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Mohamed Said Darwish, Saad Mahmoud Ammar, Yasser Hosny Abdel Rahman, and Mahmoud Helmy Alsayed

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Comparison between Intra-Aortic Balloon Pump and Levosimendan as Treatment Modalities for Cardiogenic Shock Post Cardiac Surgery

Mohamed Said Darwish[1], Saad Mahmoud Ammar[1], Yasser Hosny Abdel Rahman[1], and Mahmoud Helmy Alsayed[1*]

[1]Cardiology Department, Faculty of Medicine, Benha University, Postal code 13518, Egypt.

[*]Corresponding Author's Email: mahmoudhelmy193@gmail.com

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Abstract

Purpose: Post cardiac surgery cardiogenic shock is one of the major life threatening complications of open heart surgeries. Two modalities are widely used to improve the cardiac output and overcome the acute postoperative complication beside other conventional treatment including mechanical ventilator, inotropes and vasopressors. Those modalities are levosimendan and Intra-aortic balloon pump. The purpose of this study is to investigate the prognosis of levosimendan vs IABP in patients who developed cardiogenic shock post cardiac surgery.

Methodology: This was a prospective observational study conducted as national heart institute, Egypt on 50 patients who developed cardiogenic shock post cardiac surgery and managed by either levosimendan or Intra-aortic balloon Pump (IABP) beside other conventional therapies. Patients were then divided into two groups according to the modality used. Group I: patients who were managed by levosimendan and group II: patients who were managed by IABP. Two groups were then compared according to baseline preoperative characteristics and in-hospital course and one month follow up post discharge echocardiography.

Findings: No significant difference regarding between in-hospital mortality between levosimendan, 44% and IABP, 52% (P value 0.5). Levosimendan was associated with significantly shorter ICU stay, 5.56±2.85 compared to IABP, 8±3.34 days (P value 0.02). Levosimendan seems to be a better option than IABP or at least equivalent to it in postoperative cardiogenic shock.

Recommendation: Levosimendan is an alternative cost effective modality for patients with post-operative low cardiac output syndrome especially when IABP isn't available.

Keywords: *Cardiogenic shock, levosimendan, intra-aortic balloon pump.*

INTRODUCTION

Postoperative cardiogenic shock is seen in 2% to 6% of patients who undergo cardiac surgery [1]. It represents a spectrum of hemodynamic deficits in patients with cardiovascular disease. It describe state in which cardiac output is insufficient to provide adequate tissue perfusion [2]. Levosimendan is an inotrope used for treatment of cardiogenic shock. Among its mechanisms of action, it sensitizes the cardiac troponin C to calcium in cardiac muscle. Due to its pharmacological actions, levosimendan improves cardiac mechanical efficiency without increasing myocardial oxygen consumption [3].

Intra-aortic balloon pump (IABP) counter pulsation provides hemodynamic support and/or control of ischemia both before and after surgery. In contrast to the inotropic drugs, the IABP provides physiologic assistance to the failing heart by decreasing myocardial oxygen demand and improving coronary perfusion [4]. IABP has been the most commonly used mechanical assist circulatory device in many postcardiotomy low output disorders for decades. Mechanism of IABP is based on its inflation in time of the diastolic pressure in the aortic root resulting increase in the blood and oxygen amount of the coronary artery and its deflation in left ventricular afterload during the systolic period [5].

PATIENTS AND METHODS

This was single center observational prospective study that was conducted at open heart surgical ICU in the National Heart Institute from January 2021 to July 2021 and included 50 patients with post cardiac surgery cardiogenic shock which was managed by either levosimendan or IABP. They were divided into two groups, group I: 25 patients who were managed by levosimendan and group II: 25 patients who were managed by IABP. The study was approved by ethical committee in our hospital.

Inclusion Criteria

Patients aged group > 18 years underwent cardiac surgery, coronary artery bypass grafts (CABG) or valve surgery, and developed postoperative cardiogenic shock defined as frank or relative hypotension defined as systolic blood pressure below 80 or 90 mm Hg or reduction of mean arterial pressure (MAP) of 30 mmHg, inadequate cardiac index defined as less than 1.8 L/min/m^2 without mechanical or pharmacological support, elevated end-diastolic pressures on the right (>10 to 15 mm Hg) and evidence of end-organ hypo perfusion, which manifests as altered mental status, decreased urine output, acute kidney injury, cold or mottled extremities, acute liver injury or lactic acidosis [6].

Exclusion Criteria

Patients with pre-operative renal impairment defined as estimated glomerular filtration rate < 60 mL/min per 1.73 m2) [7], previous MI within the last two months, previous cardiac surgery and preoperative EF <35%

All patients included in the study were subjected to the following:

1-History review: History of hypertension, Diabetes mellitus, smoking and ischemic heart disease ad kind of surgery.

2-Preoperative lab review: with emphasis on serum creatinine to exclude patients with GFR < 60mL/min.

3-Preoperative echo review: with emphasis on EF.

4-Postoperative follow up: Postoperative hospital course and all routine critical care monitoring and labs will be checked daily with emphasis on continuous electrocardiography (ECG) monitoring throughout hospitalization in ICU and recording of heart rate, continuous invasive arterial blood pressure monitoring through arterial line connected to the monitor to and record systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial blood pressure (MAP) and serum lactate at time points; 0 (baseline post-operative at diagnosis of shock), after 12 hours, after 24 hours and after 2 days.

