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Weaning from IABP after CABG Surgery: Impact of Serum Lactate Levels as an Early Predictor

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ABSTRACT

Background: Impaired cardiac performance is a frequent presentation after Coronary Artery Bypass Graft (CABG) surgery. Intra-Aortic Balloon Pump (IABP), as a mechanical support, is lifesaving in many cases of low cardiac output state. IABP is needed to be in place from a few hours to a few days. Weaning is usually done according to patients' hemodynamic response. Up to now, many studies have addressed the withdrawal methods, but few are related to predict the support time.

Objectives: This study aimed to evaluate whether high serum lactate levels are early predictors of IABP dependency after CABG surgery.

Patients and Methods: This prospective cohort study was performed on 843 patients who underwent CABG surgery from April 2009 to January 2014 in Pars hospital. Among these patients, 47 ones required IABP support and were all entered into our study. Arterial blood samples were collected by 2-hour intervals during the first 12 hours after the operation. Serum lactate levels were compared according to IABP dependency. The data were analyzed using chi-square, t-test, and correlation coefficient and $\alpha = 0.05$ was considered to be the significance level.

Results: Based on the results, 97.8% of the patients (n = 46) were successfully weaned from IABP support and 95.7% (n = 45) survived to discharge from the hospital. Two patients with persistent serum lactate levels > 15 mmol/L in the first 12 hours of IABP support had the worst prognosis. A significant association was found between the mean serum lactate levels ≥ 6 mmol/L in the first 12 hours after the surgery and ≥ 48 hours dependency on IABP (P = 0.030).

Conclusions: Prediction of IABP dependency may be possible by measuring serum lactate levels in the first 12 hours after CABG surgery.

►*Implication for health policy/practice/research/medical education:*
This study may help physicians in early prediction of outcomes in post CABG low cardiac output states.

1. Background

Low cardiac output syndrome is a serious and life-threatening state after cardiac surgery, which needs proper and effective steps to manage impaired cardiac function (1). Intra-Aortic Balloon Pump (IABP) is the most commonly used temporary mechanical support device perioperatively (2). IABP predominantly reduces Left Ventricular (LV) afterload. It also improves myocardial oxygen supply/demand ratio and LV diastolic function (1-3). CABG in the setting of severe LV dysfunction, failure to wean from Cardiopulmonary Bypass (CPB), and postoperative low cardiac output syndrome have been suggested as the perioperative indications to use IABP as a bridging device for cardiac transplant and perioperative diastolic dysfunction (2, 4-6). Up to now, many studies have addressed the indications, complications, and perioperative

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prognostic factors for in-hospital mortality in the CABG patients requiring IABP (7-11). However, a few papers have referred to weaning protocols and withdrawal indications of IABP (12-14). We believe that prolonged balloon support is an important issue and early weaning the individuals who need longer support is of great importance, as well.

Elevated serum lactate levels and lactic acidosis after cardiac surgery is an indicator of systemic hypo-perfusion and tissue hypoxia (15-17). Persistent anaerobic metabolism is an important contributor to inadequate postoperative ventricular function (14, 16, 17). It has also been shown that early post cardiac surgery hyperlactatemia is an independent risk factor for increase of morbidity and mortality in adults (16). Additionally, two recent multicenter trials have suggested that measuring lactate level, as an early treatment guidance might improve the clinical outcome in critically ill patients (18).

2. Objectives

The present study aims to determine whether high serum lactate levels early after CABG surgery are predictors of IABP dependency.

3. Patients and Methods

The present prospective cohort study was conducted on 47 patients with IABP out of the 843 ones (5.57%) who underwent isolated CABG surgery at our hospital from April 2009 to January 2014. All the 47 patients had low cardiac output syndrome after CABG surgery. Routine cardiopulmonary bypass and myocardial protection techniques were used. Additionally, cardioplegia was delivered both via the aortic root and the coronary sinus.

The clinical data gathered in this study included age, sex, diabetes mellitus, peripheral vascular disease, urgent operations (including critical left main lesions, failed Percutaneous Coronary Intervention (PCI), and intractable angina pectoris), history of recent acute Myocardial Infarction (MI) (< 21 d), and preoperative ejection fraction. Moreover, the patients were risk-stratified using the additive Euro SCORE. The intraoperative variables also consisted of aortic cross clamp time, CPB time, and number of grafts. Finally, the postoperative variables were intubation time, IABP time, arterial blood gas data, serum lactate levels every 2 hours during the first 12 hours after the operation, length of ICU stay, and final outcome (death or discharge). Successful weaning was defined as stable hemodynamic state after removal of the IABP for at least 48 hours. However, the complications related to IABP were not included in this study. The patients were divided into two groups according to their dependency on IABP; group A (n = 27) who needed < 48 hours and group B (n = 20) who needed ≥ 48 hours of IABP support.

