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A study of serial pH, Lactate and PO_2 levels (pre-op/ intra-op/ ICU) over outcome of patients undergoing cardiopulmonary bypass surgery - A single center study

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Abstract: *In the practice of cardiac surgery, anesthesia and surgery per se are both regarded as stress givers to the normal homeostatic mechanism of human body. The effect of drugs, incision, cardiovascular systemic manipulations during surgery and ventilation in ICU which is a cementing element of management of patients after weaning from bypass, all have the potential to alter the blood gas profile. As a sentinel against these effects the practice of taking repeated arterial blood gas samples is followed universally in cardiac surgery. The analysis of ABG samples predominantly focuses on pH, PO2, lactate, PCO_2, bicarbonate and electrolyte levels. There have been attempts to predict the outcome of surgery on the basis of these levels by various researchers but more importantly correction of the levels of the mentioned parameters has proven its steel in proper management of cardiac patient both in operation theater and ICU. Here we have made an attempt to predict the outcome of cardiac surgery based on analysis of serial values of pH, Lactate and PO_2 at our center after collecting a data of 91 patients. It is worth mentioning that during the conduct of study the correction of the mentioned parameters was not compromised keeping the interest of patient on top.*

Keywords: *pH, Lactate, PO_2, Arterial blood gas analysis, Outcome of cardiac surgery*

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I. Introduction

Arterial blood gas and pH analysis are performed during anesthesia or critical care /ICU for (1) assessment of acid base balance, (2) assessment of pulmonary oxygenation of arterial blood, and (3) assessment of alveolar ventilation by measurement of arterial blood pO_2 and pCO_2 [(1)]. The normal physiological pH of arterial blood is strictly maintained at 7.40 (7.35 -7.45). pH buffers are mainly hemoglobin and albumin. A decrease of more than 0.05 units from the normal pH results in acidosis. In contrast to intracellular and blood pH, interstitial fluid pH can easily be reduced by acid stress. This can disturb homeostasis of the intracellular metabolism, leading to the development of metabolic diseases [(2)]. Arterial pO_2 does not reveal how much oxygen is in blood but only the partial pressure exerted by dissolved O_2 molecules against the measuring electrode [(3)]. Aerobic metabolism is dependent on oxidative phosphorylation, a process by which the oxido-reduction energy of mitochondrial electron transport is converted to the high-energy phosphate bond in the synthesis of ATP. O_2 serves as the final electron acceptor [(4)]. Oxygen is given to treat hypoxaemia, initially given at high concentration and then adjusted according to the results of pulse oximetry and ABG analysis.The dangers of reducing hypoxic drive have been overemphasised; hypoxaemia is more dangerous than hypercapnia.The theoretical dangers of oxygen toxicity are unimportant if the patient is hypoxaemic [(5)]. Finally, ABG is an essential part of diagnosing and managing a patient's oxygenation status and acid-base balance, the usefulness is highly observer dependent on being able to correctly interpret the results [(6)].

II. Background

Normal blood lactate level is 0–2 mmol/L, value above 3–5 mmol/L is variably used to define hyperlactatemia. In cardiac surgical patients, hyperlactatemia can arise from both hypoxic and non-hypoxic mechanisms. Major non-hypoxic mechanism is stress-induced accelerated an-aerobic metabolism when elevated

lactate results from a mass effect on lactate/ pyruvate equilibrium. The lactate/pyruvate ratio is normal (<20) here. Hyperlactatemia can also result from impaired global/ regional oxygen delivery and the lactate/ pyruvate ratio is typically elevated (>20). Further, categorized as early or late onset. Early-onset develops in the operating room or very early following ICU admission and has adverse outcomes and arises as a consequence of both hypoxic (e.g., microcirculatory shock) and nonhypoxic (accelerated aerobic metabolism) mechanisms. Late-onset is benign, self-limiting arising within 6-12 hours of ICU admission and spontaneously resolving within 24 hours[7]. Hyperlactatemia in early postoperative cardiogenic shock was mainly related to increased tissue lactate production, alterations of lactate utilization played minor role. Patients had hyperglycemia and increased nonoxidative glucose disposal, suggesting that glucose-induced stimulation of tissue glucose uptake and glycolysis may contribute significantly to hyperlactatemia [8].The persistence of hyperlactatemia is a more important determinant of postoperative outcome than absolute value of peak lactate. Mortality is proposed to be secondary to a state of ongoing hypoperfusion [9]. Lactate clearance in early postoperative period (6 h) is associated with decreased mortality rate. Patients with higher lactate clearance (>10%) after 6 hours have improved outcome compared with lower lactate clearance [10]. In one study, Lactime - time during which the lactate remains >2 mmol/L, was noted. Lactime was a useful predictor of mortality in children undergoing repair or palliation of congenital cardiac defects under cardiopulmonary bypass. Initial and peak lactate levels had a poor positive predictive value for mortality. Lactime also was associated with the number of ventilator days and hospital days in those who survived [11].

