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Evaluation of Myocardial Contractility Determination with Tissue Tracking Echocardiography after Levosimendan Infusion in Patients with Poor Left Ventricular Function and Hemodynamics

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ABSTRACT

Background: The aim of this study was to assess the effect of conventional inotropic drugs compared to levosimendan using tissue tracking echocardiography in the early postoperative period for patients with low ejection fraction undergoing coronary artery bypass graft (CABG) surgery.

Methods: We prospectively analyzed 115 patients (69 male, 46 female) who planned for elective coronary artery bypass surgery with low ejection fraction, ≤% 30, from September 2012 to December 2013. Patients were divided into two groups. Levosimendan was used at a loading dose of 15 µg/kg/min for the first twenty minutes, and continued at a maintenance dose of 0.2 µg/kg/min six hours before the anesthetic induction in group I (n = 47, 23 male, mean age 67.16 ± 4.72 years). Dopamine at 10 µg/kg/min and/or dobutamine at 10 µg/kg/min were used at the time of weaning from cardiopulmonary bypass in group II (n = 68, 47 male, mean age 65.43 ± 6.12 years). The patients were evaluated preoperatively and on the fifth postoperative day by transthoracic echocardiography. Patients were also evaluated just before the cardiopulmonary bypass and at the 12th and 24th hours on the first postoperative day by transesophageal echocardiography. Student *t* test and χ^2 test were used for statistical analyses.

Results: There were no significant differences in demographics and preoperative hemodynamic parameters between groups I and II. Hemodynamic and echocardiographic parameters were significantly better in group I receiving levosimendan, compared to group II.

Conclusion: Levosimendan enhances functional myocardial tissue mass and ensures positive hemodynamic effect in the early postoperative period in patients with low ejection fraction undergoing elective CABG.

INTRODUCTION

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Coronary artery disease has been one of the most prominent causes of mortality and morbidity worldwide. Along with percutaneous coronary interventions, coronary artery bypass surgery (CABG) is also frequently performed in the treatment of coronary artery disease. Left ventricular systolic dysfunction particularly increases the risk of the surgery. Hemodynamically unstable patients require inotropic drug therapy. Traditional inotropic drugs used for that purpose (dopamine, dobutamine) exert inotropic action by increasing intracellular calcium levels. On the other hand, oxygen consumption of the myocardium is also increased by the administration of those drugs. Increase in oxygen consumption leads to myocardial cell injury due to many metabolites including free oxygen radicals. Subsequently, a number of complications, primarily arrhythmias, may arise. Recently, levosimendan was introduced as a new inotropic drug that does not increase myocardial oxygen consumption in patients with poor left ventricular function; it is a vasodilatory, cardioprotective agent with inotropic effects via increasing the calcium sensitivity of myocardial cells and binding to troponin C. Persistence of the hemodynamic effects of levosimendan for 7-10 days after its injection has also been considered an advantage [De Luca 2006; Öner 1996; Önem 2012; Borges 2003].

Today, the importance of cardiac imaging techniques is growing rapidly. Among them, echocardiography is an effective, safe-to-use, and less expensive technique, but relies on the operator's experience. In recent years, myocardial functions can be evaluated more sensitively and elaborately owing to some new echo techniques. Tissue tracking echocardiography (TT) procedure is a tissue Doppler-based technique allowing the assessment of myocardial longitudinal movements during systole [Pan 2001].

The technique provides information about the segmental displacement based on the velocity signals of the myocardial segments. Using computer-assisted data analysis software, echocardiographic data allow the evaluation of the level of myocardial deformation by assigning color codes to the myocardial regions from end-diastole to end-systole. Strain analysis (S) represents the deformation quantity developed against the forces applied towards myocardium. It gives an idea of dimensional alteration of the investigated segment, and the change compared to the original size is determined

as a percent rate. Longitudinal strain gives information about stretching-shortening functions, whereas radial strain provides a sense of myocardial functions related to thickening-thinning. Strain rate (SR), though, represents the rate of regional deformation—in other words, the stretching-shortening functions over time. SR can be calculated by dividing the difference of the velocities of two determined points on the myocardium by the distance in between. Longitudinal strain and SR values are calculated by TT method. For clinical purposes, Goebel et al determined S and SR values in various age ranges in healthy adults. A normal reference interval for longitudinal systolic rate was designated to be 15-25% [Goebel 2007; Voigt 2004]. The value of 1.4 ± 0.6 has been suggested as the normal threshold for longitudinal strain rate [D'hooge 2000].

In our study, the effects of traditional inotropic drugs and levosimendan on myocardial tissue and hemodynamic parameters by TT method were evaluated during the period of weaning off from cardiopulmonary bypass (CPB) and early postoperatively in patients with deteriorated left ventricle functions who underwent elective CABG.