3.1. Statistical Analysis

The parameters expected to be predictive of IABP dependency were selected and analyzed. Such parameters had to occur within the first 12 hours of IABP support after cardiac surgery. Chi-square test with Yates correction factors for small numbers was used. Additionally, continuous variables were analyzed using two-sample t-test. All the statistical analyses were performed using the SPSS statistical software, version 19 and P values less than 0.05 were considered to be statistically significant.

3.2. Statistical Analysis

Quantitative variables were presented as mean ± standard deviation, while qualitative ones were expressed as percentage. All the statistical analyses were performed using the SPSS statistical software, version 18 (Chicago, USA). Frequency of biochemical, environmental, and personal risk factors was statistically described in the case and control populations. Student's T-test was used to assess the significance of differences between the case and control groups regarding gene expression. Moreover, Chi-square test was used to compare the qualitative variables, and ANOVA was utilized to examine the possible changes in ANIRL gene expression levels in the presence of each genotype. P values < 0.05 were considered as statistically significant.

4. Results

The mean age of our 47 patients was 63 ± 10.9 years. Besides, 36 patients (76.6%) were male and 11 ones (23.4%) were female. Demographic, operative, and postoperative variables of the two study groups were analyzed and compared using univariate analysis (Table 1). Accordingly, 15 patients (31.9%) had the history of recent (< 21 d) MI and 8 ones (17.02%) were operated urgently. They stayed in ICU between 3 and 39 days, with the mean of 4.6 ± 1.05 days.

According to Euro SCORE preoperative risk assessment, the mean mortality rate of our patients was 4.91% (min: 1, max: 11). It should be mentioned that surgical, anesthetic, CPB, and IABP techniques were standard throughout the study. The mean CPB time was 83.1 minutes (range: 35 - 152 min) and the mean aortic cross-clamp time was 39.4 minutes (range: 16 - 83 min). In addition, the mean intubation time was 18 ± 16.8 hours. Statistical analyses were performed to compare different preoperative variables between the two groups of patients (Table 2). According to the results, 45 patients (95.7%) were successfully weaned from the IABP and discharged from the hospital. None of the patients required recommencement of IABP support after weaning. In hospital mortality was 4.3% (n = 2) and both groups had persistent serum lactate levels > 15 mmol/L in the first 12 hours of ICU stay. Yet, the patients who needed more than 48 hours of IABP support had higher mean serum lactate levels during the first 12 hours of ICU stay (≥ 6 mmol/L, P = 0.003) (Figure 1). Also, the patients who needed more than 1 inotrope or ≥ 0.07 μg/kg/min of epinephrine or norepinephrine in their first 12 hours of ICU stay were dependent on IABP for ≥ 48 hours (P < 0.05) (Table 3).

The results showed a significant adverse relationship between the mean serum lactate level and mean arterial blood pressure in first few hours after surgery, except for on arrival to the ICU (Table 4).

5. Discussion

The role of mechanical circulatory supports in postcardiotomy low cardiac output states has been well established (5-8). However, most studies have focused on the predictors of IABP failure or mortality, while selection

Table 1. Univariate Analysis of Pre- and Intra-Operative Variables

Patients' Characteristics	Definition	IABP < 48 h	IABP ≥ 48 h	Total	P value
Age	< 50	5	21	7	0.41
	≥ 50	22	8	40	
Sex	Male	20	16	36	0.63
	Female	7	4	11	
Diabetes mellitus	Yes	11	9	20	0.77
	No	16	1	27	
PVD	+	4	3	7	0.98
	-	23	1	40	
Emergent operation	+	4	4	8	0.64
	-	23	1	39	
History of recent AMI (< 21 d)	+	8	7	15	0.69
	-	19	1	32	
EF (%)	< 40	21	19	40	0.10
	≥ 40	6	1	7	
CPB time (min)	< 60	11	6	17	0.25
	61 - 90	10	5	15	
	> 91	6	9	15	
Aortic cross clamp Time (min)	< 30	11	9	20	0.95
	31 - 90	12	8	20	
	> 91	4	3	7	

Abbreviations: IABP, intraaortic balloon pump; PVD, peripheral vascular disease; AMI, acute myocardial infarction; EF, ejection fraction; CPB, cardiopulmonary bypass

Table 2. Comparison of Postoperative ICU Variables

Variables	Definitions	IABP < 48 h	IABP ≥ 48 h	Lac < 6	Lac ≥ 6 mg/dL	Total	P value
Serum Lactate	< 6 mmol/L	25	11	-	-	36	0.030
	≥ 6 mmol/L	2	9	-	-	11	
ICU stay	< 5	26	12	*	-	38	0.020
	> 5	1	8	-	-	9	
Inotropes	Low	27	0	-	-	27	< 0.001
	High	0	20	-	-	20	
Inotropes	Low	-	-	25	2	27	0.003
	High	-	-	11	9	20	

of the patients who may benefit form timely implantation of a Ventricular Assist Device (VAD) before development of septicemia or multiorgan failure is important, as well (7, 9-11). Harald Haussmann et al. created an IABP score to predict survival based on measurement of hemodynamic parameters 1 hour after commencement of counter pulsation (9). They emphasized four parameters to predict survival or death, including adrenaline dose > 0.5 µg/kg/min, diuresis < 100 mL/h, SVO2 < 60%, and left atrial pressure > 15 mm Hg. They reported a mortality rate of 34% in their IABP patients. In another study, Karimi et al. discussed early mortality predictors, including left main lesion, diabetes mellitus, postoperative renal failure, and cardiac arrest, in CABG patients on IABP (10, 11). Their patients had an in-hospital mortality rate of 17.3%.

