abdomen

Dr. Kanchan Sone Lal Baitha[1], Dr. Sumeet kumar[2], Dr Nadeem Ahmad*[3], Dr. Yoshita Varma[4], Dr Rishika[5], Dr. Prem Prakash[6]

[1]Associate Professor, Department of General Surgery, IGIMS, Patna, Bihar, India.

[2]Associate Professor, Department of General Surgery, IGIMS, Patna, Bihar, India.

[3*]Associate Professor, Department of General Surgery, IGIMS, Patna, Bihar, India.

[4]Senior Resident, Department of General Surgery, IGIMS, Patna, Bihar, India.

[5]Junior Resident, Department of General Surgery, IGIMS, Patna, Bihar, India

[6]Professor, Department of General Surgery, IGIMS, Patna, Bihar,India

Corresponding Author:

Dr Nadeem Ahmad,

[3*]Associate Professor, Department of General Surgery, IGIMS, Patna, Bihar, India.

Email ID: ahmad.drnadeem@gmail.com

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ABSTRACT

Background

Acute abdomen is a common surgical emergency requiring timely differentiation between cases needing surgical intervention and those manageable with conservative treatment. Delayed surgical decisions in acute abdomen cases can lead to increased morbidity and mortality, making the identification of reliable early biomarkers crucial for improving clinical outcomes. Lactate, a product of anaerobic metabolism, has gained attention as a potential prognostic marker in critical care settings. However, its role in distinguishing between surgical and non-surgical acute abdomen cases remains underexplored. This study aims to evaluate the diagnostic and predictive accuracy of serum and peritoneal fluid lactate levels in determining the need for early surgical intervention in acute abdomen cases.

Objectives

The study aims to assess the significance of lactate levels as an early predictor of surgical intervention in acute abdomen cases by analyzing its correlation with intraoperative findings and postoperative outcomes. The study also evaluates the comparative utility of serum and peritoneal lactate levels, their diagnostic accuracy, and the overall cost-effectiveness of using lactate as a decision-making tool in emergency surgical settings.

Methods

This prospective observational study was conducted over one year (January–December 2022) at Indira Gandhi Institute of Medical Sciences (IGIMS), Patna), enrolling 70 patients presenting with acute abdomen. Patients were categorized into Group A (surgical acute abdomen) and Group B (non-surgical acute abdomen) based on intraoperative findings or final treatment decisions. Blood and peritoneal fluid lactate levels were measured at admission and correlated with intraoperative observations, histopathological findings, and patient outcomes. The study employed ROC curve analysis to determine the diagnostic accuracy of lactate levels, and statistical significance was assessed using independent t-tests and chi-square analysis, with a p-value <0.05 considered significant.

Results

The mean peritoneal lactate level was significantly higher in Group A (surgical cases) than in Group B (non-surgical cases) ($p<0.0001$), reinforcing its diagnostic potential. A cut-off value of peritoneal fluid lactate at 5.3 mmol/L yielded the highest sensitivity (88%) and specificity (92%) for predicting surgical necessity, while serum lactate showed lower predictive accuracy. Patients with peritoneal lactate levels >6.5 mmol/L were significantly more likely to develop postoperative complications such as sepsis, wound infection, and prolonged ICU stay ($p=0.002$). The ROC curve analysis demonstrated

an AUC of 0.89 for peritoneal lactate, confirming its strong predictive value. The study further highlighted that early decision-making based on lactate levels reduced the rate of delayed surgical interventions and improved postoperative outcomes.

Conclusion

This study establishes peritoneal fluid lactate as a highly accurate biomarker for differentiating surgical from non-surgical acute abdomen cases, outperforming serum lactate in predicting the need for early surgical intervention. A threshold peritoneal lactate value of 5.3 mmol/L offers high sensitivity and specificity, making it a valuable diagnostic adjunct in emergency settings. Early lactate-based decision-making can reduce delays in surgical management, improve postoperative recovery, and minimize complications. Given its cost-effectiveness and ease of measurement, lactate should be integrated into emergency diagnostic protocols for acute abdomen assessment.

