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Blood lactate levels during cardiopulmonary bypass as indicator of outcome in pediatric cardiac surgery

M. Tatang Puspanjono, Antonius H. Pudjiadi, Jusuf Rachmat, S. Harry Purwanto

Abstract

***Objectives*: In pediatric cardiac surgery, high blood lactate levels during cardiopulmonary bypass (CPB) are associated with tissue hypoperfusion and contribute to postoperative complications. Studies indicate that blood lactate level is proportional to tissue oxygen debt. The objective of this study was to evaluate the change in blood lactate levels and perioperative morbidity and mortality.**

***Methods*: We conducted a retrospective analysis of 81 pediatric patients who have undergone cardiac surgery with continuous monitoring of serial measurement of blood lactate in Integrated Cardiac Service Unit, Dr. Cipto Mangunkusumo Hospital, Jakarta. Arterial blood samples were taken before, during CPB, and on admission to the Intensive Care Unit (ICU) and every 6 hours afterward. Duration of CPB, hemodynamic parameters, inotrope dosage and perioperative outcome were documented.**

***Results*: The largest increment in lactate level occurred during CPB and decreased on admission to the ICU. Patients who had complications exhibited higher lactate levels at all time points. Lactate levels were higher in the group with complications at the end of surgery (4.4 vs 2.7 mmol/l; p=0.000), immediately after ICU admission (2.9 vs 1.9 mmol/l; p=0.000), 6 hours (1.9 vs 1.4 mmol/l; p<0.003), and 12 hours after admission (4.6 vs 2.8 mmol/l; p=0.000). Increased lactate concentration was reliably associated with patient length of ICU stay, liver function parameter and anion gap. Logistic regression analysis revealed that peak blood lactate levels of 3.5 mmol/l or higher during CPB were strongly associated with postoperative mortality and morbidity.**

***Conclusions*: Hyperlactatemia occurs during CPB may become an early indicator/predictive index for postoperative morbidity and mortality in pediatric patients. This study generates the hypothesis that strategies aimed to preserve oxygen delivery during CPB may reduce the occurrence of elevated lactate levels.**

Key words: Serial blood lactate, cardio pulomanary bypass, pediatric cardiac surgery.

From Faculty of Medicine University of Indonesia (Fellow in Pediatric Emergency and Critical Care Medicine Program) (M. Tatang Puspanjono), Department of Child Health, Division of Pediatric Emergency and Critical Care Medicine, Faculty of Medicine University of Indonesia (Antonius H. Pudjiadi and S. Harry Purwanto), Integrated Cardiac Service Unit, Division of Pediatric Cardiac Surgery, Dr. Cipto Mangunkusumo National General Hospital (Jusuf Rachmat).

Address for correspondence:
M. Tatang Puspanjono
Pediatric Emergency and Critical Care Medicine Fellowship Program
Faculty of Medicine University of Indonesia, Jakarta, Indonesia
Email: m_tatang_puspa@yahoo.co.id

Introduction

In pediatric cardiac surgery, high blood lactate levels during cardiopulmonary bypass (CPB) are associated with tissue hypoperfusion and contribute to postoperative complications. Studies indicate that blood lactate level is proportional to tissue oxygen debt. (1,2)

Monitoring of blood lactate level is important to evaluate shock. Blood lactate level has been studied to be used as a biochemical marker for tissue hypoxia. Serial blood lactate levels can predict shock, multiple organ failure, and survival better than cardiac output, oxygen delivery, and interleukin-6 (IL-6). Blood lactate level has been studied as biochemical marker for hypoxia, severity of disease, shock therapy, and prognosis in critical con-

dition. Bedside serial blood lactate level was a sensitive indicator to evaluate severity of shock. (3,4)
Hyperlactatemia during cardiopulmonary bypass is relatively frequent and is associated with an increased postoperative morbidity. Hyperlactatemia during CPB is a common event and is associated to a high morbidity and mortality after cardiac operations. Tissue perfusion may not be adequate during cardiac surgery, especially with the use of CPB. Tissue perfusion is at risk during cardiac surgery and in the immediate postoperative period. The association of low blood flow with metabolic acidosis and accumulation of lactate perioperatively has been well established. With the improvements in cardiopulmonary bypass and overall hemodynamic management, severe peri- and postoperative hypoperfusion has become rare. Inadequate perfusion is usually associated with anaerobic metabolism, metabolic acidosis, and lactate accumulation. (5-7)
The objective of this study was to evaluate the role of changes in blood lactate level during CPB in pediatric cardiac surgery and perioperative morbidity and mortality.