III. Methods

In our study, we randomly selected a group of 91 patients. The patients were randomly selected in terms of age (Figure - 1), sex (male - 51.6% and 48.4% females), smoking habits (25.3% smokers vs 74.7% non smokers), co-morbities - HTN (11% hypertensive vs 89% normotensive), weight, economic and educational background, , ejection fraction and and primary diagnosis which was the indication for surgery involving the use of cardiopulmonary bypass. Serial pH, Lactate and PO2 values were recorded at- baseline, after intubation, after rewarming, after protamine, after shift in ICU and after 6/12/18 and 24 hours respectively. The data was drafted in a tabular fashion (Table - 1)and standard statistical methods were used for computation of results. Survival reported at the end of the study was 85.7% while 14.3% didn't survived.

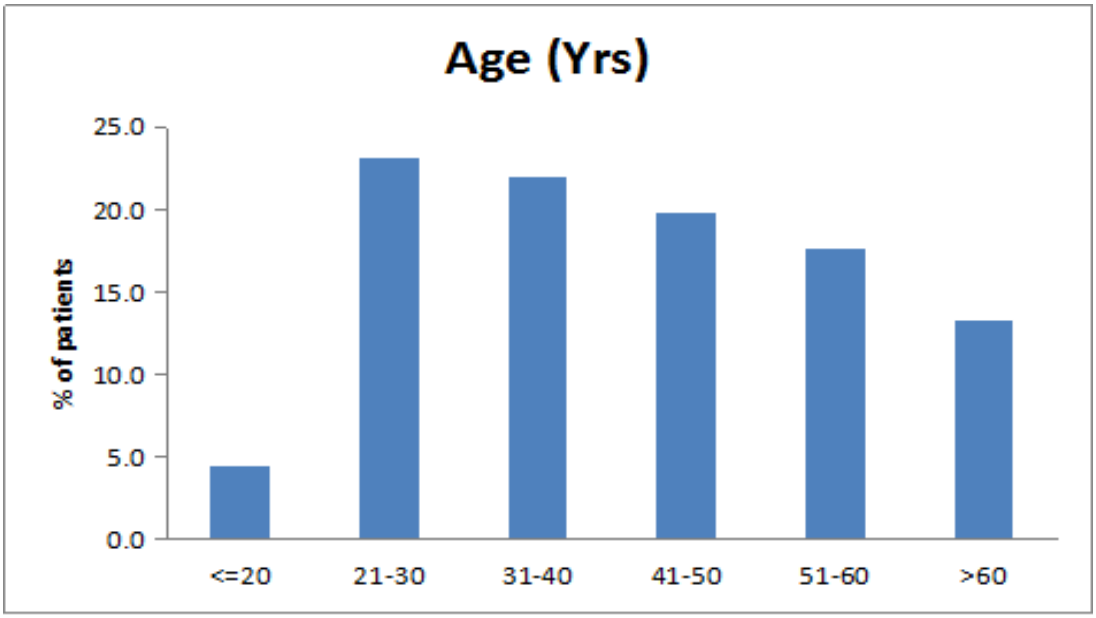


Figure - 1

	LACTATE (mean)			PO2 (mean)			pH (mean)		
	Survive	Mortality	p-value	Survive	Mortality	p-value	Survive	Mortality	p-value
BASELINE	1.32	4.62	.0001**	80.48	78.90	.626	7.38	7.22	.0001**
AFTER INTUBATION	1.44	5.31	.0001**	341.62	315.38	.422	7.37	7.26	.0001**
AFTER REWARMING	3.97	6.73	.0001**	435.53	379.81	.048	7.37	7.24	.0001**

AFTER PROTAMINE	4.82	7.80	.0001**	427.03	414.54	.699	7.37	7.23	.0001**
AFTER SHIFT IN ICU	5.23	7.81	.0001**	393.70	343.65	.100	7.36	7.23	.0001**
AFTER 6 HR	7.95	9.08	.583	358.48	345.27	.601	7.37	7.23	.0001**
AFTER 12 HR	5.56	7.73	.013	333.71	344.03	.729	7.37	7.20	.0001**
AFTER 18 HR	3.93	6.83	.0001**	299.44	301.27	.941	7.37	7.20	.0001**
AFTER 24 HR	2.73	7.26	.0001**	238.34	242.59	.865	7.38	7.22	.0001**

