

DOES PERIOPERATIVE SERUM LACTATE PREDICT ACUTE KIDNEY INJURY IN ON-PUMP CABG PATIENTS

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ABSTRACT:

BACKGROUND: AKI is a serious complication following the on-pump CABG which contributes to increased morbidity and mortality. Perioperative serum lactate has gained attention as an early of adverse outcomes. Raised lactate levels during and after the cardiopulmonary bypass may reflect the systemic hypoxia and impaired organ perfusion which predisposing patients to renal injury. Assessing perioperative serum lactate might provide a simple and timely tool for predicting the AKI within the CABG patients.

OBJECTIVE: To determine the diagnostic accuracy of serum lactate to predict acute kidney injury in patients undergoing on-pump coronary artery bypass grafting, with serum creatinine as the gold standard.

METHODOLOGY: This cross sectional validation study included two hundred sixty one patients aged 20 to 80 years from October 2025 to March 2026, who underwent elective on-pump CABG were enrolled at department of cardiac surgery and intensive care unit, armed forces institute of cardiology and national institute of heart diseases Rawalpindi. Patients with emergency surgery, re-do surgery, valvular procedures, left ventricular ejection fraction < 25%, or history of kidney disease were excluded. Serum lactate was measured at four hours postoperatively, and level > 4 mmol/L was considered the threshold/cut off. Acute kidney injury was diagnosed according to KDIGO guidelines based on serum creatinine. Diagnostic accuracy were calculated using 2x2 contingency tables. Data were analysed using with SPSS 27. Chi square/Fisher exact test was used with p value ≤ 0.05 considered significant.

RESULTS: Acute kidney injury was diagnosed in 56 patients (21.5%). At four hours postoperatively 78 patients (29.9%) had serum lactate > 4 mmol/L. The sensitivity of serum lactate > mmol/L for predicting AKI was 78.57%, specificity 83.41% and the diagnostic accuracy was 82.38%. Significant associations of AKI were observed for age ≥ 65 years, male gender, diabetes, hypertension, and obesity.

CONCLUSION: Serum lactate is an accurate and efficient marker to predict acute kidney injury in on-pump CABG patients with diagnostic accuracy of 82.38%

KEYWORDS: Acute kidney injury, serum lactate, coronary artery bypass grafting, cardiopulmonary bypass, diagnostic accuracy, KDIGO criteria

INTRODUCTION: Coronary artery disease (CAD) is a leading cause of morbidity and mortality across the globe. Coronary artery bypass grafting (CABG) is a widely performed surgical procedure in cases of complex coronary artery lesions. Regardless of significant advances in the surgical techniques and perioperative management, complications after CABG remain frequent and can considerably effect the postoperative outcomes. Acute kidney injury (AKI) has been reported as a most serious adverse event following the cardiac surgery in procedures performed with the cardiopulmonary bypass (on-pump CABG).¹⁻³ AKI after the Cardiac surgery is characterised by abrupt deterioration with in the renal function after the cardiac surgery which is generally recognized by elevation in the serum creatinine or reduction in the urine output. Reported incidence of AKI following the CABG was 17.72%.⁴

Pathophysiology of AKI after the on-pump CABG is complex. However, numerous mechanisms have been suggested such as renal hypoperfusion, inflammatory response initiated by the cardiopulmonary bypass and oxidative stress. Such processes impair the renal microcirculation and oxygen transfer which results in the tubular injury and decreased glomerular filtration rate.⁵ Early identification of at risk patients of AKI is vital for enabling the prompt preventive and therapeutic strategies. Serum creatinine has been used as main biomarker in diagnosis of AKI which is widely recognised as insensitive indicator of renal injury that usually rise merely following the

considerable kidney damage has already happened.⁶ Several biomarkers are investigated within the recent years, such as NGAL, cystatin-C and the urinary interleukins. However, these tests remain expensive or are not usually available within the resource scarce settings.⁷

Serum lactate has been emerged as a surrogate marker reflecting the tissue hypoperfusion and reduced oxygen delivery in surgical procedures. Lactate accumulation generally occurs when oxygen supply is inadequate to fulfill the metabolic demands which results in the anaerobic metabolism. Raised perioperative lactate levels may indicate the hypoperfusion, inadequate perfusion during cardiopulmonary bypass.⁸ A study found higher peak and lactate concentrations during the surgery were strongly associated with the increased AKI occurrence signifying that lactate thresholds may be valuable for the perioperative risk stratification.^{9,10} Moreover, raised postoperative lactate levels were reported to predict severe renal injury and negative outcomes in cases of major cardiovascular operations [10].

