Blood Lactate Level as Predictor of Early Outcome after Cardiac Surgery under Cardiopulmonary Bypass

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Abstract:

We examined the hypothesis that high blood lactate level in ICU patient after adult cardiac surgery under cardiopulmonary bypass is associated with early adverse outcome. The objective of this study was to evaluate whether blood lactate level after cardiac surgery is predictor of the early outcome after adult cardiac surgery under CPB. In this prospective observational study total 100 patients were enrolled who underwent elective cardiac surgery under CPB as per inclusion and exclusion criteria. Blood lactate levels > 3mmol/ L 6 hours after ICU transfer were present in 57(57%) patients. The binary logistic regression analysis showed that blood lactate level 6 hours after ICU transfer is an independent predictor for prolonged mechanical ventilation time (OR 2.417, 95% CI 1.272 - 4.596, p = .007), prolonged ICU stay (OR 1.562, 95% CI 1.181 - 2.067, p = .002), neurological deficit (OR 2.432, 95% CI 1.539 - 3.843, p = .001), pulmonary complication (OR 1.301, 95% CI 1.011 - 1.676, p = .041), arrhythmia (OR 1.444, 95% CI 1.102 - 1.893, p = .008), renal dysfunction (OR 1.838, 95% CI 1.352 - 2.497, p = .001) and mortality (OR 1.822, 95% CI 1.123- 2.955, p = .015). In conclusion, blood lactate level 6 hours after ICU transfer is an independent risk factor for worse outcomes in adult patients including mortality after cardiac surgery under CPB.

Key Words: Blood Lactate Level, Cardio-Pulmonary ByPass.

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Introduction:

High blood lactate level is a well-recognized marker of circulatory failure, and its severity has been associated with morbidity and mortality in different clinical conditions.[1,2] After cardiac surgery, hyperlactatemia (HL) is relatively common[3] and is associated with morbidity and mortality.[4]

Irrespective of its origin, hyperlactataemia and its persistence have been demonstrated to be an early indicator of worse outcome in cardiac surgical patients.[5] The liver removes 70% of lactate. Within the Periportal hepatocytes, metabolism involves the processes of gluconeogenesis. The liver receives 25% of cardiac output. Only when the liver blood flow is reduced to 25% of normal is there a reduction in lactate clearance. Under anaerobic conditions, glycolysis becomes the predominant mode of hepatic energy production. As such, the liver becomes a lactate-producing organ rather than using lactate for gluconeogenesis.[6]

Various preoperative factors or comorbidities may create the right environment for HL during CPB. Age, female gender, congestive heart failure, low left ventricular ejection fraction, hypertension, atherosclerosis, diabetes, preoperative low hemoglobin value, redo or complex surgery, and emergency procedures were found to be risk factors for HL.7 Cardiologic arrest induces anaerobic myocardial metabolism with a net production of lactate from glycolysis. Persistent lactate release during reperfusion suggests a delayed recovery of normal aerobic metabolism and may lead to depressed myocardial function.[8]

In current practice, lactate is frequently measured usually with the goal of detecting tissue hypoxia during ICU care. However, high blood lactate levels in ICU are getting more importance to predict early outcome after cardiac surgery in recent publications. The aim of this study was to evaluate whether blood lactate level after cardiac surgery is predictor of early adverse outcomes.

Methods:

This prospective observational study was carried out in the department of Cardiac Surgery at NICVD, Sher-e-bangla Nagor Dhaka from July, 2013 to June 2014.

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Inclusion criteria:

1. All the adult patients irrespective of sex undergoing elective CPB during cardiac surgery.

Exclusion criteria:

1. Patients with pre-CPB high blood lactate level
2. Emergency surgery
3. Redo surgery
4. Adult complex congenital heart defects
5. Hepatic dysfunction
6. End-stage renal disease
7. Intraoperative mortality or mortality less than 6 hours after ICU transfer.
8. Patient's refusal for enrollment in the study.

Considering the inclusion and exclusion criteria, a total number of 100 consecutive adult patients age ranged from 18 to 70 years of both sexes undergoing elective cardiac surgery under cardiopulmonary bypass were included. Demographic data like age, sex, BMI were recorded. Risk factors profile including diabetes mellitus, hypertension, dyslipidemia and impaired LVEF were noted. Patients were grouped into group A (Lactate < 3 mmol/L): Those patients who had less than 3 mmol/L of blood lactate level 6 hours after transfer in ICU and group B (Lactate > 3 mmol/L): Those patients who had >3 mmol/L of blood lactate level 6 hours after transfer in ICU.

Operative Procedure

Anesthesia

All patients undergoing cardiac surgery were given general anesthesia with intubation under standard anesthetic techniques.

Cardiopulmonary bypass

All patients were treated with the same CPB technique. Mean systemic arterial pressure was continuously monitored and maintained between 60 and 80 mm Hg. During perfusion, HCT was maintained around (25-28%).