Table - 1

Serial charting of mean Lactate, PO2 and pH values of survived and not survived patients along with p-value computed for the same

IV. Results

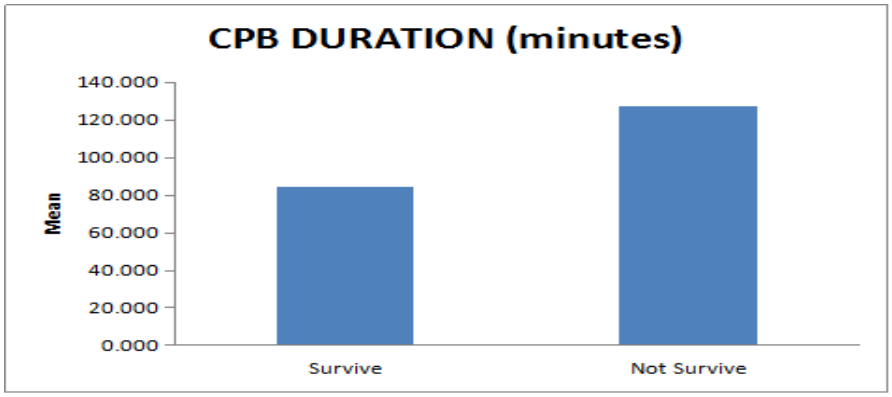
Standard Chi square test was used to evaluate the effect of the variables of age, sex, smoking and hypertension on survival and the statistical association were found to be inconclusive with p-values of 0.344, 0.104, 0.115 and 0.681 respectively.

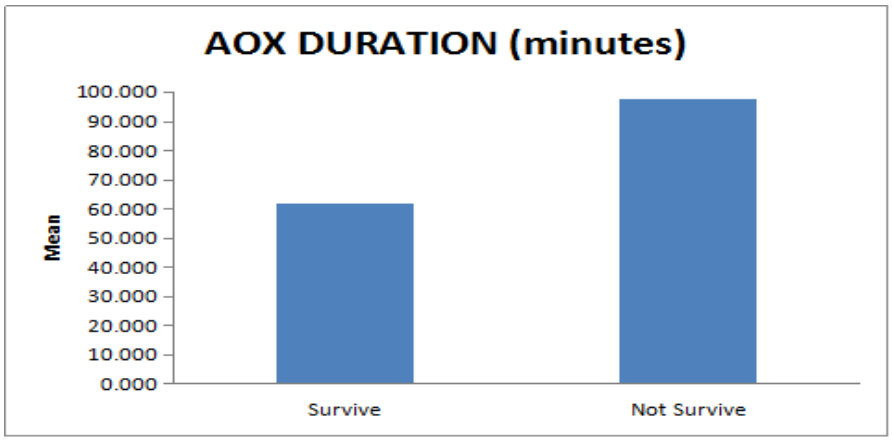
Analysis of table 1 -

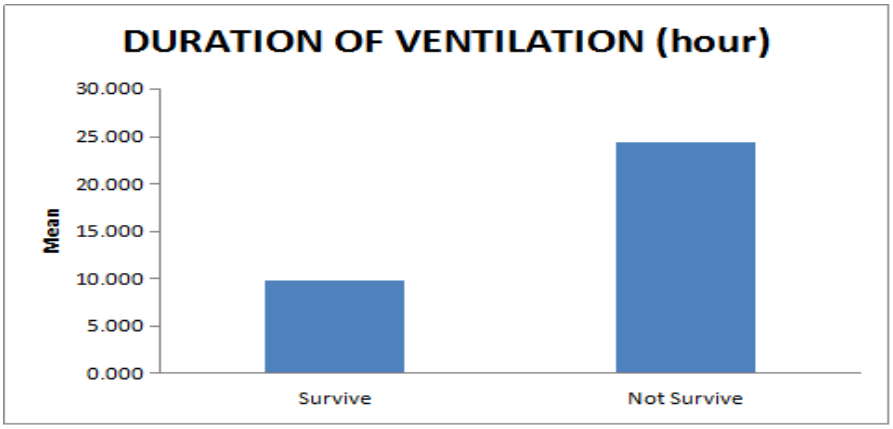
1. At each time slot we see that mean lactate values are higher and mean pH values are lower (acidotic) for the mortality group with mostly very high statistical significance.
2. Mean PO_2 values for the mortality group were lower than the survived group but statistically not significant.
3. A baseline pH of 7.22 vs 7.38 and lactate of 4.62 vs 1.32 mmol/l and the first ICU value of pH of 7.23 vs 7.36 and lactate of 7.81 vs 5.23 mmol/l in the mortality and survive group respectively are statistically significant (p-value = 0.001) markers of mortality.
4. A pH of 7.22 vs 7.38 and lactate of 7.26 vs 2.73 mmol/l at 24 hours post operatively in the mortality and survive group respectively are statistically significant (p-value = 0.001) markers of mortality.