Considering the limitations of biomarkers and increasing the evidence relating the lactate metabolism with the organ perfusion; perioperative serum lactate measurement may provide the inexpensive and easily available tool for the early prediction of AKI in patients undergoing on-pump CABG. Recognizing patients at risk through the perioperative lactate surveillance may allow clinicians for optimizing the haemodynamic management, improve renal perfusion and minimize the postoperative complications.

METHODOLOGY:

This cross-sectional validation study was conducted in the Department of Cardiac Surgery and Intensive Care Unit, Armed Forces Institute of Cardiology and National Institute of Heart Diseases Rawalpindi from October 2025 to March 2026. Ethical approval was obtained from the hospital before commencing the study (9/2/R&D/2025/348). The sample size was 261, which was calculated using sensitivity and specificity from previous literature, an expected sensitivity of 70%, specificity of 83%, of serum lactate with cut off 4.05mmol/L,¹² and a prevalence of acute kidney injury of 40.5%,¹³ with absolute precision 10% were used for the calculation. Non-probability consecutive sampling was used.

Patients of both genders between the ages of 20 and 80 years, with body weight between 45 to 120 kilograms, who underwent elective on-pump coronary artery bypass grafting, were considered for inclusion in the study. Those patients undergoing emergency surgery, re-do surgery, or valvular surgery, those with LVEF < 25% and those with previous history of kidney disease were excluded from the study. Acute kidney injury was diagnosed in accordance with KDIGO guidelines,¹⁴ defined as an increase in serum creatinine ≥ 0.3 mg/dl (≥ 26.5 μ mol/l) within 48 hours, or increase in serum creatinine to ≥ 1.5 times baseline levels within the previous 7 days or the urine output < 0.5 ml/kg/h for the period of 6 to 12 hours. Serum lactate level was measured at predefined intervals, postoperative 0 hour and at 4 hours, the critical threshold/cut off used as > 4mmol, which was derived from a previous literature.¹²

All the patients were assessed for comorbidities such as diabetes which was defined as HbA1c > 6.7%, hypertension defined as systolic blood pressure > 140 mmHg and diastolic > 90 mmHg on two different timings, and obesity was defined as BMI ≥ 30 kg/m² according to the WHO guidelines.¹⁵ Informed consent was taken from the patients. All the patients who underwent on-pump CABG, their perioperative data was collected including preoperative serum creatinine, serum urea, and serum lactate levels at 0 and 4 hours along. All the procedures were performed by an experience cardiac surgeon. The data was collected by the researcher himself.

SPSS 27 was used for analysis, for numerical variables such as age, BMI and serum lactate levels, Shapiro Wilk test was applied for assessing the normality, then median IQR were calculated. For categorical data like acute kidney injury, serum lactate level > 4 mmol at 4 hours, comorbidities, and gender frequency and percentages were used. Chi square/Fisher exact test were used for the stratification of AKI with age, gender, and comorbidities, keeping p value significant at ≤ 0.05 . 2x2 contingency tables were created for assessing the diagnostic accuracy of serum lactate level > 4 mmol/L at 4 hours with AKI, along with sensitivity, specificity, positive predictive value, and negative predictive value.

RESULTS:

A total of 261 patients were included in this study who underwent on-pump coronary artery bypass grafting. The median age of the patients was 50 years, with interquartile range 34 to 66 years. 58.4 $\pm$ 9.6 years. The median BMI was 27.35 kg/m² with interquartile range 25.28 to 29.40 kg/m². The mean postoperative serum lactate at 4 hours was 3.43 mmol/L with interquartile range 2.72 to 5.78 mmol/L.

Figure 1 presents the gender distribution of the patients. Table I presents the comorbidities found in the patients. Acute kidney injury developed in 56 patients (21.5%) according to the KDIGO criteria based on serum creatinine. At four hours postoperatively seventy eight patients (29.9%) had serum lactate levels > than the threshold of 4 mmol/L.

Among the 56 patients who developed AKI 44 were correctly identified by elevated lactate levels > 4 mmol/L (true positives), while 12 had lactate levels of ≤ 4 mmol/L (false negatives). Out of 205 patients who did not develop AKI 171 were correctly identified as negative by lactate levels ≤ 4 mmol/L (true negatives), while 34 had elevated lactate > 4 mmol/L (false positives).