Daily EF measurement at day 1,2 and 3 postoperative was done by bedside transthoracic echo using Philips machine with 2.5 MHz transducer. Two-dimensional guided M-Mode echocardiograms were obtained just below the mitral valve leaflets at the chordal level. EF was then calculated by obtaining Left ventricular internal dimensions in systole and diastole and calculation of EDV and ESV then calculation of SV and calculating the percentage of SV to EDV [8]. Follow-up echocardiography after one month of hospital discharge will be done for all survived patients with emphasis on EF.

Follow-up prognosis during hospital stay was done with emphasis on length of ICU stay and in-hospital mortality with differentiation between cardiovascular (CV) causes like myocardial infarction, heart failure or arrhythmia and all-cause mortality including cardiovascular and other causes like septic shock, pneumonia, bleeding among others.

Statistical Analysis

Data were coded and entered using the statistical package for the Social Sciences (SPSS) version 28 (IBM Corp., Armonk, NY, USA). Data was summarized using mean and standard deviation for quantitative variables and frequencies (number of cases) and relative frequencies (percentages) for categorical variables. Comparisons between groups were done using unpaired t test in normally distributed quantitative variables while non-parametric Mann-Whitney test was used for non-normally distributed quantitative variables [9] .For comparing categorical data, Chi square ($\chi 2$) test was performed. Exact test was used instead when the expected frequency is less than 5 [10]**.** P-values less than 0.05 were considered as statistically significant**.**

RESULTS

There was no statistical difference between both groups regarding all baseline demographic and pre-operative clinical data presence of ischemic heart disease (IHD), 36% in levosimendan group vs 72% in IABP group P value 0.01 and kind of surgery where 36% of patients underwent CABG and 64% underwent isolated valve surgery in group I compared to 68% underwent CABG and 32% underwent isolated valve surgery in group II, P value = 0.02 as shown in table 1 and figure 1.

Table 1: Baseline demographic and clinical characteristics of both groups

	Levosimendan group I		IABP group II (n=25)		
Variable	**Count (%)**	**Mean±SD**	**Count (%)**	**Mean±SD**	**P**
Age (years)		47.1±12.45		54±15.11	0.102
Sex					0.152
Male	12 (48%)		17 (68%)		
female	13 (52%)		8 (32%)		
Smoker	9 (36%)		10 (40%)		0.771

Hypertension	12 (48%)		16 (64%)		0.254
Diabetes Mellitus	8 (32%)		10 (40%)		0.556
IHD	9 (36%)		18 (72%)		**0.011***
LVEF (%)		53±12.59		52.28±11.39	0.833
CABG surgery	9 (36%)		17 (68%)		
Valve surgery	16 (64%)		8 (32%)		
MVR	10		6		**0.024***
AVR	3		2		
Mitral repair	3		0		

** Significant, IABP; intra-aortic balloon pump, SD; standard deviation, IHD; ischemic heart disease, LVEF; left ventricular ejection fraction, CABG; coronary artery bypass graft, MVR; mitral valve replacement, AVR; aortic valve replacement*

