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The effect of Cardiopulmonary Bypass on different laboratory values: A retrospective analysis of Data

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Abstract

Introduction: During cardiopulmonary bypass, numerous organ functions may be negatively impacted, either directly or indirectly. Organ ischemia-reperfusion injury and the inflammatory stress response can both exacerbate existing organ damage, resulting in a systemic, diffuse, multiorgan inflammatory stress response.

Aim of the study: To highlight the effects of CPB on different laboratory values by performing a secondary analysis of available data from previous studies.

Subjects and Methods: The entries for this study were originally collected for an observational study to assess the predictive value of lung ultrasound scores in predicting postoperative intensive care length of stay. 191 patients above 18 years and scheduled for elective cardiac surgery for valve replacement or on-pump Coronary Artery Bypass Grafting (CABG) via median sternotomy were included.

Results: A noted decrease in platelet count (297.91±80.77 versus 233.74±79.56), hemoglobin level (13.4±1.38 versus 10.9±1.04), and serum potassium level (4.14±0.53 versus 3.51±0.45). An increase in INR (1.13±0.1 versus 1.27±0.15), serum lactate (0.57±0.34 versus 4.88±3.03), and serum AST (27.68±13.43 versus 41.37±21.08) was also seen.

Conclusions: After cardiopulmonary bypass, platelet count, hemoglobin level, and serum potassium tend to decrease, whereas INR, AST, and serum lactate tend to increase.

Keywords: Cardiopulmonary Bypass; Lactate; Cardiac Surgery; Platelet Count.

1. Introduction

Cardiac surgeries have become a cornerstone in the treatment of various cardiac issues, including congenital heart disease, ischemic heart disease, and severe valvular lesions. Apart from off-pump cardiac surgeries, cardiopulmonary bypass is usually instituted to replace cardiopulmonary functions; meanwhile, the heart and lungs are set to a standstill during the procedure [1].

When a patient undergoes cardiopulmonary bypass, blood is drawn from the superior vena cava, inferior vena cava, and right atrium and returned to the heart and lung machine for the release of oxygen and carbon dioxide before passing through the blood pump to resume blood circulation [2]. When the internal environment of the body is exposed to foreign objects like oxygenators and ducts during cardiopulmonary bypass, they can cause monocyte and macrophage activation, which results in massive production of inflammatory cytokines and waterfall release. However, patients with cardiac diseases have poor anesthetic tolerance [3].

During cardiopulmonary bypass, numerous organ functions may be negatively impacted, either directly or indirectly. Organ ischemia-reperfusion injury and the inflammatory stress response can both exacerbate existing organ damage, resulting in a systemic, diffuse, multiorgan inflammatory stress response. Even acute organ failure, including that of the liver, kidney, and lungs, may result from it [4].

In this paper, we have performed a secondary analysis of available data from the previous study to highlight the effects of CPB on different laboratory values.

2. Subjects and methods

2.1. Subjects

This retrospective observational study was conducted at Fayoum University Hospital from patients' data who had cardiac on-pump surgery from August 2020 to March 2022, following the tenets of the Declaration of Helsinki. Those entries were originally collected for an observational study to assess the predictive value of lung ultrasound scores in predicting postoperative intensive care length of stay [5].

Inclusion criteria

One hundred ninety-one patients above 18 years of age and scheduled for elective cardiac surgery for valve replacement or on-pump Coronary Artery Bypass Grafting (CABG) via median sternotomy were included.

Exclusion criteria

They were subjects with inadequate acoustic windows or preliminary examinations, patients with emergency surgeries, thoracic deformities, or preexisting pulmonary pathology.

2.2. Study design

All patients were preoperatively examined and investigated by complete blood count, coagulation profile, renal functions, and electrolytes. Electrocardiography, chest x-ray, and echocardiography were routinely done. Coronary angiography and carotid arterial duplex could be requested on demand. Those labs were done in the week preceding the operation. Arterial blood gas (ABG) values were collected as follows: baseline after induction of anesthesia, before and after weaning from cardiopulmonary bypass, and postoperatively in critical care 12 hours after admission in intensive care.