The diagnostic accuracy of a 4 mmol/L lactate cut-off at four hours for predicting AKI showed a diagnostic accuracy of 82.38% (Table II).

Several associations with AKI were observed, AKI was significantly more common in patients aged 65 years or older ($p < 0.001$). Male gender was significantly associated with AKI ($p = 0.012$). Diabetes mellitus was also associated with increased AKI risk of developing AKI ($p = 0.003$). Hypertension showed a strong association with the development of AKI ($p < 0.001$). Obesity was similarly associated with AKI ($p = 0.002$) (Table III).

Figure 1 Gender distribution of the patients

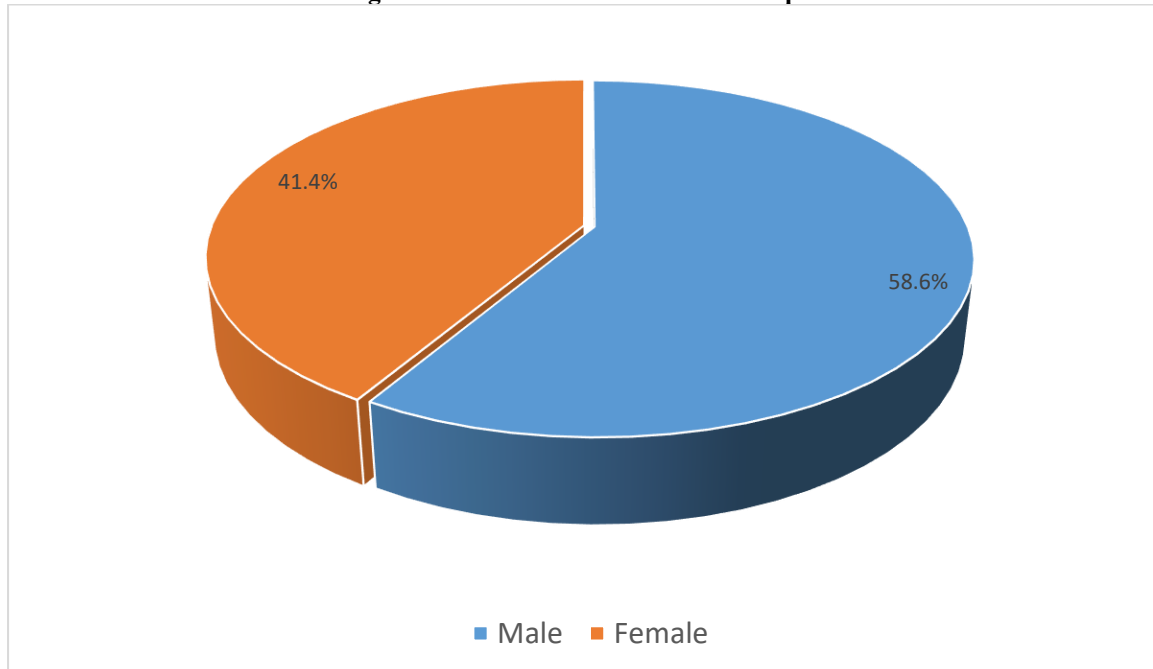


Table I Distribution of comorbidities among study patients

Comorbidities		n	%
Diabetes	Yes	104	39.8%
	No	157	60.2%
Hypertension	Yes	136	52.1%
	No	125	47.9%
Obesity	Yes	51	19.5%
	No	210	80.5%

Table II Diagnostic accuracy of serum lactate >4 mmol/L at four hours for predicting acute kidney injury after on-pump CABG

Sensitivity	Specificity	PPV	NPV	Diagnostic accuracy
78.57%	83.41%	56.41%	93.44%	82.38%

Table III Association between clinical risk factors and development of acute kidney injury

		Acute Kidney Injury (on Scr)				p value
		Yes		No		
		n	%	n	%	
Age >= 65 years	Yes	33	42.3%	45	57.7%	< 0.001
	No	23	12.6%	160	87.4%	
Gender	Male	41	26.8%	112	73.2%	0.012
	Female	15	13.9%	93	86.1%	
Diabetes	Yes	32	30.8%	72	69.2%	0.003
	No	24	15.3%	133	84.7%	

Hypertension	Yes	44	32.4%	92	67.6%	< 0.001
	No	12	9.6%	113	90.4%	
Obesity	Yes	19	37.3%	32	62.7%	0.002
	No	37	17.6%	173	82.4%	

DISCUSS:

The current study analysed the role of serum lactate measured at four hours postoperatively in predicting acute kidney injury among patients undergoing on-pump coronary artery bypass grafting.

