ORIGINAL ARTICLE

CORRELATION BETWEEN POST-OPERATIVE SERUM LACTATE LEVELS AND LOW CARDIAC OUTPUT SYNDROME IN PATIENTS UNDERGOING CORONARY ARTERY BYPASS GRAFTING SURGERY: A PROSPECTIVE STUDY IN A TERTIARY CARE HOSPITAL

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Objectives: This study aimed to assess the correlation between the development of low cardiac output syndrome (LCOS) and post-operative serum lactate levels in patients undergoing coronary artery bypass grafting (CABG) surgery at a tertiary care hospital.

Methodology: A prospective cross-sectional study was conducted from January to June 2021, involving 50 patients undergoing CABG surgery with cardiopulmonary bypass. Arterial samples were obtained immediately post-surgery and at six, twelve, and twenty-four-hour intervals post-operatively. The association between lactate levels and the occurrence of LCOS, need for inotropic support, and intra-aortic balloon pump (IABP) utilization was evaluated.

Results: The study comprised predominantly male patients (84%). Patients were categorized into two groups based on lactate levels: Group 1 (> 4 mmol/L) and Group 2 (< 4 mmol/L). In Group 1, 32% of patients developed LCOS, 10% required IABP, and 20% needed inotropic and vasopressor support. Immediately post-CABG, the mean lactate level was 7.5 mmol/L, with 3% requiring IABP and 20% needing double inotropic support. Lactate levels decreased over time, with mean levels at six, twelve, and twenty-four hours post-surgery being 6.3 mmol/L, 3.8 mmol/L, and 3.3 mmol/L, respectively. Correspondingly, the need for IABP and inotropic support decreased. LCOS occurrence within 24 hours post-surgery correlated significantly with elevated lactate levels ($p < 0.05$).

Conclusion: Elevated lactate levels were associated with the development of LCOS within 24 hours post-CABG surgery. Monitoring lactate levels postoperatively may serve as a valuable tool in predicting and managing LCOS in CABG patients.

Keywords: Lactate; Coronary artery bypass grafting; Low cardiac output syndrome

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INTRODUCTION

Cardiopulmonary bypass (CPB) is a crucial component of on-pump cardiac surgery, facilitating tissue perfusion and oxygenation.[1] However, it's well understood that both pre- and post-cardiac surgery, anaerobic metabolism can lead to tissue hypoperfusion, resulting in elevated lactate levels.[2] Lactate, an organic acid produced during glucose metabolism, serves as a key indicator of tissue perfusion status.[3] Maintaining a balance between lactate production and clearance is essential for ensuring proper circulation.[4] Elevated serum lactate levels, known as hyperlactatemia, are closely associated with increased morbidity and mortality, often signaling circulatory failure.[5]

Preoperative and early postoperative hyperlactatemia, particularly in the ICU setting, has been consistently linked to poor prognoses following cardiac surgery.[6] Several factors contribute to hyperlactatemia, including coagulation abnormalities, inadequate myocardial protection, suboptimal revascularization, and tissue hypoxia. Additionally, preoperative low

cardiac output syndrome may exacerbate postoperative hyperlactatemia, further complicating patient outcomes.[7]

A seminal study conducted by Broder and Weil demonstrated a significant association between serum lactate levels and mortality risk. Patients with serum lactate levels exceeding 4.0 mmol/L were found to have a substantially higher risk of mortality due to circulatory shock. Moreover, the study illustrated a progressive increase in mortality rates as serum lactate levels rose from 2.0 mmol/L to 8.0 mmol/L, underscoring the critical importance of lactate monitoring in predicting patient outcomes post-cardiac surgery.[8]

In this study, our objective is to evaluate the outcomes of patients with serum lactate levels exceeding 4 mmol/L following coronary artery bypass grafting (CABG) surgery. Additionally, we aim to investigate the relationship between hyperlactatemia and adverse postoperative events, such as low cardiac output syndrome, the necessity for intra-aortic balloon pump (IABP) support, and the requirement for positive inotropic and vasopressor support. By comprehensively analyzing these associations, we aim to enhance our understanding of hyperlactatemia as a prognostic marker in the context of cardiac surgery, ultimately informing clinical decision-making and improving patient care.