2.3. Statistical Methods:

Descriptive statistics are presented as the minimum, maximum, mean, and standard deviation for numerical variables, while numbers and percentages are used for categorical variables. In addition, the median and IQR are used for the LUS score in each quadrant. IBM SPSS 28 for windows software was used for the analysis, *P-value < 0.05* is considered statistically significant.

3. Results

For this study, 191 patients' data were analyzed. There was no statistically significant difference in the demographic characteristics, as shown in Table 1.

Table 1: Socio-demographic and clinical characteristics of participants in the current study.

Variables		Frequency (N=191)
Sex	**Male**	108 (56.5%)
	Female	83 (43.5%)
BMI (%) Mean ± SD		29.44±4.4
Planned Operation	**CABG**	121 (63.35%)
	Valvular	70 (36.65%)
Comorbidities	**DM**	38 (19.9%)
	HTN	38 (19.9%)
Euro score Mean ± SD		1.41±1.65
CPB time Mean ± SD		104.11±27.46
Inotropes	**Single inotrope**	108 (56.5%)
	Multiple inotropes	83 (43.5%)

SD: standard of deviation; N: number, DM: Diabetes mellitus, HTN: Hypertension; CABG: Coronary Artery Bypass Grafting.

A total of 191 patients were included in this study. The characteristics of the patients are shown in Table 1. 56.5% of the patients are males, while 43.5% of the patients are females. The mean age of the patients was 57.36±8.95, and their mean BMI was 29.44±4.4.

63.35% of the planned operations were CABG, while 36.65% of the planned operations were valvular heart operations. 19.9% of the patients suffered from Hypertension (HTN) as a comorbidity, and 19.9% had Diabetes mellitus (DM). The mean euro score was 1.14±1.65, while the mean Cardiopulmonary bypass (CPB) time was 104.11±27.46.

In the original study, patients were classified as having a short Intensive Care Unit (ICU) stay of three days or less and a long ICU stay of more than three days. Table 2 shows a comparison between patients' laboratory findings with long and short ICU stays. There was a statistically significant difference regarding ICU lactate (*P<0.001*), as it was higher in patients who stayed in ICU for more than 3 days (mean =6.25±3.22) than in patients who stayed in ICU for less than 3 days (mean = 3.42±1.98).

Table 2: Comparison of laboratory findings for patients with long and short ICU stay.

Variables		Short (3 days or less)	Long (More than 3 days)	*P-value*
Preoperative	PLT count (×10^3/µl)	297.74±84.43	298.06±77.57	0.978
	PT (sec.)	14.39±1.44	14.74±1.35	0.091
	PC (%)	87.77±8.47	85.71±8.75	0.100
	INR	1.12±0.11	1.13±0.10	0.447
	HG (g/dl)	13.41±1.52	13.38±1.23	0.876
	HCT (%)	39.17±3.89	39.04±3.19	0.804
	Urea (mg/dl)	33.04±11.33	33.10±11.69	0.972
	sCR (mg/dl)	0.78±0.25	0.84±0.29	0.128
	AST (U/L)	27.09±12.07	28.24±14.64	0.552
	ALT (U/L)	26.37±10.33	26.24±11.95	0.938
	Na (mmol/L)	139.45±4.32	139.20±4.89	0.712
	K (mEq/L)	4.15±0.52	4.14±0.54	0.846
Postoperative	PLT count (×10^3/µl)	232.05±74.11	235.34±84.76	0.776
	PT (sec.)	16.32±1.91	16.49±1.95	0.543
	PC (%)	74.1±12.1	73.87±11.76	0.894
	INR	1.27±0.15	1.27±0.15	0.780
	HG (g/dl)	10.94±1.08	10.86±1.01	0.638
	HCT (%)	32.2±3.4	31.91±3.22	0.543
	Urea (mg/dl)	41.66±15.67	41.78±13.26	0.955
	sCR (mg/dl)	0.82±0.25	0.88±0.34	0.158
	AST (U/L)	40.31±17.74	42.38±23.87	0.497
	ALT (U/L)	32.15±12.83	34.15±12.66	0.279
	Na (mmol/L)	137.69±4.54	137.73±4.53	0.944
	K (mEq/L)	3.49±0.38	3.53±0.51	0.530
Base ABG	PH	7.39±0.04	7.39±0.04	0.578
	PaO_2 (mmHg)	81.63±7.31	81.88±7.36	0.819
	$PaCO_2$ (mmHg)	38.03±3.59	37.78±7.04	0.753