Measurement of Blood Lactates

Arterial blood samples were analyzed by blood gas analyzer, model - Siemens RAPIDlab 1265, manufactured by Beckman int. California, USA.

ICU Management

Standard ICU management protocols were used and the patients were subsequently shifted to Post-ICU and then to ward or cabin and discharged whenever appropriate according to operating consultant's judgment.

Follow up

All patients were closely followed up and Data were recorded using a pre-formed case record form (questionnaire) up to the time of discharge from hospital, and at the time of 1st Follow up after 1 month of surgery.

Statistical analysis

Data was processed using SPSS (Statistical Package for Social Science) version 17.0. Potential risk factors were assessed using a x^2 test, Fisher's exact test, and t test. A forward multiple logistic regression analysis was then performed to estimate independent predictive factors for complications. For all analysis a p-value <0.05 were considered statistically significant.

Results:

A total of 100 patients were enrolled in this study from which 57% patients were in high lactate group. Death occurred in 7(7%) patients. There was no significant difference in demographic variables and co-morbidities (Table -I).

The patients in group B had a longer duration of operation time, CPB time and ACC time. The Operation time was 319.02 ± 70.479 in group A and 359.47 ± 83.274 in group B (p = .012), CPB time was 121.65 ± 43.449 in group A and 141.88 ± 42.312 in group B (p = .021) and ACC time was 72.88 ± 29.124 in group A and 86.32 ± 26.156 in group B (p = .017) (Table -II).

Regarding the outcome variables in this study, we found in group A and group B neurological deficits [1(2.3%) vs 12(21.1%); p=0.006], pulmonary complication [9(20.9%) vs 17(29.8%); p=0.001], arrhythmia [4(9.3%) vs 19(33.3%); p=0.005], renal dysfunction [5(11.6%) vs 23(40.4%) ; p=0.002] (Table - III)

In binary logistic regression analysis shows that blood lactate level 6 hours after ICU transfer is an independent predictor for prolonged mechanical ventilation time (OR 2.417, 95% CI 1.272 - 4.596, p = .007), prolonged ICU stay (OR 1.562, 95% CI 1.181 - 2.067, p = .002), neurological deficit (OR 2.432, 95% CI 1.539 - 3.843, p = .001), pulmonary complication (OR 1.301, 95% CI 1.011 -1.676, p - .041), arrhythmia (OR 1.444, 95% CI 1.102 - 1.893, p - .008), renal dysfunction (OR 1.838, 95% CI 1.352 - 2.497, p = .001) and mortality (OR 1.822, 95% CI 1.123- 2.955, p = .015) (Table - IV)

Table-I

Preoperative variables screening findings

Variables		Lactate Group (mmol/L)		Total	P Value
		Group A (n=43) <3	Group B (n=57) ≥3		
Age#	>60 years	4 (9.3%)	5 (8.8%)	9 (9%)	1.000^{NS}
Sex*	Female	18 (41.9%)	20 (35.1%)	38 (38%)	0.490^{NS}
BMI*	Obese &Overweight	4 (9.3%)	9 (15.8%)	13 (13%)	.340^{NS}
DM*		11 (25.6%)	14 (24.6%)	25 (25%)	.907^{NS}
HTN*		7 (16.3%)	7 (12.3%)	14 (14%)	.568^{NS}
Dyslipidemia*		8 (18.6%)	9 (15.8%)	17 (17%)	.711^{NS}
ImpairedLVEF#		5 (11.6%)	6 (10.5%)	11 (11%)	1.000^{NS}

Data were analyzed using *Chi-Square test, #Fisher Exact test: Level of significance was 0.05. (n = number of patients, NS= not significant), BMI, body mass index; DM, Diabetes mellitus; HTN, Hypertension; LVEF, Left ventricular ejection fraction.

Table-II

Comparison of Operation time, CPB time, ACC time between groups

Peroperative Variables	Lactate Group (mmol/L)		*P Value*
	Group A (n - 43) <3 Mean ± SD	Group B (n = 57) >3 Mean ± SD	
Operation time*	3 19.02 ±70.479	359.47 ±83.274	*.012^{s}*
CPB time*	121.65 ±43.449 72.88	141.88 ±42.312	*.021^{s}*
ACC time*	±29.124	86.32 ±26.156	*.017^{s}*

Data were analyzed using't' test, (n = number of patients, S = significant), CPB, Cardiopulmonary bypass; ACC, Aortic cross clamp.