Methods
Standard cardiopulmonary bypass was performed during surgery. Lactic acid levels and blood gas analyses were measured. This study consisted of a retrospective cohort and a cross sectional method. Data were analyzed with Chi-square test. Continous data tested using Mann-Whitney method. To know the correlation between blood lactate level and shock risk factors we used logistic regression test.
We conducted a retrospective cohort study of 81 pediatric patients with congenital heart disease who underwent cardiac surgery on CPB with continuous monitoring of serial measurement of blood lactate level in Integrated Cardiac Service Unit, Dr. Cipto Mangunkusumo Hospital, Jakarta, between February 2010-January 2012.

Blood lactate levels were checked in serial manner:
L1=before surgery;
L2=highest level during surgery;
L3=on Intensive Care Unit (ICU) admission after surgery;
L4=6 hours after surgery;
L5=12 hours after surgery;
L6=highest level during hospital stay

Duration of CPB, hemodynamic parameters, inotrope dosage, and perioperative outcomes were documented.

Results
Standard cardiopulmonary bypass was performed during surgery. Lactic acid levels and blood gas analyses were measured. Duration of CPB, hemodynamic parameters, inotrope dosage, and perioperative outcomes were documented (**Figure 1** and **Table 1**).
The highest lactate level occurred during CPB and decreased on admission to the ICU. Patients who had complications showed higher lactate levels at all time points (**Figure 2**).
Significant correlations of serial blood lactate level with other variables were found in these relationship:
- Intraoperative lactate level (L2) with serum glutamic oxaloacetic transaminase (SGOT) level (p=0.008)
- On ICU admission lactate level (L3) and 6 hours after surgery (L4) with CPB time (p=0.02)
- In hospital highest lactate level (L6) with length of stay (p=0.05) and SGOT level (p=0.008) (**Figures 3A**, **3B**, and **Table 2**)
Logistic regression analysis revealed that peak blood lactate levels of 3.472 mmol/l or higher during CPB were strongly associated with postoperative complications.
L3 was associated with predicted poor outcome with 74.4% sensitivity value, 62.5% specificity value, with positive predictive value 65.9% and negative predictive value 71.4%.

Discussion
Evaluation of cardiac output and oxygen delivery are important tools in the intensive care unit. Blood lactate levels might help in minimizing morbidity and mortality. Serial blood lactate level or range has not been defined that correlates accurately with outcome of postoperative in ICU, and it is likely that the change in blood lactate during CPB is a better indicator of patient outcome. (1-4)
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- Intraoperative lactate level (L2) with SGOT level (p=0.008)
- On ICU admission lactate level (L3) and 6 hours after surgery (L4) with CPB time (p=0.02)
- In hospital highest lactate level (L6) with length of stay (p=0.05) and SGOT level (p=0.008)
These results was consistent with the previous study that measuring blood lactate level in serial time intraoperative, on ICU admission, and after

ICU admission. (8-11)

The rising of blood lactate during cardiopulmonary bypass is related to a condition of insufficient oxygen delivery. The duration of cardiopulmonary bypass is also related to the development of lactic acidosis. Pathophysiology of lactic acidosis in cardiopulmonary bypas is due to inadequate perfusion and lactate washout after adequate perfusion. (12-14)

Logistic regression analysis revealed that peak blood lactate levels of 3.472 mmol/l or higher during CPB were strongly associated with postoperative complications. L3 was associated with predicted poor outcome with 74.4% sensitivity value, 62.5% specificity value, with positive predictive value 65.9% and negative predictive value 71.4%.