	HCO_3 (mEq/L)	22.16±2.57	22.04±2.83	0.759
	Lactate (mmol/L)	0.55±0.25	0.58±0.40	0.515
Before CPB ABG	**PH**	7.41±0.04	7.4±0.04	0.854
	PaO_2 (mmHg)	393±63.76	394.11±72.46	0.911
	$PaCO_2$ (mmHg)	36.17±4.32	35.98±5.38	0.786
	HCO_3 (mEq/L)	22.21±2.45	21.84±2.68	0.320
	Lactate (mmol/L)	0.63±0.35	0.71±0.49	0.204
After CPB ABG	**PH**	7.28±0.06	7.27±0.06	0.487
	PaO_2 (mmHg)	266.05±89.27	253.13±85.05	0.307
	$PaCO_2$ (mmHg)	38.63±4.2	38.54±4.45	0.882
	HCO_3 (mEq/L)	17.15±2.15	17.62±2.16	0.715
	Lactate (mmol/L)	7.53±3.82	7.96±4.17	0.461
ICU ABG	**PH**	7.37±0.04	7.37±0.04	0.537
	PaO_2 (mmHg)	132.82±45.76	135.18±49.95	0.734
	$PaCO_2$ (mmHg)	39.35±3.76	39.32±4.39	0.948
	HCO_3 (mEq/L)	20.09±2.59	20.07±2.48	0.956
	Lactate (mmol/L)	3.42±1.98	6.25±3.22	<0.001

ABG: Arterial Blood Gas; ALT: Alanine Transaminase; AST: Aspartate Aminotransferase; CBP: Cardiopulmonary Bypass; HCO_3: Bicarbonate; HCT: Hematocrit; HG: Hemoglobin; ICU: Intense Care Unit; INR: International Normalized Ratio; K: Kalium (Potassium); Na: Natrium (Sodium); PaO_2: Partial Pressure of Oxygen; $PaCO_2$: Partial Pressure of Carbon Dioxide; PC: Protein C; PLT: Platelets; PT: Prothrombin Time; sCR: serum Creatinine.

In the original study, patients were classified as having a short hospital stay of seven days or less and a long hospital stay of more than seven days. Table 3 shows the effect of CPB duration on ICU lactate. Another comparison between preoperative and postoperative laboratory values is shown in Table 4. Comparing preoperative and postoperative values, A noted decrease in platelet (PLT) count (297.91±80.77 versus 233.74±79.56), hemoglobin (HG) level (13.4±1.38 versus 10.9±1.04), and serum potassium (K) level (4.14±0.53 versus 3.51±0.45). An increase in INR (1.13±0.1 versus 1.27±0.15), serum lactate (0.57±0.34 versus 4.88±3.03), and serum AST (27.68±13.43 versus 41.37±21.08) was also seen.

Table 3: The effect of CPB duration on ICU lactate

CPB duration (min.)	Frequency N (%)	Mean ±SD
<60	1 (0.5%)	2.1±0
60-90	64 (33.5%)	4.86±2.97
90-120	90 (47%)	4.9±3.04
120-150	27 (14%)	4.92±3.05
150-180	4 (2%)	4.99±3
>180	6 (3%)	4.87±3

Table 4: Comparison between preoperative and postoperative values.

Variables	Preoperative	Postoperative
PLT count (×10^3/µl)	297.91±80.77	233.74±79.56
PT (sec.)	14.57±1.4	16.41±1.93
PC (%)	86.72±8.66	73.98±11.89
INR	1.13±0.1	1.27±0.15
HG (g/dl)	13.4±1.38	10.9±1.04
HCT (%)	39.11±3.54	32.05±3.3
Urea (mg/dl)	33.07±11.49	41.72±14.44
sCR (mg/dl)	0.81±0.27	0.85±0.3
AST (U/L)	27.68±13.43	41.37±21.08
ALT (U/L)	26.31±11.16	33.18±12.75
Na (mmol/L)	139.32±4.61	137.71±4.52
K (mEq/L)	4.14±0.53	3.51±0.45
PH	7.39±0.04	7.37±0.04
PaO_2 (mmHg)	81.76±7.32	134.03±47.84
$PaCO_2$ (mmHg)	37.9±5.62	39.34±4.08
HCO_3 (mEq/L)	22.1±2.7	20.08±2.53
Lactate (mmol/L)	0.57±0.34	4.88±3.03