METHODOLOGY

Study Design: The study employed a prospective cross-sectional design, conducted from January 2021 to June 2021.

Setting: The research was conducted at the Pir Abdul Qadir Shah Jilani Institute of Medical Sciences in Gambat (GIMS), providing a conducive environment for the collection and analysis of data pertaining to the study objectives.

Participants: Fifty patients who visited the outside patient department (OPD) for isolated elective coronary artery bypass graft surgery were included in the study. No discrimination based on age or gender was practiced against patients. All participants provided written and informed consent prior to their inclusion in the study.

Variables: The primary variables of interest included lactate levels, low cardiac output syndrome (LCOS), the need for an IABP, and the amount of chemical support (number of inotropic medications used) at various time points (immediately at 6 hours, 12 hours, and 24 hours after CABG). Demographic characteristics and co-morbidities of patients were also recorded.

Data Sources/Measurement: Data were collected prospectively using a standardized Performa, ensuring uniformity and accuracy in data collection. Arterial samples were obtained to measure lactate levels, and patients were assessed for LCOS, need for IABP, and inotropic medication usage at specified time intervals post-CABG.

Bias: Efforts were made to minimize bias, ensuring inclusion without discrimination based on age or gender, obtaining written and informed consent from participants, and using standardized data collection procedures.

Ethics: Ethical review board permission was obtained from the institute prior to the commencement of the study.

Study Size: Fifty participants were included in the study, providing a sufficient sample size to assess the relationship between lactate levels and post-CABG outcomes of interest, while also ensuring feasibility and practicality in data collection and analysis.

Quantitative Variables: Quantitative variables were presented as frequencies for discrete variables and as mean with standard deviation for continuous variables. The independent sample t-test was utilized to compare groups for continuous variables, with a 95% confidence level and a significance level set at $p < 0.05$.

Statistical Methods: Data analysis was performed using Version 16 of the Statistical Package for the Social Sciences (SPSS). The independent sample t-Test was employed to compare groups for continuous variables, and results were reported with a 95% confidence level, accepting a p-value of 0.05 as significant.

RESULTS

Participants: Fifty patients undergoing elective primary coronary artery bypass graft surgery participated in the study, with 84% being male and 16% female. Among them, 72% had diabetes mellitus, 66% had hypertension, 16% had carotid stenosis, 16% had left main involvement, 4% had diffuse coronary disease, 10% had COPD, and 38% were smokers (Table 1).

Descriptive Data: The study found that 36% of patients had HFpEF, while 64% had HFrEF. Postoperatively, 6% experienced reopenings, 10% had postoperative strokes, 32% developed low cardiac output syndrome (LCOS), 66% required blood products, and 2% of participants died (Table 1).

Table 1: Pre and post-operative variables

Variables	Frequency (%)
Total (N)	**50**
Pre-operative	
Diabetic mellitus	72%
Hypertension	66%
Smoking	38%
Carotid stenosis	16%
Stroke	10%
Chronic obstructive pulmonary disease	10%
Left main	16%
Diffuse disease	4%
Post-operative	
Reopen	6%
Atrial fibrillation	16%
Blood product transfusion	66%
Low cardiac output syndrome	32%
Intra-aortic balloon pump	10%
Mortality	2%

Outcome Data: Patients were categorized based on post-operative serum lactate levels into two groups: Group 1 with lactate levels > 4 mmol/L and Group 2 with lactate levels ≤ 4 mmol/L. Group 1 exhibited a higher frequency of LCOS (32%), IABP use (10%), and inotropic and vasopressor support requirement (62%), compared to Group 2, which had lower rates of intervention (8%) (Table 3).