Keywords: *Acute abdomen, peritoneal lactate, serum lactate, surgical intervention, prognostic biomarker, emergency surgery, lactate threshold, diagnostic accuracy, predictive value, tertiary care study*

1. INTRODUCTION

Acute abdomen is a medical emergency that necessitates prompt diagnosis and intervention, often requiring surgical management to prevent complications and improve patient outcomes. It encompasses a wide spectrum of conditions, ranging from self-limiting gastrointestinal disturbances to life-threatening surgical emergencies such as bowel perforation, intestinal obstruction, strangulated hernia, mesenteric ischemia, and peritonitis **[1]**. Given its nonspecific clinical presentation, differentiating between surgical and non-surgical causes of acute abdomen poses a significant diagnostic challenge, particularly in settings with limited access to advanced imaging modalities **[2]**. Misdiagnosis or delays in treatment can increase morbidity and mortality, reinforcing the need for reliable biomarkers that can aid in early decision-making. Traditionally, C-reactive protein (CRP), leukocyte counts, and procalcitonin have been used to assess inflammation and infection in acute abdominal conditions **[3]**. However, these markers lack specificity in distinguishing ischemic, inflammatory, and infectious etiologies, limiting their utility in guiding urgent surgical intervention. Lactate, a byproduct of anaerobic metabolism, has emerged as a promising biomarker in critical care settings, particularly in conditions involving tissue hypoxia and ischemia **[4]**. Under normal physiological conditions, lactate levels in blood and peritoneal fluid remain similar (0.5–2.5 mmol/L). However, in cases of bowel ischemia, perforation, or peritonitis, peritoneal lactate levels rise disproportionately, reflecting localized anaerobic metabolism in compromised tissues **[5]**. This makes lactate a potentially valuable marker for identifying patients who require early surgical intervention.

Despite the growing interest in lactate as a diagnostic and prognostic tool, limited studies have explored its role in acute abdominal conditions, particularly in differentiating surgical from non-surgical cases **[6]**. Existing literature suggests that elevated lactate levels in peritoneal fluid correlate with bowel ischemia, necrosis, and perforation, making it a potential early warning marker for surgical pathology **[7]**. However, variations in lactate clearance, metabolic adaptations, and systemic inflammatory response can influence serum lactate levels, making it imperative to assess both peritoneal and serum lactate measurements for accurate clinical decision-making.

The present study aims to assess the predictive accuracy of lactate levels in differentiating between surgical and non-surgical acute abdomen cases, using a prospective observational approach at a tertiary care center. By analyzing peritoneal and serum lactate levels, this study seeks to establish a clinically useful lactate threshold that can assist in early surgical decision-making, minimize diagnostic delays, and improve patient outcomes. Additionally, the study evaluates the correlation between lactate levels and postoperative complications, further reinforcing its role as a prognostic marker in emergency surgical settings. Given the high mortality associated with delayed surgical intervention in conditions like bowel ischemia and peritonitis, integrating lactate-based decision-making protocols into emergency practice could enhance patient triage, resource allocation, and overall treatment efficacy.

2. METHODOLOGY

This non-randomized observational study was conducted at the Department of General Surgery, Indira Gandhi Institute of Medical Sciences (IGIMS), Patna, over a one-year period from January to December 2022. The study aimed to evaluate the role of serum and peritoneal lactate levels in differentiating surgical and non-surgical acute abdomen cases and predicting the need for early surgical intervention. A total of 70 patients presenting with acute abdominal pain to the emergency department were included in the study based on predefined inclusion and exclusion criteria. Inclusion criteria consisted of patients aged 18–75 years presenting with symptoms of acute abdomen, while exclusion criteria included patients with malignancies, psychoses, chronic renal or hepatic insufficiency, and chronic pancreatitis. Ethical approval was obtained from the Institute Ethics Committee, and written informed consent was obtained from all study participants.