The incidence of AKI in this study was 21.5% (n = 56). Yu et al. observed a 20.6% incidence in their study, while Flores-Salinas et al. reported a 25% AKI rate in their study of 264 patients.^{11,12} A slightly higher incidence of 37.6% of AKI was reported by Lin et al.¹⁶ Kwon et al. reported a 40.5% AKI rate in their on-pump CABG population.¹⁷ The variability in AKI incidence across studies highlight the importance of standardised definitions and the influence of local patient characteristics.

The prevalence of comorbidities in the present study revealed that diabetes mellitus was present in 39.8% (n = 104) patients. A study conducted by Iqbal et al. reported a higher diabetes prevalence of 58.4%, while Amjad et al. reported the incidence of diabetes 55.8%, which may reflect the particularly high burden of metabolic disease in their South Asian population.^{18, 19} Hypertension was observed in 52.1% (n = 136) patients, which is similar to the 57.8% reported by Amjad et al.¹⁹ Obesity in the present study was defined as body mass index 30 kg/m² or greater was present in 19.5% of patients, Amjad et al. reported that 32 out of 120 patients in their study had BMI higher than 30 kg/m².¹⁹

At four hours postoperatively 78.6% (n = 44) of patients who developed AKI had lactate levels > 4 mmol/L, compared with only 16.6% (n = 34) of those who did not develop AKI. This pattern is consistent with the findings of Flores-Salinas and colleagues, who observed that AKI patients had substantially higher lactate levels at four hours (median 6.6 mmol/L) than non-AKI patients (median 3.0 mmol/L).¹² The diagnostic accuracy of serum lactate > 4 mmol/L at 4 hours was 82.38%, sensitivity was 78.57% and specificity was 83.41%. These findings align well with Flores-Salinas et al. as they reported that sensitivity and specificity 70% and 83% respectively for elevated serum lactate at 4 hours postoperatively.¹²

The prognostic value of lactate reflects its role as a marker of tissue hypoperfusion and oxygen debt during and after cardiopulmonary bypass, studies have shown that elevated lactate level, especially > 4mmol/L are associated with the risk of mortality.²⁰ Chen et al. in their study demonstrated that various lactate parameters such as mean, peak and time-weighted average concentrations showed significant associations with AKI risk.⁴ They identified thresholds of 2.96 mmol/L for mean lactate and 4.50 mmol/L for peak lactate which aligns with the 4 mmol/L threshold used in the present study.

The present study found several risk factors associated with the development of AKI, such as age ≥ 65 years, diabetes, hypertension and obesity. Lin et al. reported an odds ratio of 2.86 for patients aged ≥ 70 years and Kwon et al. age as a significant predictor in their univariate analysis.^{16,17} Amjad et al. identified hypertension and high BMI as significant predictors of AKI, which aligns with the findings of the present study.¹⁹

The diagnostic performance of a 4 mmol/L lactate threshold at four hours with 78.57% sensitivity and 83.41% specificity in the present study suggests clinical utility for early risk stratification. The high negative predictive value of 93.44% indicates that patients with lactate levels below this threshold are unlikely to develop AKI. The study contributes to existing knowledge by validating previous findings from international studies, in a local regional setting.

Several limitations of the present study needs consideration. The study had a single-centre design which may limit generalisability to other institutions with different patient populations or perioperative protocols. The lack of long-term follow-up prevents the assessment of whether early lactate elevation predicts persistent renal dysfunction or chronic kidney disease development.

CONCLUSION:

In conclusion, the present study validated that perioperative elevated serum lactate levels at 4 hours is an accurate and efficient diagnostic marker for the prediction of acute kidney injury in patients undergoing on-pump coronary artery bypass grafting, with diagnostic accuracy of 82.38%. Routine measurement of serum lactate at four hours after on-pump CABG should be considered for early identification of patients at risk of acute kidney injury.

No conflict of interest declared by the authors

Ethical approval was obtained (9/2/R&D/2025/348)

Consent was taken from the patients

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