Table 2: Low cardiac output syndrome (LCOS) relation with lactate

Lactate levels	Low cardiac output syndrome		P-value
	Yes	No	
Total (N)	**16**	**34**	**-**
Immediate	7.5 ± 1.7	5.7 ± 1.7	0.002
At 6 hours	6.3 ± 1.1	5 ± 1.6	0.005
AT 12 hours	3.8 ± 1.2	3.4 ± 1.9	0.004
AT 24 h ours	3.3 ± 1.1	2.6 ± 0.6	0.018

Main Results: Immediately following CABG, the mean lactate level was 7.5 mmol/L, with 3% of patients requiring IABP and 20% needing inotropic and vasopressor drugs. Over time, lactate levels decreased, with mean levels at 6, 12, and 24 hours post-surgery being 6.3, 3.8, and 3.3 mmol/L, respectively (Table 2). Correspondingly, the need for IABP and inotropic/vasopressor support decreased, indicating an improvement in cardiac function and stability. Statistical analysis revealed significant associations between lactate levels and the development of LCOS, the requirement for IABP, and the number of inotropic medications used within 24 hours post-surgery, with p-values < 0.05.

Table 3: lactate association with Low cardiac output syndrome, IABP and inotropes

	Lactate		P-value
	More than 4	Less than 4	
Intra-aortic balloon pump			
Yes	5	0	0.005
No	41	4	
Low cardiac output syndrome			
Yes	16	0	0.01
No	30	4	
Number of inotropes			
Yes	31	4	0.01
No	15	0	

DISCUSSION

The LCOS is a common complication following CABG surgery, with predictors such as central venous oxygen saturation, lactate levels, and CO2 gap playing pivotal roles in its evaluation. The dynamics of lactate levels in the ICU following CPB surgery can provide valuable insights into patient outcomes.

In our study, we investigated the outcomes of patients who underwent CABG and presented with elevated lactate levels. The majority of our patient cohort exhibited Heart Failure with Reduced Ejection Fraction (HFrEF), hypertension, and diabetes, highlighting the prevalence of comorbidities in this population.[9] Additionally, a significant proportion of patients required blood transfusions postoperatively, reflecting the hemodynamic challenges often encountered in CABG surgery.

Consistent with previous research by Totataro and Reper et al., our findings underscored the association between hyperlactatemia and the need for inotropic support, with patients presenting elevated lactate levels requiring higher doses of inotropes.[10, 11] Moreover, we observed a correlation between decreasing lactate levels and reduced inotrope requirements, suggesting a potential therapeutic benefit in lactate normalization.

Early postoperative lactate levels, as highlighted in a study by Toramman et al., serve as prognostic indicators for adverse outcomes such as the need for IABP support, blood transfusions, and increased mortality risk.[10] Our study corroborated these findings, demonstrating a higher incidence of IABP utilization among patients with hyperlactatemia post-CABG surgery.

Furthermore, Ranuccii et al. elucidated independent factors contributing to hyperlactatemia, including elevated serum glucose levels and inadequate oxygen delivery during and after CABG surgery.[10,11] Our results aligned with these findings, revealing a direct correlation between elevated lactate levels and the development of low cardiac output syndrome, leading to increased morbidity and mortality in our patient cohort.

Overall, our study emphasizes the clinical significance of lactate monitoring in the postoperative period following CABG surgery. Early identification of hyperlactatemia can aid in risk stratification and prompt intervention to mitigate adverse outcomes such as LCOS and the need for advanced hemodynamic support. Further research is warranted to elucidate the optimal management strategies for patients with elevated lactate levels post-CABG surgery, ultimately improving patient care and outcomes in this high-risk population.

CONCLUSION

Lactate emerges as a crucial predictor of significant postoperative changes following CABG surgery. Our study underscores the importance of monitoring serum lactate levels, as evidenced by the observed decrease over time post-surgery, which correlates with reduced risk of developing LCOS and the need for interventions such as IABP and inotropic support. Moreover, our findings align with global research highlighting the impact of serum lactate on postoperative outcomes in CABG patients. However, further investigation is warranted to comprehensively understand the complex interplay between lactate dynamics and patient prognosis following CABG surgery. By elucidating the underlying mechanisms and optimizing management strategies, future studies can contribute to enhancing patient care and outcomes in this population.

AUTHORS' CONTRIBUTION

MFK and AAK: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. MFK, AAK, IHP, NN, HMB, and MID: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

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