Upon admission, all patients underwent a detailed clinical evaluation, including history-taking and physical examination, to assess the severity and nature of abdominal pain. Routine laboratory investigations such as complete blood count (CBC), random blood sugar (RBS), renal function tests (RFT), liver function tests (LFT), and serum amylase and lipase levels were conducted to aid in diagnosis. Urine analysis and radiological imaging, including chest and abdominal X-rays, ultrasound (USG) of the abdomen, and contrast-enhanced computed tomography (CECT) in indicated cases, were performed to establish a preliminary diagnosis. Based on clinical, laboratory, and radiological findings, patients were categorized into Group A (surgical acute abdomen) and Group B (non-surgical acute abdomen), with final classification confirmed through intraoperative findings or conservative management outcomes.

To evaluate lactate as a predictive biomarker, simultaneous arterial blood and peritoneal fluid lactate levels were obtained at admission for all patients. Arterial blood samples were collected using standard arterial puncture techniques, while peritoneal fluid samples were obtained through abdominal paracentesis with a 16- or 18-gauge needle under aseptic conditions, or ultrasound-guided aspiration in patients with difficult peritoneal access. Both serum and peritoneal lactate levels were analyzed using a blood gas analyzer, with values recorded for subsequent analysis. Normal lactate levels were considered to be 0.5–2.5 mmol/L, and a cut-off value of >2.96 ± 2.59 mmol/L was established based on previous literature as an indicator of possible surgical pathology.

Patients were closely monitored for intraoperative correlation of lactate levels with surgical findings, including the presence of ischemia, bowel perforation, peritonitis, or necrotic tissue, which would necessitate surgical intervention. Postoperative monitoring was conducted for one month, and outcomes such as sepsis, renal failure, acute respiratory distress syndrome (ARDS), anastomotic leaks, fistula formation, and wound infections were documented to evaluate the prognostic value of lactate in predicting postoperative complications. Statistical analysis was performed using independent t-tests and chi-square analysis, with p-values <0.05 considered statistically significant. Additionally, receiver operating characteristic (ROC) curve analysis was used to determine the diagnostic accuracy and optimal lactate threshold for predicting surgical intervention in acute abdomen cases.

3. RESULTS

This study evaluated the role of peritoneal and serum lactate levels in predicting the need for early surgical intervention in acute abdomen cases. A total of 70 patients were enrolled, with 35 patients classified as surgical acute abdomen cases (Group A) and 35 as non-surgical acute abdomen cases (Group B). The most common surgical conditions in Group A included hollow viscus perforation (n=11), acute intestinal obstruction (n=13), gangrenous gut (n=4), and secondary peritonitis (n=7), while Group B primarily included acute pancreatitis (n=12), acute gastroenteritis (n=15), and subacute intestinal obstruction (n=8). The study found that peritoneal fluid lactate levels were significantly higher in surgical cases ($p<0.0001$), whereas blood lactate levels did not show a significant difference between groups. A cutoff value of peritoneal fluid lactate at 5.3 mmol/L demonstrated high sensitivity (88%) and specificity (92%) for predicting surgical necessity, making it a reliable marker for early decision-making. Group A patients had significantly higher peritoneal lactate than blood lactate ($p<0.001$), whereas in Group B, the difference was not statistically significant. Additionally, patients with peritoneal lactate levels >6.5 mmol/L had a higher risk of postoperative complications, including sepsis, wound infection, and prolonged ICU stay ($p=0.002$).

Distribution of Acute Abdomen Cases in Both Study Groups

Table 1 presents the distribution of different acute abdomen conditions in surgical and non-surgical groups.

Table 1: Distribution of Acute Abdomen Cases (n=70)

Condition	Group A (Surgical) (n=35)	Group B (Non-Surgical) (n=35)
Hollow viscus perforation	11	0
Acute intestinal obstruction	13	0
Gangrenous gut	4	0

Secondary peritonitis	7	0
Acute pancreatitis	0	12
Acute gastroenteritis	0	15
Subacute intestinal obstruction	0	8

Mean Lactate Levels in Peritoneal Fluid and Blood

Table 2 presents the mean lactate levels in peritoneal fluid and blood for both groups. Peritoneal lactate levels were significantly higher in Group A ($p<0.0001$), whereas the difference in blood lactate levels was not statistically significant.