Blood lactate levels is correlated with the degree of hypothermia while the patient was supported by cardiopulmonary bypass, and the intensive care unit length of stay. In a study before, the initial mean lactate level after heart surgery in a pediatric population was 2.38 mmol/l for survivors (n=34 patients) and 6.86 mmol/l for nonsurvivors (n=7 patients); no patient with blood lactate level more than 4.5 mmol/l survived. (15)

Hyperlactatemia during cardiopulmonary bypass appears to be related mainly to a condition of insufficient oxygen delivery (type A hyperlactatemia). The duration of cardiopulmonary bypass and especially the occurrence of hypotension at the start of the bypass period appears to be related to the development of lactic acidosis. (14,15)

Conclucions

Hyperlactatemia occurs during CPB may become an early indicator/predictive index for postoperative morbidity and mortality in pediatric patients. This study generates the hypothesis that strategies aimed to preserve oxygen delivery during CPB may reduce the occurrence of elevated lactate levels.

Table 1. Characteristic of patients

	Group without complication	Group with complication	p value
ICU length of stay - ≤7 days - >7 days	 22 (55%) 18 (45%)	 15 (38.5%) 24 (61%)	0.141
SGOT level - ≤37 U/l - >37 U/l	 21 (52.5%) 19 (47.5%)	 27 (69.2%) 12 (30.8%)	0.128
Albumin level - 3-4.5 g/dl - <3 or >4.5 g/dl	 25 (62.5%) 15 (37.5%)	 15 (61.5%) 24 (38.5%)	0.033
Blood glucose - 45-110 mg/dl - <45 or >110 mg/dl	 4 (10%) 36 (90%)	 1 (2.6%) 38 (97.4%)	0.187
Anion gap - 8-16 - <8 or >16	 30 (75%) 10 (25%)	 20 (51.3%) 19 (48.7%)	0.029
CPB time - ≤100 min - >100 min	 2 (5%) 38 (95%)	 4 (10.3%) 35 (89.7%)	0.378

Legend: ICU=intensive care unit; SGOT=serum glutamic oxaloacetic transaminase; CPB=cardiopulmonary bypass.

Table 2. Lactate mean level in group without and with complication

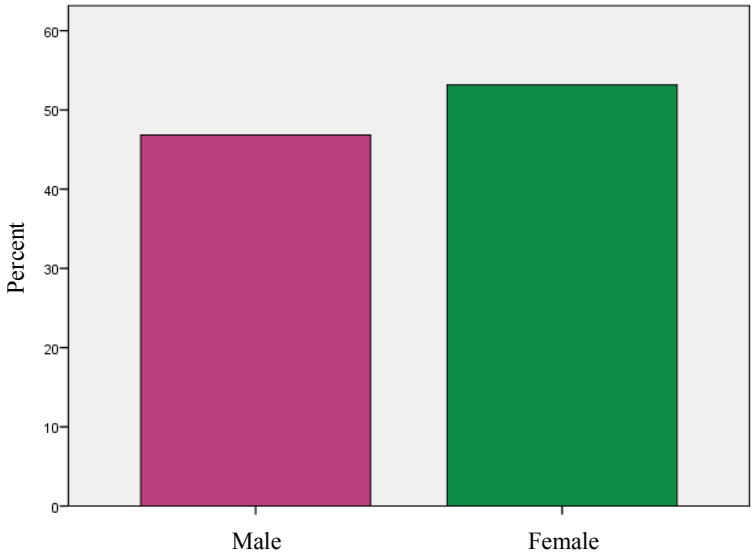
	Complication	Lactate mean level (mmol/l)±SD	p value
L2	- +	2.74±0.68 4.40±1.18	0.000
L3	- +	1.90±0.76 2.86±0.98	0.000
L4	- +	1.40±0.47 1.92±0.84	0.003
L6	- +	2.82±0.74 4.55±1.19	0.000