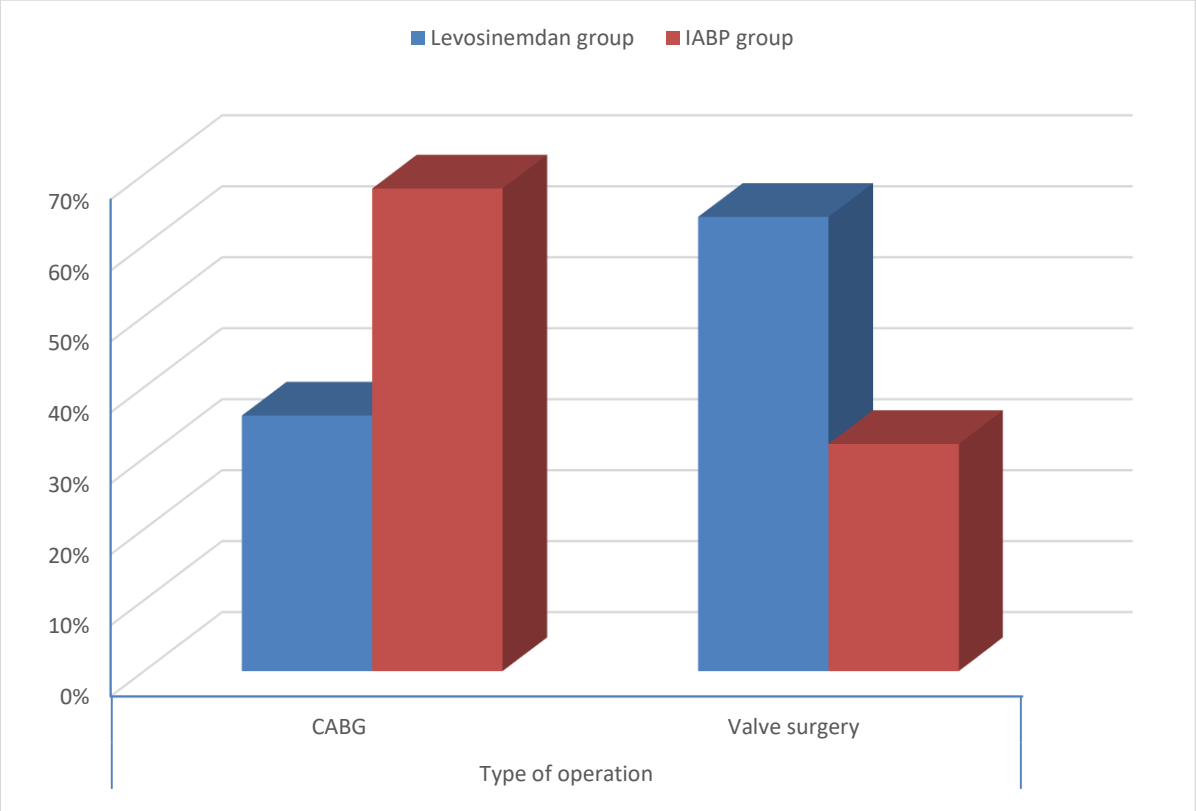

Figure 1: The percentage of each kind of surgeries in both groups

IABP; intra-aortic balloon pump, CABG; coronary artery bypass graft

Hemodynamic variables, heart rate and mean arterial pressure and serum lactate at postoperative time points 0, 12, 24 and 48 hours showed no statistical significance except for time 0 mean arterial pressure where it was lower in IABP group, 64.16±7.47 compared to 67.96±4.21 mmHg in levosimendan group, P value = 003 as shown in table 2 and figures 2, 3, and 4.

Table 2: The heart rate in both groups at time points

	Levosimendan group I	IABP group II	
Variable	**Mean±SD**	**Mean±SD**	**P value**
Time 0			
HR (bpm)	127.36±8.27	128.28±6.27	0.660
MAP(mmHg)	67.96±4.21	64.16±7.47	**0.033***
Lactate (mmol/l)	10.60±1.76	10.96±2.13	0.518
After 12 hours			
HR (bpm)	124.20±8.35	121.60±8.21	0.272
MAP(mmHg)	76.40±4.40	76.72±6.54	0.840
Lactate (mmol/l)	8.02±2.97	8.70±2.51	0.386
After 24 hours			
HR (bpm)	118.56±13.60	114.56±11.06	0.260
MAP(mmHg)	80.60±10.10	81.40±7.95	0.757
Lactate (mmol/l)	5.64±4.62	5.14±3.57	0.569
After 2 days			
HR (bpm)	105.00±20.87	106.16±19.70	0.841
MAP(mmHg)	80.40±17.87	83.12±16.01	0.573
Lactate (mmol/l)	5.73±5.14	4.95±3.98	0.922

** Significant, IABP; intra-aortic balloon pump, SD; standard deviation, HR; heart rate, bpm; beats per minute, MAP; Mean arterial pressure, mmol/l; millimoles per one litre*