Andrew R. Davies et al. also tried to identify early, readily available prognostic markers for patients receiving IABP support (7). They concluded that serum lactate levels > 10 mmol/L in the first 8 hours of IABP support predicted a 100% mortality. Base deficit > 10 mmol/L, mean arterial pressure < 60 mmHg, urine output < 30 mL/h for 2 hours, and epinephrine or norepinephrine dose > 10 µg/min were other highly prognostic markers. Besides, they found a 46% hospital survival rate in the cardiac surgical patients receiving IABP support. However, we did not find the previously identified prognostic variables, such as acute myocardial infarction, emergent operation, preoperative LV ejection fraction, prolonged aortic cross-clamp time (8, 9), prolonged CPB time (7, 8), and age (9), as significant negative predictive markers in our CABG patients. Additionally, 95.75% of our patients survived to hospital discharge, and no major complications of IABP were reported.

Overall, IABP mortality and complications seem to be more reasonable in the current study. Although the sample size of this study is a limiting factor to perform multivariate analysis, it represents a 5 - year experience in our hospital. The results indicated that in case of mean serum lactate levels > 6 mmol/L in the first 12 hours of IABP commencement, weaning process might not be expected before 48 hours. Furthermore, the ability to predict dependency on IABP in early phases results in easier decision making to use LV assist devices in low cardiac output states after CABG surgery.

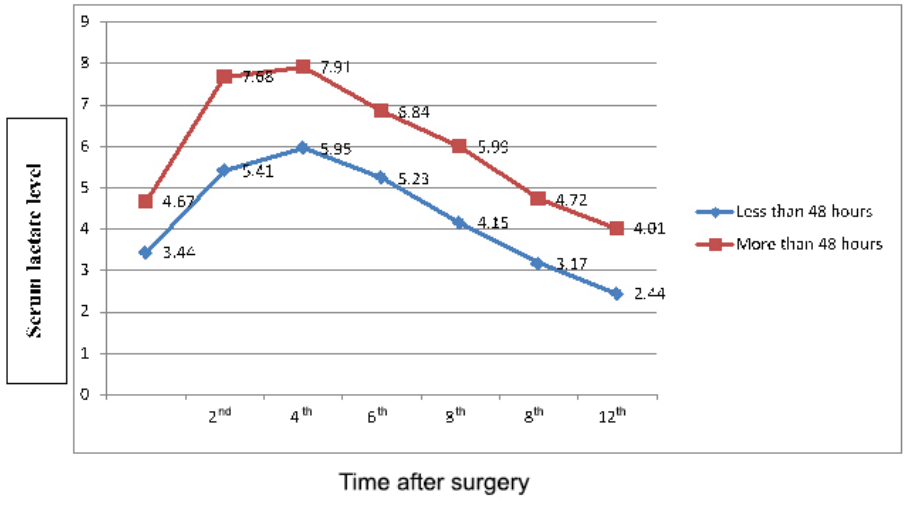

Figure 1. Comparison of Mean Serum Lactate Levels in the Two Groups of Patients on IABP

Table 3. Comparison of the Mean Serum Lactate Levels and Mean Blood Pressures at ICU

Time of Arrival at ICU (h)	Mean Serum Lactate Level (mmol/L)	Mean Blood Pressure (mmHg)
0	3.9	77.4
2	6.4	78.9
4	6.8	83.4
6	5.9	85.4
8	4.9	85.8
10	3.8	89.1
12	3.1	89.0

Table 4. The Association between the Mean Serum Lactate Levels and Mean Arterial Blood Pressures in the First Few Hours at ICU

	Time (h)	Correlation Coefficient (r)	P value
Mean serum lactate levels and mean arterial blood pressures	0	0.19	0.900
	2	-0.37	0.010
	4	-0.5	< 0.001
	6	-0.42	0.003
	8	-0.43	0.003
	10	-0.5	< 0.001
	12	-0.45	0.002

5.1. Conclusions

There are many hemodynamic and physiologic criteria, which should be kept in mind before deciding to remove IABP. The weaning time may be simply predicted by measuring serum lactate levels early after CABG surgery.

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Authors' Contribution

Daryoosh Javidi: Idea, surgeon conductor, consults, Marjan Ladan: data collection, manuscript preparation, manuscript revise, data interpretation; Amin Vahdani: data collection, manuscript preparation; Yousef Alimohamadi: data analysis, manuscript preparation; Azar Nazar: data collection, manuscript preparation; Ali Zarin Ara: data analysis, manuscript preparation

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