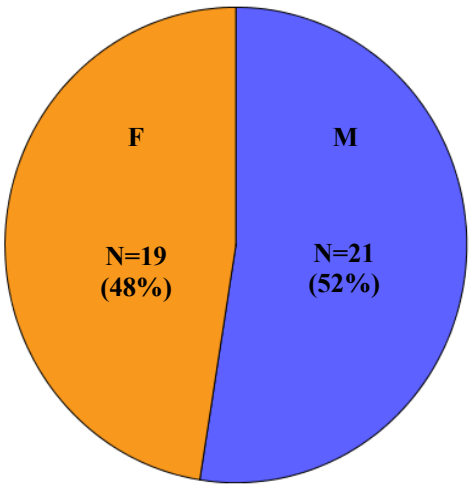
Normal distribution unpaired t-test

	Complication	Lactate level ≤2 mmol/l	Lactate level >2 mmol/l	p value
L1	- +	37 (94.9%) 25 (71.4%)	2 (5.1%) 10 (28.6%)	0.010
L5	- +	38 (95%) 30 (76.9%)	2 (5%) 9 (23.1%)	0.025

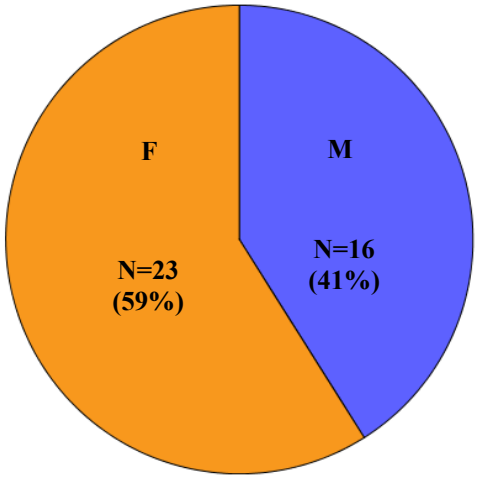
Fisher test

Figure 1. Demography of respondents



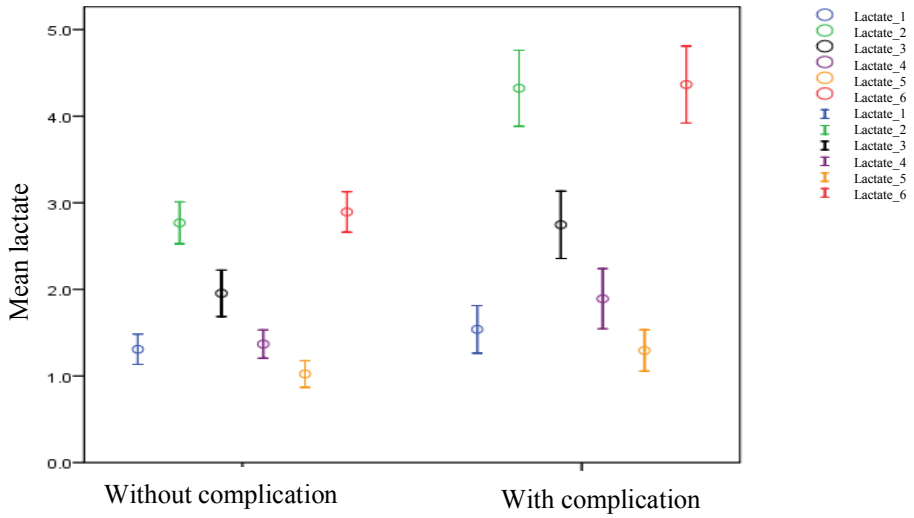


Proportion of male and female in without complication group



Proportion of male and female in with complication group

Figure 2. Serial mean lactate level



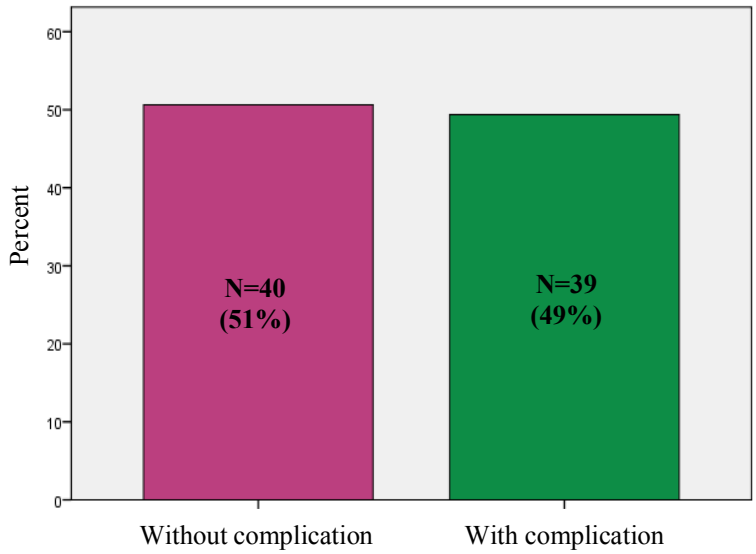


Figure 3A. Distribution of proportion in blood lactate level in group without complication