Table-III

Postoperative variables

Variables	Lactate Group (mmol/L)			
	Group A(n = 43) <3	Group B(n = 57) >3	Total	*P Value*
LOS	08(18.6%)	36(63.1%)	44 (44%)	*< .0001**
Prolonged MVT	0 (0%)	6 (10.5%)	6 (6%)	*.036^{s}*
Prolonged ICU stay	7 (16.3%)	18(31.6%)	25 (25%)	*.080*™
Reoperation for bleeding	0 (0%)	3 (5.3%)	3 (3%)	*.257^{NS}*
Neurological deficits	1 (2.3%)	12(21.1%)	13 (13%)	*.006^{s}*
Pulmonary complication	9 (20.9%)	17 (29.8%)	26 (26%)	*.001^{s}*
Arrhythmia	4 (9.3%)	19 (33.3%)	23 (23%)	*.005^{s}*
Renal dysfunction	5(11.6%)	23 (40.4%)	28 (28%)	*.002^{s}*
Mortality	1 (2.3%)	6 (10.5%)	7 (7%)	*.234^{NS}*

Data were analyzed using *Chi-Square test, #Fisher Exact test; Level of significance was 0.05. (n = number of patients, NS = not significant); LOS, Low output syndrome; MVT, Mechanical ventilation time; ICU, Intensive care unit.

Table-IV

Binary Logistic Regression Analyses of Predictors for adverse outcome

Input variable	Outcome Variables	B	*P value*	OR	95.0% Lower	C.I. Upper
Blood	LOS	.247	*.108*	1.281	.947	1.732
lactate 6h	Prolong MVT	.883	*.007*	2.417	1.271	4.596
after ICU	Prolong ICU stay	.446	*.002*	1.562	1.181	2.067
transfer	Reoperation for bleeding	.385	*.260*	1.469	.753	2.869
	Neurological deficit	.889	*.001*	2.432	1.539	3.843
	Pulmonary complication	.263	*.041*	1.301	1.011	1.676
	Arrhythmia	.368	*.008*	1.444	1.102	1.893
	Renal complication	.608	*.001*	1.838	1.352	2.497
	Mortality	.600	*.015*	1.822	1.123	2.955

LOS, Low output syndrome; MVT, Mechanical ventilation time; ICU, Intensive care unit; OR, Odds ratio; CI, Confidence interval.

Discussion:

This study has demonstrated that a lactate level > 3mmol/L at 6 hours after ICU transfer are related to postoperative adverse events and is independently associated with risk of major complication after cardiac surgery.

Outcome after cardiac operation is determined by preoperative characteristics of the patients in addition to intra operative factors such as operation time, CPB time, and ACC time. The mean with standard deviation of these characteristics were recorded. The difference between the two groups is statistically significant which indicates that operation time; CPB time and ACC time are one of the important causes of hyperlactatemia. Similarly, Rao et al (2001), Hajjar et al (2013), Maillet et al (2003) and Ranucci et al (2006) stated that there is significant correlation between CPB time and postoperative adverse outcome.[4,5,8,9] Maillet et al (2003) and Demers et al (2000) also found ACC time as an important peroperative factor that had statistically significant difference between two groups. In current study, operation time is found as a risk factors causing postoperative high lactate and is statistically significant.[4,7]

The present study also showed that the difference between two groups is statistically significant in prolong mechanical ventilation. Maillet et al (2003) showed in previous study that prolong mechanical ventilation and ICU stay found in hyperlactatemia group after cardiac surgery.[4]

In this study in case of low output syndrome and arrhythmia the difference between the two groups are statistically significant. Rao et al (2001) and Arnold et al (2009) stated that the development of postoperative LOS and cardiovascular complications in the absence of an intraoperative misadventure revealed a failure of myocardial protection causing persistent anaerobic metabolism and lactate release.[8,10]

In our study we evaluate the outcome variables for major adverse outcome and found neurological deficit, pulmonary complication and renal dysfunction have statistically significant differences between groups, Nichol et al (2010) showed a strong positive correlation between blood lactate levels and the risk of morbidity and mortality with neurological deficits.11 Hajjar et al (2013), Malliet et al (2003) and Ranucci et al (2006) showed in their studies a strong correlation between high lactate and major complications after cardiac surgery that are similar with current study.[4,5,9]

In our study, binary logistic regression analysis shows that blood lactate level 6 hours after ICU transfer is an independent predictor for prolonged mechanical ventilation time, prolonged ICU stay, neurological deficit, pulmonary complication, arrhythmia, renal dysfunction and mortality. The results of this study and discussion thereof prompt us to recommend that routine lactate level measurement is essential for postoperative cardiac ICU to detect early adverse outcome.

Limitations of the study

The main limitation of the study is the absence of randomization. The study has been prospectively designed; but no real randomization has been performed. Finally, it is performed in a single center, which could restrict the generalization of our findings.

Conclusion:

The findings of this study permit to conclude that blood lactate level 6 hours after ICU transfer is associated with an increased risk of postoperative morbidity and

mortality after cardiac surgery. It reveals that after balancing the cofounding variables, blood lactate level after ICU transfer will be remain as predictor of adverse outcome. So, normolactatemia after cardiac surgery is essential to achieve the aim to maintain tissue perfusion and to minimize postoperative morbidity and mortality.

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