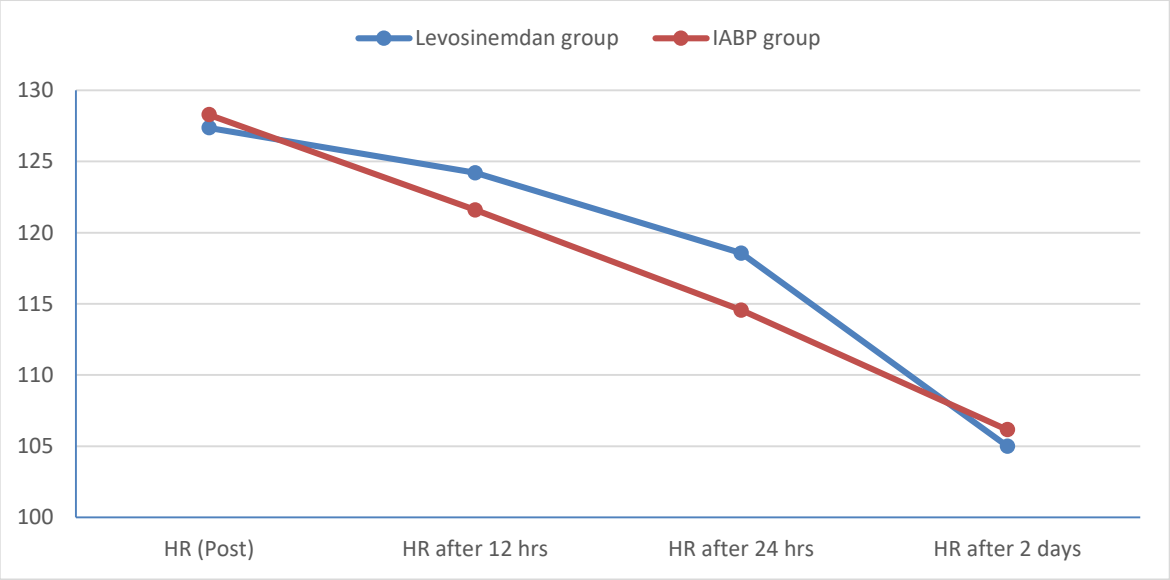

Figure 2: The heart rate in both groups at time points

IABP; intra-aortic balloon pump, HR; heart rate

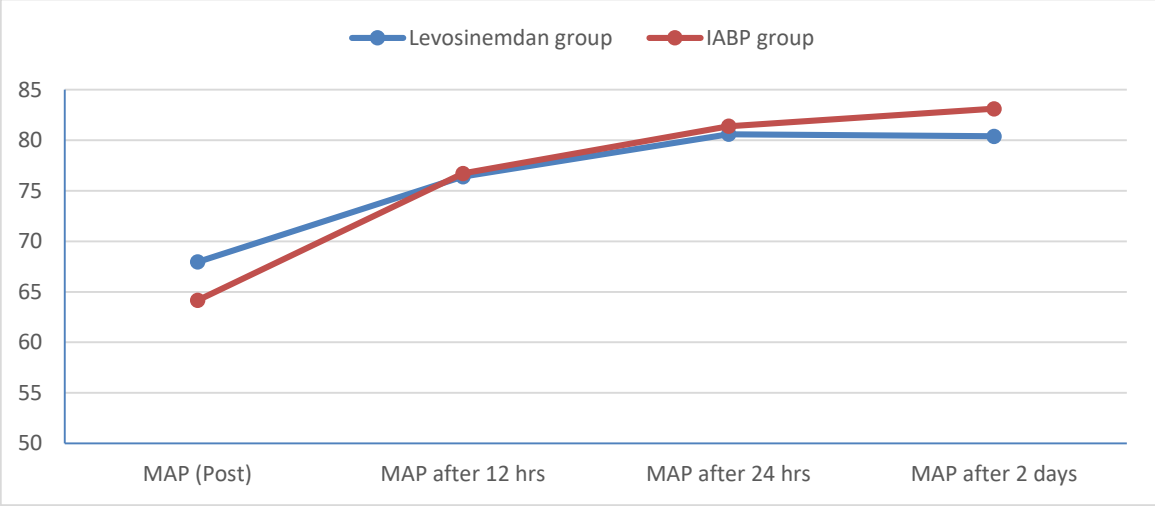

Figure 3: Mean arterial pressure in both groups at time points

IABP; intra-aortic balloon pump, MAP; mean arterial pressure

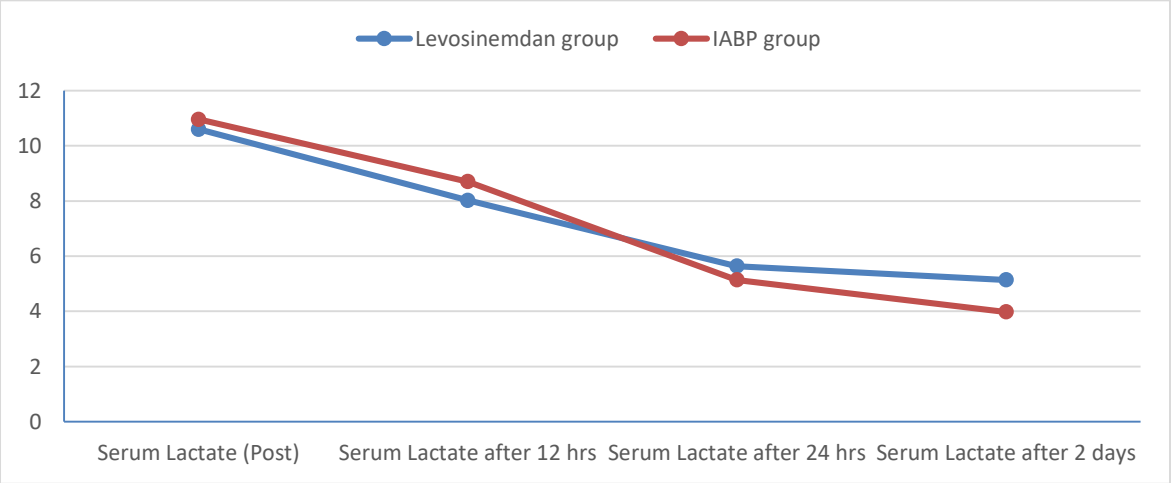

Figure 4: Serum lactate in both groups at time points

IABP; intra-aortic balloon pump

Postoperative Left ventricular ejection fraction (LVEF) measurements at day 0, 1, 2, 3 and after one month weren't statistically significant between both groups.

Table 3: LVEF in both groups at time points

	Levosimendan group I	IABP group II	
Variable	**Mean±SD**	**Mean±SD**	**P value**
LVEF (Post) (%)	24.72±4.27	26.40±4.86	0.200
LVEF at day 1 (%)	27.08±5.42	29.16±5.71	0.193
LVEF at day 2 (%)	28.52±6.91	30.52±7.44	0.330
LVEF at day 3 (%)	30.96±8.73	32.28±8.58	0.599
EF after one month (%)	48.71±7.06	46.25±8.01	0.413

IABP; intra-aortic balloon pump, SD; standard deviation, LVEF; left ventricular ejection fraction