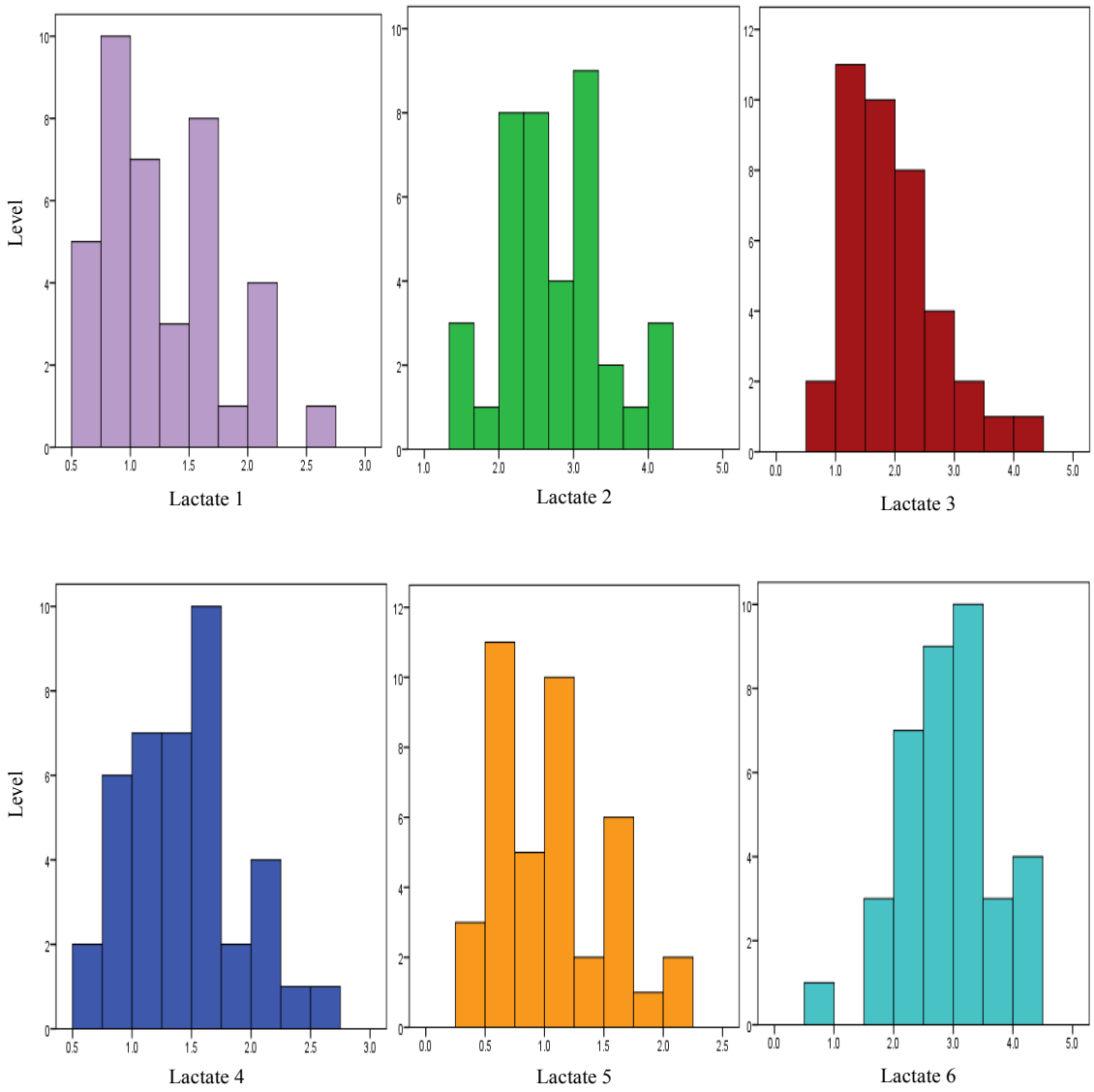
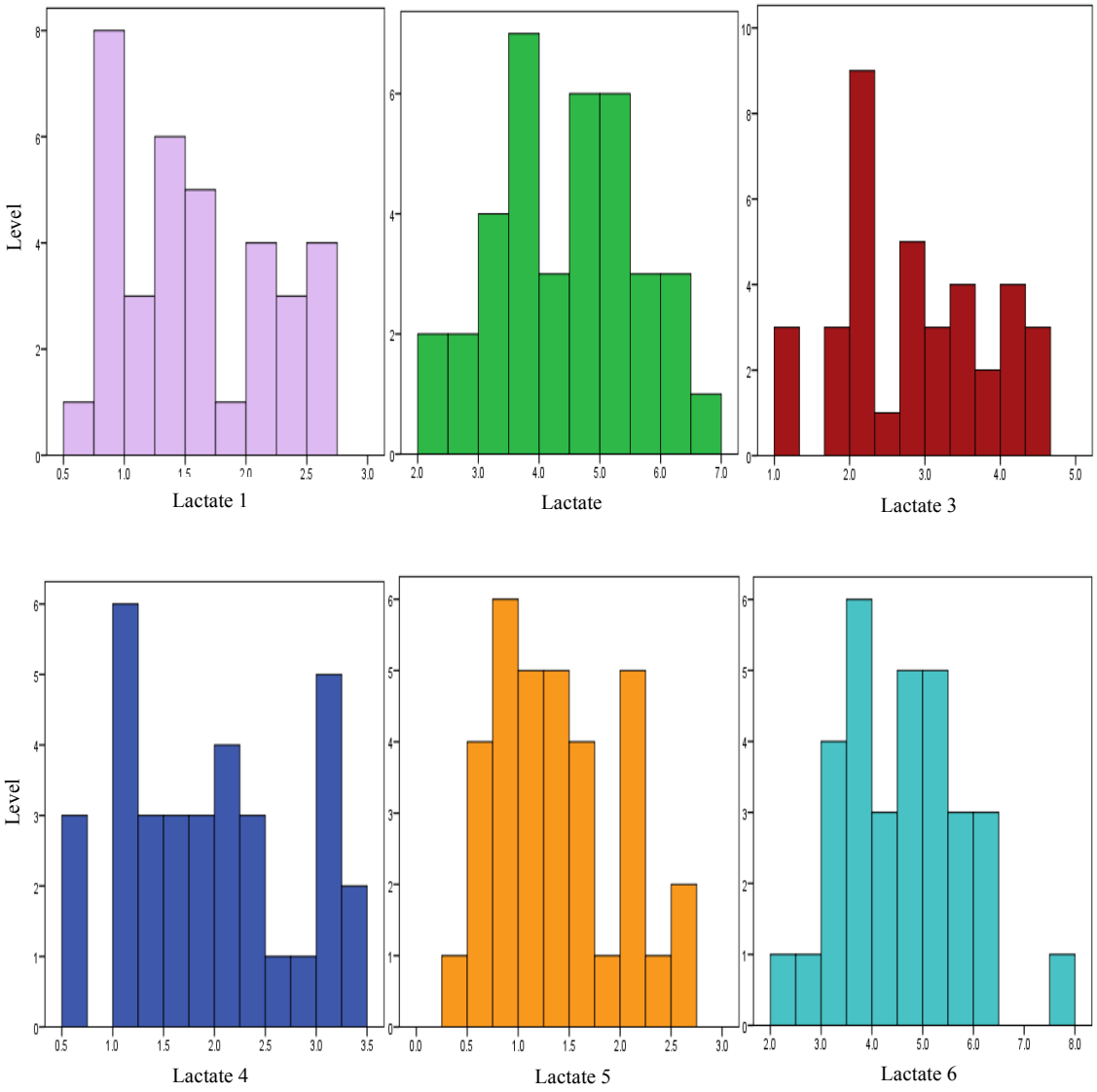


Figure 3B. Distribution of proportion in blood lactate level in group with complication



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