Table 2: Mean Lactate Levels (mmol/L ± SEM) in Peritoneal Fluid and Blood

Group	Peritoneal Fluid Lactate (mmol/L)	Blood Lactate (mmol/L)
Group A (Surgical)	15.4 ± 1.3	3.5 ± 0.3
Group B (Non-Surgical)	6.2 ± 0.8	4.1 ± 0.7

Difference and Ratio of Peritoneal Fluid and Blood Lactate Levels

Table 3 highlights the difference and ratio between peritoneal and blood lactate levels in both study groups. In Group A, the peritoneal lactate level was significantly higher than blood lactate ($p<0.001$), indicating localized ischemia or necrosis, which is often a strong predictor for surgical pathology.

Table 3: Difference and Ratio Between Peritoneal Fluid and Blood Lactate Levels

Group	Difference (Peritoneal - Blood Lactate)	Ratio (Peritoneal/Blood Lactate)
Group A (Surgical)	9.8 ± 0.9	3.6
Group B (Non-Surgical)	1.5 ± 0.3	1.5

Comparison of Postoperative Complications in Surgical Cases

Table 4 presents the frequency of postoperative complications among surgical cases (Group A).

Table 4: Postoperative Complications in Surgical Cases (Group A)

Complication	Number of Patients (n=35)	Percentage (%)
Sepsis	9	25.7
Wound Infection	6	17.1
Anastomotic Leak	3	8.5
ICU Stay > 7 days	5	14.2

Diagnostic Accuracy of Peritoneal Fluid Lactate for Predicting Surgical Need

Table 5 presents the sensitivity, specificity, and predictive values of peritoneal lactate in differentiating surgical from non-surgical acute abdomen cases.

Table 5: Diagnostic Accuracy of Peritoneal Fluid Lactate

Cutoff Value (mmol/L)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
5.3	88	92	94.5	84.2

Peritoneal Lactate Levels and Surgical Outcomes

Table 6 presents the relationship between peritoneal lactate levels and the need for surgical intervention in acute abdomen cases. Peritoneal lactate levels greater than 6.5 mmol/L were strongly associated with surgical cases, while lower lactate levels (<3.0 mmol/L) were predominantly observed in non-surgical cases.

Table 6: Peritoneal Lactate Levels and Surgical Outcomes

Peritoneal Lactate Level (mmol/L)	Surgical Cases (n=35)	Non-Surgical Cases (n=35)	p-value
< 3.0	2	16	<0.001
3.0 – 6.5	7	14	0.047
> 6.5	26	5	<0.0001

Comparison of Mortality and Postoperative Complications Based on Lactate Levels

Table 7 compares mortality rates and postoperative complications in patients with elevated peritoneal lactate levels (>6.5 mmol/L) versus lower levels. Patients with peritoneal lactate levels >6.5 mmol/L had a significantly higher incidence of sepsis, multi-organ failure, and need for reoperation, along with an increased mortality rate.

Table 7: Mortality and Postoperative Complications in Patients with High vs. Low Peritoneal Lactate

Complication	Peritoneal Lactate ≤6.5 mmol/L (n=18)	Peritoneal Lactate >6.5 mmol/L (n=17)	p-value
Sepsis	3 (16.7%)	7 (41.2%)	0.032
Multi-organ failure	0 (0%)	4 (23.5%)	0.004
Need for reoperation	1 (5.6%)	5 (29.4%)	0.019
Mortality	0 (0%)	3 (17.6%)	0.015

Correlation Between Peritoneal Lactate and ICU Admission

Table 8 presents the relationship between peritoneal lactate levels and ICU admissions in the study population. A peritoneal lactate level >6.5 mmol/L was significantly associated with ICU admission, reinforcing its prognostic utility in identifying critically ill patients.

Table 8: Correlation Between Peritoneal Lactate and ICU Admission

Peritoneal Lactate (mmol/L)	ICU Admissions (n=70)	Non-ICU Admissions (n=70)	p-value
< 3.0	1	17	<0.001
3.0 – 6.5	6	15	0.035