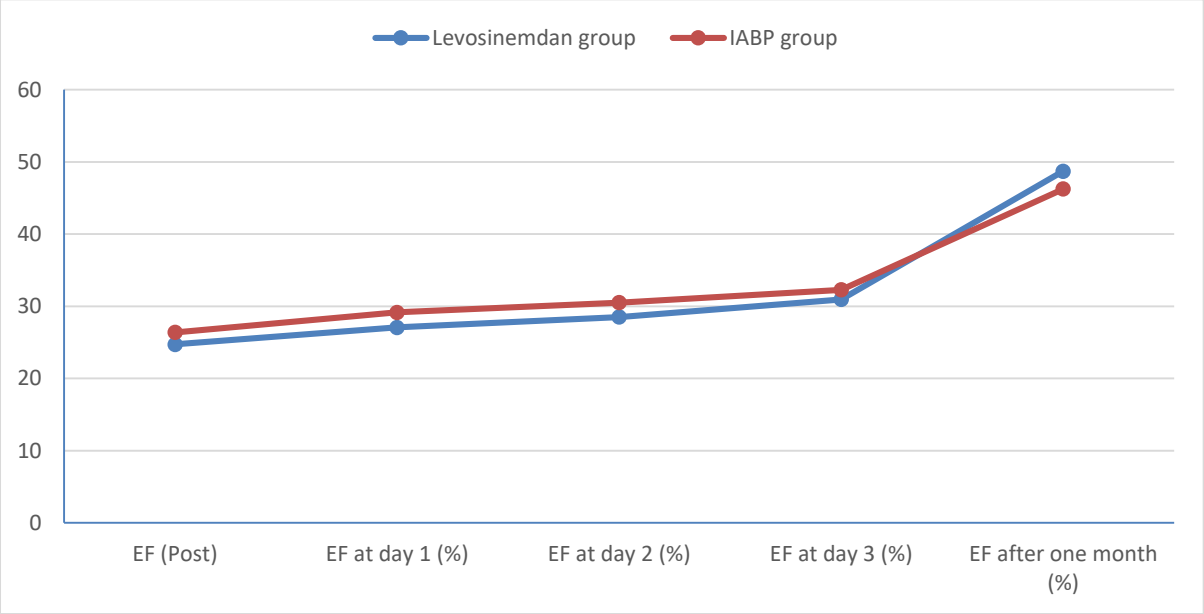

Figure 5: LVEF in both groups at time points

IABP; intra-aortic balloon pump, EF; ejection fraction

Regarding all cause in-hospital mortality either cardiac or non-cardiac causes, Cardiac causes are cardiogenic shock, myocardial infarction, heart failure or arrhythmia and non-cardiac causes are sepsis, bleeding, chest infection or stroke. 44 % of patients in levosimendan group died during hospital stay compared to 52% in IABP group, but this wasn't statistically significant (P value = 0.57). As regard to cardiovascular (CV) mortality 36 % of patients in levosimendan group died due to cardiac causes compared to 40 % in IABP with no statistical significance (P value = 0.77) as shown in table 4.

As regard patients who underwent CABG operation, all cause in-hospital mortality was 47.1% in the IABP group and 55.6% in levosimendan group. This wasn't statistically significant P value was (1). The cardiovascular mortality was 35.3% in the IABP group and 44.4% in levosimendan group and this wasn't statistically significant as P value was (0.69) as shown in table 4.

As regard patients who underwent valve surgery operation, all cause in-hospital mortality was 62.5% in the IABP group and 37.5% in levosimendan group. But this wasn't statistically significant as P value was (0.39). The cardiovascular mortality was 50% in the IABP group and 31.3% in levosimendan group and this wasn't statistically significant as P value was (0.41). Regarding Mitral valve replacement, there was 45% mortality in levosimendan group compared to 62.5% mortality in IABP with no statistical significance P value was 0.76. Regarding Aortic valve replacement, there was 50% mortality in levosimendan group compared to 66% mortality in IABP with no statistical significance P value was 0.83. Regarding mitral valve repair there was no mortality in levosimendan group and no case studied with IABP. So, there was no significance as shown in table 4.

Table 4: Prognosis of patients in both groups during hospital stay

	Levosimendan group I		IABP group II		
Variable	**Count**	**%**	**Count**	**%**	**P**
In hospital Death	11	44.0%	13	52.0%	0.571
CV Mortality	9	36.0%	10	40.0%	0.771
CABG					
In hospital Death	5	55.6%	8	47.1%	1
CV Mortality	4	44.4%	6	35.3%	0.692
Valve surgery					
In hospital Death	6	37.5%	5	62.5%	0.390
MVR	5	45%	5	60%	0.76
AVR	1	50%	2	66%	0.83
Mitral repair	0	0%	0	0%	---
CV Mortality	5	31.3%	4	50.0%	0.412

IABP; intra-aortic balloon pump, CV; cardiovascular, CABG; coronary artery bypass graft, MVR; Mitral valve replacement, AVR; Aortic valve replacement

As regard to length of ICU stay, levosimendan showed better results by shorter ICU stay in days with statistical significance (P value = 0.02). The mean days was 6.16±2.88 in levosimendan group compared to 8.32±3.72 days in IABP group. For CABG patients, the length of ICU stay was 7.22±2.77 days in levosimendan group compared to 8.47±3.97 days in IABP group and this wasn't statically significant (P value = 0.42). For isolated valve surgery patients the length of ICU stay was 5.56±2.85 days in levosimendan group compared to 8±3.34 days in IABP group and this statistically borderline significant (P value = 0.05) as shown in table 5 and figure 6.