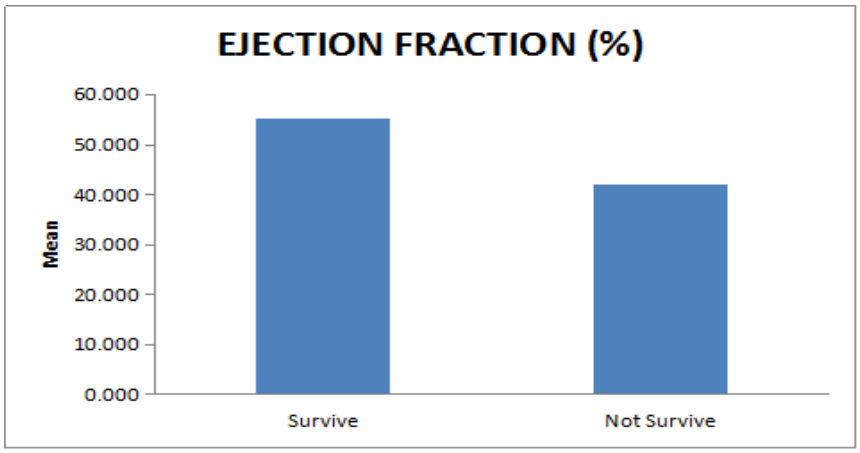
On T-test analysis, the co-relation of mortality was also established with -

1. Aortic cross clamp duration 97 minutes vs 62 minutes and total cardiopulmonary bypass duration time 127 minutes vs 84 minutes in mortality and survive groups respectively. The increased duration of aortic cross clamp time and CPB duration in mortality cases are both statistically significant (p-value = 0.001).
2. Requirement for ventilation in ICU in terms of mean duration were 24 hours vs 10 hours in mortality and survive groups respectively. The increased duration of post op ventilation time in mortality patients is statistically significant (p-value = 0.001).
3. Mean Ejection Fraction in mortality cases was low (mean 42%) as compared to mean 55% in survived cases. This association is statistically significant (p-value = 0.001).