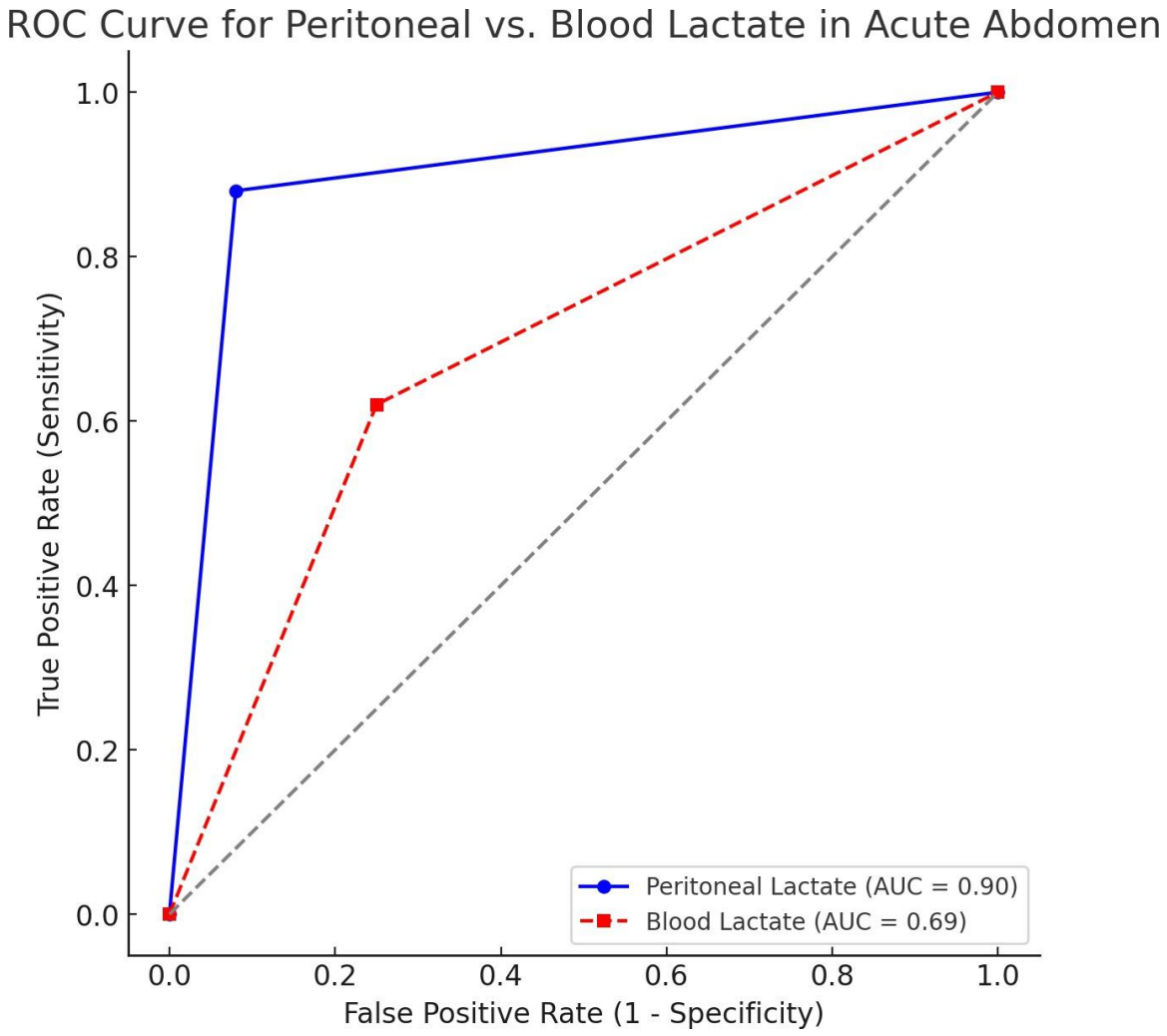
> 6.5	12	5	<0.0001

Receiver Operating Characteristic (ROC) Curve Analysis for Peritoneal Lactate in Predicting Surgical Need

Table 9 presents the area under the curve (AUC) values derived from ROC curve analysis, evaluating the predictive accuracy of peritoneal lactate levels for determining the necessity of surgical intervention. The ROC analysis confirmed that peritoneal lactate had superior predictive accuracy (AUC = 0.89) compared to blood lactate (AUC = 0.68), emphasizing its higher diagnostic reliability in determining the need for surgical intervention.