Table 5: Length of ICU stay in both groups

	Levosimendan group I	IABP group II	
Length of ICU stay	**Mean±SD**	**Mean±SD**	**P value**
All surgeries (days)	6.16±2.88	8.32±3.72	**0.023***
CABG (days)	7.22±2.77	8.47±3.97	0.426
Valve surgery (days)	5.56±2.85	8.00±3.34	0.052

** Significant, IABP; intra-aortic balloon pump, SD; standard deviation, ICU; intensive care unit, CABG; coronary artery bypass graft*

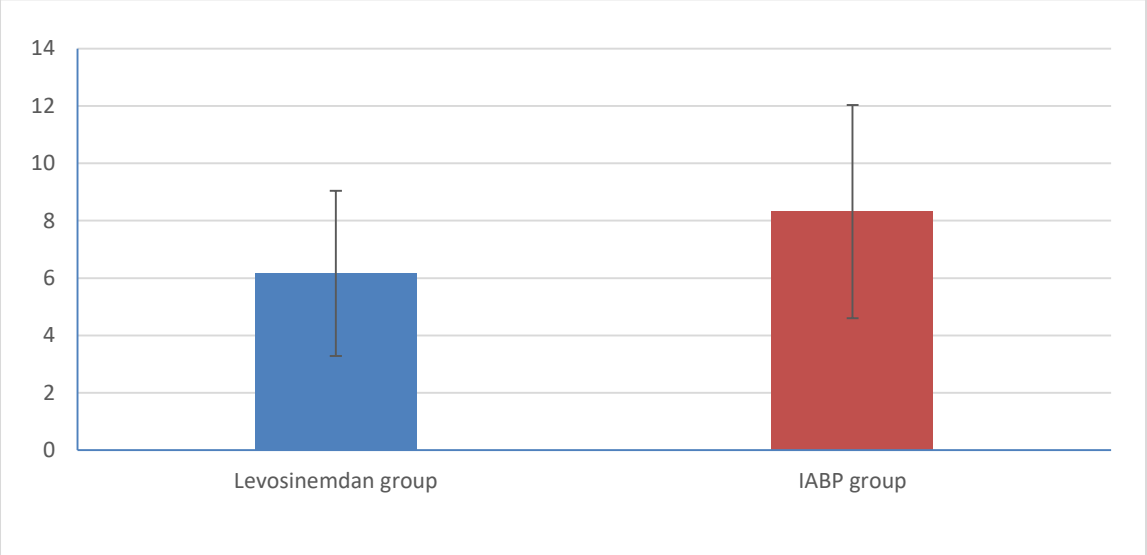

Figure 6: Length of ICU stay in both groups

IABP; intra-aortic balloon pump, ICU; intensive care unit, CABG; coronary artery bypass graft

Regarding correlation between demographic, preoperative clinical data, length of ICU stay and postoperative LVEF with in hospital mortality, the mean age for patients who died during their hospital stay was significantly higher than mean age of survivors, 55.5±13.5 and 45±12.6 years, respectively P value was (0.007). At time 0 post-operative, the mean LVEF was 23.67±4.50 % in deaths compared to 27.31±4.05 % in survivors P value 0.004. At day 1 post-operative, the mean LVEF was 25.42±5.12 % in deaths compared to 30.62±4.91 % in survivors P value 0.001. At day 2 post-operative, the mean LVEF was 25.63±5.12 % in deaths compared to 33.12±4.73 % in survivors P value <0.001. At day 3 post-operative, the mean LVEF was 26.05±8.77 % in deaths compared to 36.38±4.76 % in survivors with P value <0.001. All others weren't significant Figure 6: Length of ICU stay in both groups as shown in table 6.

Table 6: Correlation between all variables and in hospital mortality

	IN-hospital mortality				
	YES (n=24)		NO (n=26)		
Variable	**Count (%)**	**Mean±SD**	**Count (%)**	**Mean±SD**	**P**
Age (years)		55.5±13.5		45±12.6	**0.007***
Sex					0.271
Male	12 (50%)		17 (65.4%)		
female	12 (50%)		9 (34.6%)		
Smoker	7 (29.2%)		12 (46.2%)		0.216
Hypertension	14 (58.3%)		14 (53.8%)		0.749
Diabetes Mellitus	8 (33.3%)		10 (38.5%)		0.706
IHD	14 (58.3%)		13 (50%)		0.555
Pre-op LVEF (%)		51.33±10.72		53.85±12.96	0.461

CABG surgery	13 (54.2%)	13 (50%)		0.768
Valve surgery	11 (45.8%)	13 (50%)		
MVR	8 (33.3%)	8 (30.8%)		
AVR	3 (12.5%)	2 (7.7%)		
Mitral repair	0 (0.0%)	3 (11.5%)		
ICU stay (days)		8.08±4.73	6.46±1.30	0.116
Postoperative LVEF				
Day 0 (%)		23.67±4.50	27.31±4.05	**0.004***
Day 1 (%)		25.42±5.12	30.62±4.91	**0.001***
Day 2 (%)		25.63±5.12	33.12±4.73	**<0.001***
Day 3 (%)		26.05±8.77	36.38±4.76	**<0.001***

** Significant, SD; standard deviation, IHD; ischemic heart disease, Pre-op; preoperative, LVEF; left ventricular ejection fraction, CABG; coronary artery bypass graft, MVR; Mitral valve replacement, AVR; Aortic valve replacement, ICU; Intensive care unit*

All significant variables on the univariate level were included in a multivariate logistic regression analysis to predict mortality which revealed: Age and Post-operative LVEF were significant independent predictors for in-hospital mortality for these patients with post cardiac surgery cardiogenic shock (OR = 1.06, 95% CI = 1.008 - 1.116, P value = 0.024) and (OR = 0.83, 95% CI = 0.721 – 0.965, P value = 0.015) respectively as shown in table 7.