ALT: Alanine Transaminase; AST: Aspartate Aminotransferase; HCO_3: Bicarbonate; HCT: Hematocrit; HG: Hemoglobin; ICU: Intense Care Unit; INR: International Normalized Ratio; K: Kalium (Potassium); Na: Natrium (Sodium); PaO_2: Partial Pressure of Oxygen; $PaCO_2$: Partial Pressure of Carbon Dioxide; PC: Protein C; PLT: Platelets; PT: Prothrombin Time; sCR: serum Creatinine.

4. Discussion

In this study, a decrease was noted in platelet count (297.91 SD 80.77 versus 233.74 SD 79.56), hemoglobin level (13.4 SD 1.38 versus 10.9 SD 1.04), and serum potassium level (4.14 SD 0.53 versus 3.51 SD 0.45). An increase in INR (1.13 SD 0.1 versus 1.27 SD 0.15), serum lactate (0.57 SD 0.34 versus 4.88 SD 3.03), and serum AST (27.68 SD 13.43 versus 41.37 SD 21.08) was also seen.

Hofer et al. (2016) described the decrease in coagulation function after cardiac surgeries. They declared a decrease in platelet count and a decrease in coagulation factors. This goes in line with our findings, where a decrease in platelet count and a change in coagulation are represented by increased INR [6]. Ishikawa and his colleagues (2018) also found the same decrease in platelet count after cardiac bypass and correlated that with the increased incidence of postoperative bleeding [7]. The review article by Martin et al. (2010) also described the coagulopathy resulting from cardiac bypass [8].

O'Connor et al. (2012) highlighted the value of early hyperlactatemia after cardiac surgeries and bypasses. They described it as strongly indicating tissue ischemia, and it is linked to greater postoperative mortality, a protracted stay in the intensive care unit, and a longer need for respiratory and cardiovascular support. Its presence should trigger a careful investigation of possible tissue hypoxia causes [9]. Jabbari et al. (2013) also presented the correlation between serum lactate after cardiac surgery and postoperative outcomes [10]. Those publications, along with our findings, prove the effectiveness of the bypass on tissue perfusion as presented by the increase in serum lactate levels.

Reduced arterial PH and saturation and increased lactate generation are signs of inadequate tissue perfusion and oxygenation. Despite the fact that lactic acidosis is typically associated with a high anion gap and is generally defined as a lactate level >5 mmol/L and a serum pH of 7.35, and that in CABG surgery this may be due to bicarbonate prescription during the operation, this investigation showed that serum lactate concentration in ABG samples was reliably associated with patient hemodynamic parameters but did not generally correlate with the PH of the arterial blood sample [11].

Murphy et al. (2009) and Shahbazi et al. (2013) described the changes in liver enzymes (AST) resulting from prolonged bypass time, and this is in line with our results, where an increase in AST levels was obvious after cardiopulmonary bypass [12, 13].

Aa limitations of the current study, the results couldn't be generalized to all cardiac surgeries as they only included adult elective CABG and valvular surgeries. Factors related to mechanical ventilation, including mode, PEEP, peak airway pressure, recruitment maneuvers, and FiO2, were not analyzed. There was no protocol regarding enhanced recovery after cardiac surgery applied, which might affect laboratory outcomes in our study.

Conclusion

After cardiac surgery on cardiopulmonary bypass, platelet count, hemoglobin level, and serum potassium tends to decrease, whereas INR, AST, and serum lactate tend to increase.

Ethical approval and consent to participate: That study had an ethical review board approved by Fayoum University Hospital (D 230), and the eligible participants signed a detailed informed consent.

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Conflicts of Interest: The authors declare no conflicts of interest

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