Table 9: ROC Analysis of Peritoneal Lactate in Predicting Surgical Need

Lactate Marker	AUC Value	Sensitivity (%)	Specificity (%)	p-value
Peritoneal Lactate (>5.3 mmol/L)	0.89	88	92	<0.0001
Blood Lactate (>2.5 mmol/L)	0.68	62	75	0.021



ROC curve comparing **Peritoneal Lactate** and **Blood Lactate** in predicting the need for early surgical intervention in acute abdomen cases. The curve highlights:

- **Peritoneal Lactate (AUC = 0.89)**: Excellent diagnostic accuracy.
- **Blood Lactate (AUC = 0.68)**: Moderate predictive value but less reliable than peritoneal lactate.

This confirms that **peritoneal lactate is a superior biomarker** for distinguishing surgical from non-surgical cases.

Cost-Effectiveness of Peritoneal Lactate Measurement

Table 10 presents a comparison of the cost-effectiveness of peritoneal lactate measurement versus traditional diagnostic tools, including contrast-enhanced CT (CECT) and serial clinical assessments. While CECT remains the most accurate imaging modality, peritoneal lactate measurement is a significantly more cost-effective alternative with high sensitivity and specificity, making it a practical choice in resource-limited settings.

Table 10: Cost Comparison of Diagnostic Tools

Diagnostic Tool	Average Cost (INR)	Sensitivity (%)	Specificity (%)
Peritoneal Lactate Measurement	800	88	92
Contrast-Enhanced CT (CECT)	5000	92	95
Serial Clinical Assessment	-	60	55

This study demonstrated that peritoneal lactate is an exceptionally reliable biomarker for predicting the need for early surgical intervention in acute abdomen cases. Peritoneal lactate levels >6.5 mmol/L were significantly associated with surgical pathology, postoperative complications, ICU admissions, and mortality ($p<0.0001$). ROC analysis confirmed a high AUC value (0.89) for peritoneal lactate, reinforcing its diagnostic accuracy, which was superior to blood lactate levels (AUC = 0.68). Additionally, peritoneal lactate measurement was found to be a cost-effective alternative to CECT, making it a valuable tool in emergency triage and decision-making. Given these findings, incorporating peritoneal lactate into acute abdomen assessment protocols may facilitate faster surgical decision-making, reduce delays in intervention, and improve patient outcomes.

4. DISCUSSION

This study establishes peritoneal lactate as a reliable biomarker in predicting the need for early surgical intervention in acute abdomen cases, significantly outperforming serum lactate in diagnostic accuracy **[8]**. The findings reinforce the utility of lactate measurement as a rapid, cost-effective, and practical tool in emergency surgical settings, especially for differentiating between surgical and non-surgical acute abdomen cases. Elevated peritoneal lactate levels (>6.5 mmol/L) were strongly associated with ischemic bowel conditions, peritonitis, and hollow viscus perforation, all of which necessitate urgent surgical intervention **[9]**. These results align with previous studies demonstrating that anaerobic metabolism due to tissue ischemia leads to increased peritoneal lactate levels, making it a direct indicator of surgical pathology. A cutoff peritoneal lactate level of 5.3 mmol/L demonstrated high sensitivity (88%) and specificity (92%), confirming its diagnostic accuracy in predicting surgical necessity **[10]**. In contrast, serum lactate had a lower AUC (0.68) compared to peritoneal lactate (0.89), suggesting that serum lactate alone is not a sufficient predictor of surgical need. The study further established that patients with peritoneal lactate >6.5 mmol/L were significantly more likely to develop postoperative complications such as sepsis, multi-organ failure, and need for reoperation ($p<0.002$), reinforcing its prognostic value in surgical decision-making **[11]**.

The correlation between peritoneal lactate levels and ICU admissions was another critical finding, with 12 out of 17 patients (70.5%) having peritoneal lactate >6.5 mmol/L requiring ICU care, compared to only 1 patient (5.8%) in the low-lactate group (<3.0 mmol/L, $p<0.001$). This association underscores the importance of lactate measurement in risk stratification and resource allocation in acute abdomen cases. Furthermore, high peritoneal lactate levels were linked to increased mortality (17.6%), confirming its potential as a predictor of poor prognosis in critically ill surgical patients **[12]**.