Table 7: Multivariate logistic regression analysis to predict in-hospital mortality

		P value	OR	95% C.I.	
				Lower	Upper
Death	**Age**	**0.024***	1.060	1.008	1.116
	EF (Post)	**0.015***	0.834	0.721	0.965

** Significant, EF; Ejection Fraction, OR; Odds ratio, CI; 95% confidence level*

DISCUSSION

Cardiogenic shock postoperatively occurs in 2% to 6% of patients who undergo cardiac surgery [1]. Levosimendan is an inotrope used for the treatment of acutely decompensated heart failure patients with low cardiac output or cardiogenic shock [3]. Intra-aortic balloon pump (IABP) counter pulsation provides hemodynamic support and/or control of ischemia both before and after surgery [4]. The aim of our study is to compare between levosimendan and IABP in patients who develop post cardiac surgery cardiogenic shock regarding to in hospital mortality, hemodynamics improvement and serial left ventricular ejection fraction (LVEF) improvement measured by transthoracic echo. It was conducted on fifty patients who were recruited from open heart surgical intensive care unit (SICU), national heart institute (NHI) and then divided into two groups; Group I: 25 patients were managed by levosimendan and Group II: 25 patients were managed by IABP.

Regarding baseline demographic and clinical data, there was no statistical difference between both groups regarding all baseline demographic and pre-operative clinical data presence of

ischemic heart disease (IHD), 36% in levosimendan group vs 72% in IABP group P value 0.01 and kind of surgery where 36% of patients underwent CABG and 64% underwent isolated valve surgery in group I compared to 68% underwent CABG and 32% underwent isolated valve surgery in group II, P value = 0.02 as shown in table 1 and figure 1. This can be explained as the ICU team preferred to insert IABP to patients, who are ischemic and underwent CABG to improve the perfusion through grafts by hemodynamics of balloon and preferred to administer levosimendan in valve surgeries as they don't think they will get benefit from IABP. Regarding hemodynamic variables, there was no statistically significant difference in heart rate between two groups at time 0 post-operative baseline recording, after 12 hours, after 24 hours and after 2 days as P value was 0.6, 0.2, 0.2 and 0.8 respectively as shown in table 1 and figure 1.

There was statistically significant difference in baseline post-operative mean arterial pressure (MAP) between two groups P value was 0.03 MAP was lower in IABP group. This significant difference can be explained as the IABP can be used at very low DBP in contrast to levosimendan which is an inodilator and can't be used at these low pressures except with high doses of vasopressor like noradrenaline to raise the BP to infuse levosimendan simultaneously. There was no statistically significant difference in mean arterial pressure (MAP) between two groups after 12 hours, after 24 hours and after 2 days P values were 0.8, 0.7 and 0.5 respectively. The findings are in agreement with Mate et al., [11] which enrolled 60 patients underwent CABG and divided them into two groups to compare the efficacy and short-term clinical outcomes of levosimendan versus intra-aortic balloon pump (IABP), there was no significance regarding post-operative heart rate at time points 0(baseline), after 12 hours, after 24 hours and after 48 hours, P values were 0.5, 0.7, 0.8 and 0.5 respectively. As regard MAP there were no significance at time points after 12hours, after 24 hours and after 2 days P values were 0.19, 0.2 and 0.4 respectively regarding MAP. The findings also agree with Severi et al., [12] which enrolled 22 patients with heart failure undergoing CABG and divided into two groups: one group received levosimendan and the other one received IABP. Post-operative MAP was not statistically significant between two groups (P value was 0.2).

Regarding Post-operative serum lactate, this study showed that there was no statistical difference between two groups at time 0 (baseline), after 12 hours, after 24 hours and after 2 days. P values were 0.5, 0.3, 0.5 and 0.9 respectively as shown in table 2 and figure 4. These findings agree with Mate et al., [11] which that P value were 0.6, 0.5, 0.3 and 0.1 respectively and no statistical difference between levosimendan and IABP groups**.**

Regarding Post-operative serial EF measurements, the study showed that serial post-operative EF despite being slightly better in IABP group at day 1, 2 and day 3 than levosimendan group, mean EF was 29.16±5.71 %, 30.52±7.44 % and 32.28±8.58 % at day 1, day 2 and day 3 compared to 27.08±5.42, 28.52±6.91and 30.96±8.73, but these results didn't show statistical significance. P values were 0.1, 0.3 and 0.5 at day 1, day 2 and day 3 respectively as shown in table 3 and figure 5. These findings agree with Severi et al., [12] where mean post-operative LVEF was 37±7.6 in IABP group and 36±7.4 in levosimendan with no statistical difference. P value was 0.8. These findings also agree with Omar et al., [13] which compares the use of levosimendan versus intra-aortic balloon pump (IABP) in patients with poor left ventricular function undergoing CABG. They enrolled 279 patients and divided them into two groups according to treatment received and showed that mean post-operative LVEF was 38.7±4.6 in IABP group and 34.2±2.1 in levosimendan with no statistical difference. P value was 0.5.

Regarding Follow up echo after one month, comparing between levosimendan and IABP on the follow up echo after one month for the survivors, this study found that there was no statistically significant difference between both groups P value was (0.41). The mean one moth

follow up LVEF for levosimendan group was 48.71±7.06 while for the IABP was 46.25±8.01 as shown in table 3 and figure 4.