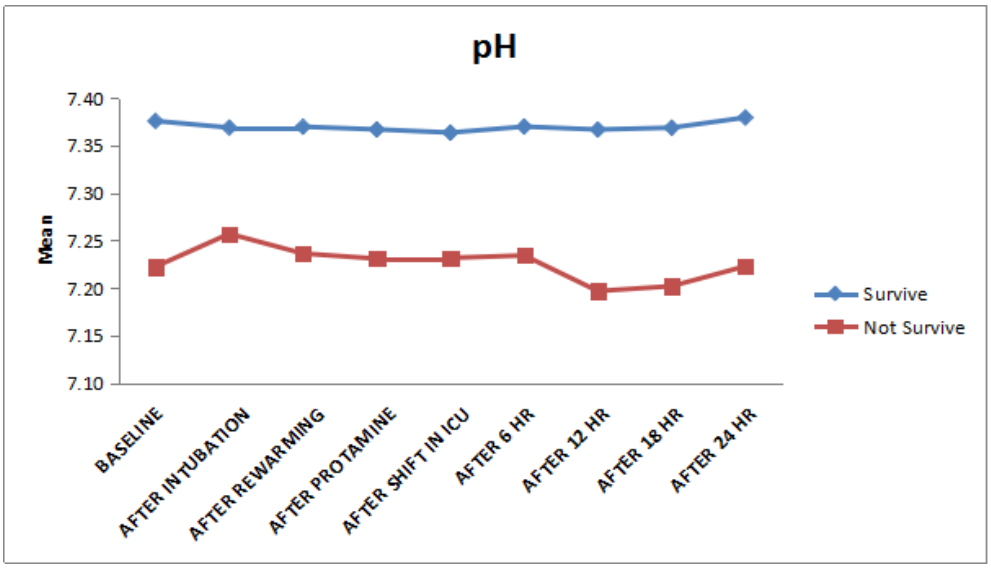


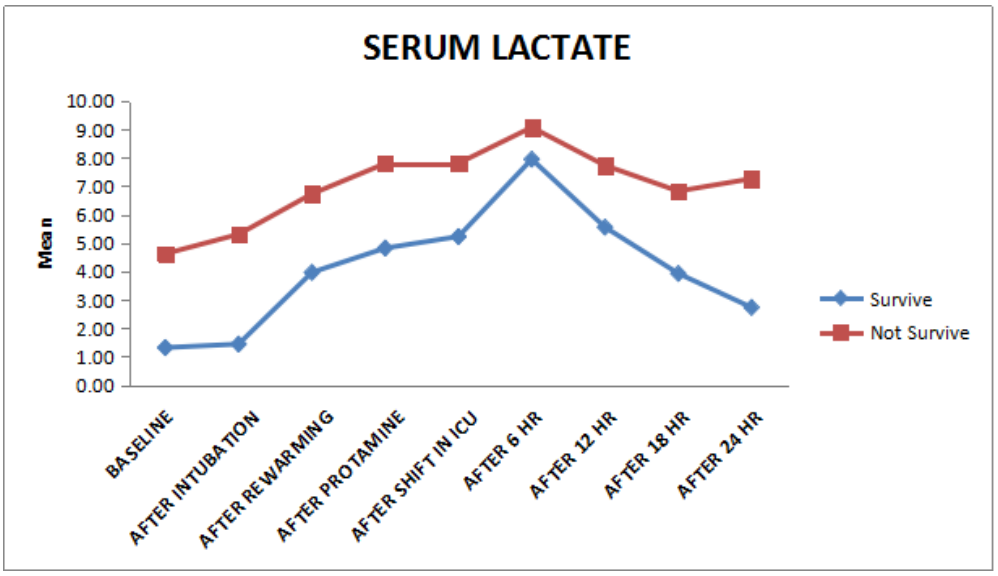




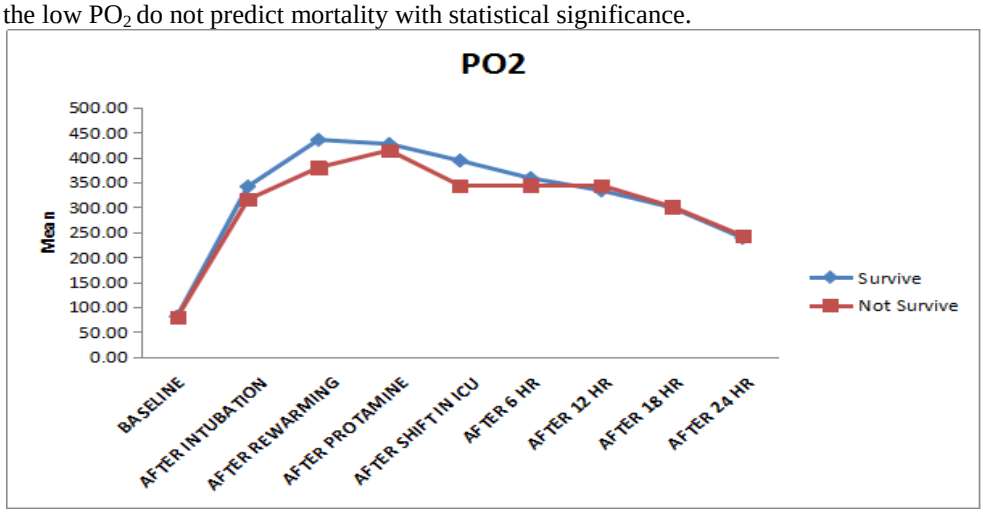
V. Discussion

To conclude we can say that in any of the time slots selected in our study a pH less than 7.22 and lactate more than 4.62 indicates towards mortality with statistical significance.





However, the low PO_2 do not predict mortality with statistical significance.



The increased duration of aortic cross clamp time, total CPB duration and post op ventilation and also low pre op ejection fraction have shown statistically significant association with mortality which is showing significant association with altered pH and lactate values.

Hence, we conclude adverse effect relationship of these parameters on blood gas profile which in turn affects mortality with statistical significance.

During surgery, the surgeon must keep aortic cross clamp time and bypass time minimal as they are both associated with mortality with statistical significance as are increased duration of post op ventilation in ICU and low pre op Ejection Fraction (mean 42%).

In a nutshell, Acidotic pH and Hyperlactatemia are strong predictors of mortality in patients undergoing open heart surgeries. Correction of these two blood gas parameters should be of paramount importance to safeguard the patient from a possible mortality. However, pO_2 values do not predict mortalities with significance and should be lower down in the correction sequence after pH and lactate values.

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