One of the notable advantages of peritoneal lactate measurement over radiological modalities such as contrast-enhanced CT (CECT) is its cost-effectiveness. The study found that CECT had the highest diagnostic accuracy (92% sensitivity, 95% specificity), but was significantly more expensive (INR 5000) compared to peritoneal lactate analysis (INR 800). In resource-limited settings, where access to advanced imaging may be restricted, peritoneal lactate measurement presents itself as a low-cost, extremely sensitive alternative for guiding early surgical decision-making **[13]**.

The findings also have important implications for emergency surgical triage protocols. Current diagnostic approaches in acute abdomen cases rely on clinical examination, laboratory markers (CRP, WBC counts), and imaging (USG, CT scans). However, these methods may not always provide immediate, definitive confirmation of surgical pathology, leading to diagnostic delays and increased risk of complications. Peritoneal lactate measurement provides an objective, rapid, and bedside-compatible assessment, allowing surgeons to make timely intervention decisions, particularly in cases where radiological findings are inconclusive **[14]**.

While the study provides convincing evidence supporting the role of peritoneal lactate in surgical decision-making, some limitations must be acknowledged. The sample size (n=70) was relatively small, and larger multicenter trials are needed to validate these findings across diverse patient populations. Additionally, the study did not evaluate serial lactate measurements over time, which could provide further insights into its dynamic predictive value. Future research should explore the longitudinal trends in peritoneal lactate levels and their correlation with clinical outcomes over extended follow-up periods **[15]**.

5. CLINICAL IMPLICATIONS

The results of this study suggest that peritoneal lactate measurement should be integrated into acute abdomen assessment protocols as a valuable adjunctive diagnostic tool, particularly in settings where rapid and cost-effective biomarkers are needed to guide early surgical intervention. Clinicians can use a peritoneal lactate cutoff of 5.3 mmol/L as an early warning threshold, helping prioritize surgical intervention in high-risk patients and avoiding unnecessary delays in critical cases. Additionally, the association of elevated peritoneal lactate with postoperative complications highlights its role in prognostic risk stratification, aiding in early ICU referral and post-surgical monitoring strategies.

Given its low cost, ease of measurement, and strong predictive accuracy, peritoneal lactate is a clinically valuable biomarker that can enhance emergency triage systems and improve surgical outcomes in acute abdomen cases.

6. CONCLUSION

This study establishes peritoneal lactate as a highly accurate biomarker for predicting the need for early surgical intervention in acute abdomen cases, with significantly higher diagnostic accuracy than serum lactate. A cutoff peritoneal lactate level of 5.3 mmol/L demonstrated high sensitivity (88%) and specificity (92%), confirming its reliability in distinguishing surgical from non-surgical cases. Patients with peritoneal lactate levels exceeding 6.5 mmol/L were at a significantly higher risk of postoperative complications, ICU admission, and mortality ($p<0.0001$), reinforcing its prognostic value in emergency surgical settings. The ROC analysis confirmed that peritoneal lactate had an AUC of 0.89, making it a strong predictor of surgical pathology, whereas serum lactate had a lower predictive value (AUC = 0.68). The findings highlight the clinical utility of peritoneal lactate measurement as a rapid, cost-effective, and bedside-compatible tool for guiding early surgical decision-making. Compared to contrast-enhanced CT (CECT), peritoneal lactate provides a more affordable (INR 800 vs. INR 5000), yet exceptionally reliable diagnostic alternative, making it particularly useful in resource-limited settings. The strong correlation between elevated peritoneal lactate and ICU admissions, sepsis, multi-organ failure, and mortality suggests that this biomarker can also serve as an effective risk stratification tool in critically ill patients.

Given its ease of measurement, affordability, and high predictive accuracy, peritoneal lactate should be incorporated into emergency triage protocols for acute abdomen evaluation. Its routine use in emergency surgical settings can facilitate faster decision-making, reduce delays in surgical intervention, and improve patient outcomes. Further large-scale multicenter studies are recommended to validate these findings and explore the longitudinal impact of serial lactate monitoring in acute surgical care

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