Regarding all in-hospital mortality either cardiac or non-cardiac causes, Cardiac causes are cardiogenic shock, myocardial infarction, heart failure or arrhythmia and non-cardiac causes are sepsis, bleeding, chest infection or stroke, this study showed that levosimendan group exhibits better results 44% mortality compared to 52% in IABP. Although this wasn't statistically significant, P value was 0.5, these results should be taken in consideration. These results can be explained by frequent complications of IABP as an invasive procedure like bleeding and infection or anticoagulation related like serious bleeding or thrombocytopenia or HIT as shown in table 4. That finding agrees with Severi et al. [12] and Omar et al. [13] where P value was 0.3 and 0.6 respectively when mortality was compared between two groups. This finding disagrees with Treskatsch et al. [14] which enrolled 159 patients with low cardiac output syndrome post-operative to assess the effects on postoperative outcome of levosimendan and showed that significant reduction of mortality with levosimendan compared with conventional therapy (P value = 0.04).

Regarding type of operation, levosimendan notably showed better results compared to IABP in isolated valve surgeries either mitral valve replacement or aortic valve replacement. Mortality was 37% compared to 62.5% with IABP, although this wasn't statistically significant (P value = 0.5). As regard CABG surgery, The IABP had better prognosis than those who received levosimendan. Mortality was 47.1% with IABP vs 55.6% with levosimendan, although this wasn't statistically significant (P value = 1) as shown in table 4.

This can be explained as the greater significance of IABP in CABG group depending on the fact that IABP improves coronary blood flow and reduces myocardial work. So, decreases ischemia. But in Valvular heart disease the mechanism of post-operative low COP syndrome is a quite different where the epicardial coronary arteries don't show impaired flow. But, LV stunning is the most common mechanism; So Levosimendan offers multiple advantages as positive inotropic effect, improving systolic function and positive lusitropic effect, improving diastolic function. Beside the non-invasive nature of levosimendan is an extra advantage. So, Levosimendan offers more advantages with lower complications. The high mortality rate of valve surgeries with IABP agrees with Parissis et al., [15] which enrolled 136 patients' performed adult cardiac surgeries and required IABP support. The mortality rate in valve operations was 64.3% [15].

Regarding length of ICU stay, this study showed that length of ICU stay was significantly shorter in levosimendan group than IABP group (P value = 0.02). Then mean ICU stay was 6.16±2.88 days with levosimendan compared to 8.32±3.72 days with IABP. This significant difference can attributed to the duration of each modality to be left connected to the patient. Levosimendan is maximally infused over 24 to 48 hours then stopped where IABP is left connected to the patient for longer time even with improvement and removed when other inotropes weaned to minimal doses as shown in table 5 and figure 6. This result agrees with Mate et al., [11] which showed that length of ICU stay in levosimendan group was 4.4±0.2 days and 6.5±0.1 days with IABP and this was statistically significant (P value <0.001). This result also agrees with Omar et al., [13] which showed that length of ICU stay in levosimendan group was 4.4±0.8 days and 5.2±0.9 days with IABP and this was statistically significant (P value <0.005).

Regarding predictors of mortality, this study showed that age and serial post-operative LVEF are significant regarding in-hospital mortality as shown in table 6. The mean age of survivors was 45±12.6 years where the mean age of patients who died was 55.5±13.5 years P value was

0.007. This result agrees with Fernandez-Zamora et al., [16] where they conducted a retrospective analysis of a prospective, multi-center, observational study of adults undergoing cardiac surgery at 3 Andalusian hospital between June 2008 and December 2012 and gathered the information and found that the age with statistically significant regarding in-hospital mortality P value was <0.001 where the mean age of survivors was 63.1±12.8 and the mean age of non-survivors was 66.2±12.6 years. At time 0 post-operative, the mean LVEF was 23.67±4.50 % in the patients who died where it was 27.31±4.05 % in the survivors P value was 0.004. At day 1 post-operative, the mean LVEF was 25.42±5.12 % in the patients who died where it was 30.62±4.91 % in the survivors P value was 0.001. At day 2 post-operative, the mean LVEF was 25.63±5.12 % in the patients who died where it was 33.12±4.73 % in the survivors P value was <0.001. At day 3 post-operative, the mean LVEF was 26.05±8.77 % in the patients who died where it was 36.38±4.76 % in the survivors P value was <0.001. By using multivariate logistic regression to detect independent predictors of mortality it was found that age and post-operative time 0 LVEF are independent predictors as shown in table 7.

Regarding the age, the regression analysis was OR = 1.06, 95% CI = 1.008 - 1.116 & P value = 0.024. This result agree with Salem et al., [17] which included 3024 adult patients who underwent cardiac operations at the Montreal Heart Institute from 1996 to 2000 and by comparing their demographic data regarding in-hospital mortality they found that age was an independent predictor of mortality where P value was <0.0001, OR was 4.225 and 95% CI 2.461–7.355. Regarding Post-operative LVEF, the regression analysis was OR = 0.83, 95% CI = 0.721 - 0.965 & P value = 0.015.

CONCLUSION

Both treatment modalities, levosimendan and IABP, were comparable as regard hemodynamics, LVEF and in-hospital mortality. Those who underwent CABG had a better outcome with IABP while those who underwent valve surgeries had better outcome with levosimendan. The length of ICU stay is significantly shorter with levosimendan than IABP. Age and postoperative LVEF are independent predictors of mortality in such patients.

RECOMMENDATIONS

Levosimendan can be an alternative cost-effective modality in managing patients with low cardiac output syndrome post cardiac surgery, especially when IABP isn't available or not afforded. More studies are needed to clarify benefits of each modality, levosimendan or IABP, taking in consideration type of surgery

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