PATIENTS AND METHODS

115 patients with ejection fraction ≤30% who underwent elective CABG at our medical center between September 2012 and December 2013 were enrolled in this prospective study. Informed consent was obtained from all patients, and the study was approved by the local institutional ethics committee. Patients with a history of previous CABG, cerebrovascular event, moderate and severe mitral insufficiency, creatinine levels higher than 2.5 mg/dL, and chronic lung and/or liver diseases were excluded from the study. Patients who were started on adrenalin, noradrenalin infusion, and intraaortic balloon pump (IABP) due to certain medical needs were also excluded from the study. All patients were divided into two groups: group I, consisting of 47 patients on levosimendan infusion initiated preoperatively; group II, consisting of 68 patients administered traditional inotropic agents (dopamine, dobutamine).

In group I, levosimendan was administered at a loading dose of 15 µg/kg/min for 20 minutes and 6 hours before the induction of anesthesia, and then followed by the infusion of the maintaining dose of 0.2 µg/kg/dk for a total of 18 hours all together. The patients with a median arterial pressure (MAP) ≤50 mmHg despite levosimendan infusion were given additional inotropic agents. However, such patients were excluded from the study. The patients who had MAP ≥120 mmHg in the early postoperative period were also excluded from the study without administering any inotropes. In patients within group II, if MAP ≤90 mmHg, only dopamine at a dose of 10 µg/kg/min was given. If MAP ≤60 mmHg, dobutamine at a dose of 10 µg/kg/min additional to the dopamine infusion was initiated. In order to determine the extensiveness of coronary arterial disease in patients, SYNTAX risk scores (www.syntaxscore.com) were calculated by two independent researchers at two different time points with the assistance of computer software, and final scores were obtained as the mean of those two values. Statistical analysis was used to determine the difference between the SYNTAX score of the groups.

Applied anesthesia procedures were the same in both groups. The operation was performed with CPB, the left thoracic artery was used for the revascularization of the left-anterior-descending coronary artery, and vena saphena graft was used for the rest. Topical hypothermia and cold blood cardioplegia were applied to protect the myocardium.

Echocardiography

All patients were evaluated by transthoracic echocardiography (TTE) preoperatively and during the time of discharge from the hospital. Transesophageal echocardiography (TEE) images were acquired before the patients' connection to the heart-lung machine and after the operation at hour 12 and hour 24. 3.5 Mhz transducer for TTE, and 5 Mhz transducer for TEE were used (iE33, Philips, Netherlands). Device parameters for imaging were adjusted to 50-90 frame/s during the evaluation. In order to achieve higher square velocities during the procedures, image frame angle was narrowed to 15-30 degrees, and the imaging records were acquired while the myocardial wall was positioned in the center of the frame, as well as parallel to the ultrasound beams for better insonation. Aortic valve opening, mitral valve closure, mitral valve opening, and aortic valve closure were marked in these records. Mid-esophageal 4-chamber (4B, 0°-20°), mid-esophageal 2-chamber (2B, 70°-90°), and mid-esophageal long axis (LAX, 110°-130°) views were obtained using TEE.

Lateral, septal, inferior, anterior and infero-lateral segments were assessed by using apical two-, three-, and four-chamber views acquired by TTE. Ejection fractions were calculated from the apical four-chamber image using modified Simpson's method. Early (E) and late (L) diastolic wave rates, deceleration time, isovolumetric contraction, and isovolumetric acceleration time were calculated for the diastolic evaluation. Left ventricle segmental wall motions were assessed for S and SR analysis using a 16-segment model recommended by the American Cardiology Association. Afterwards, through QLab (version 7.1, Philips, Netherlands) software, segmental longitudinal peak systolic S and peak systolic SR values were measured using S and SR slopes driven from the basal, mid, and apical segments of the lateral and septal walls of the left ventricle.

Statistical Analysis

Results were presented as mean ± standard deviation (SD). Statistical Package for Social Sciences (SPSS) for Windows 11.0 (SPSS, Chicago, Illinois, USA) software was used to perform statistical analyses. Study data were evaluated using Student *t* test and χ^2. $P < .05$ was accepted as statistically significant.

RESULTS

There was no significant difference between the groups regarding preoperative demographic characteristics of the cases, preoperative laboratory values, SYNTAX scores that were calculated to evaluate the extensiveness of coronary artery disease, or the data related to the operation such as the number of grafts used, cross-clamp time, and total perfusion

Table 1. Preoperative Demographic and Laboratory Characteristics*

	Group I (n = 47)	Group II (n = 68)	*P*
Age, y	65.1 (±12.7)	66.1 (±13.3)	.706
Male sex, n (%)	31 (65.9)	38 (55.8)	.229
Female sex, n (%)	16 (34)	30 (63.8)	.154
Diabetes mellitus, n	12 (25.5)	16 (23.5)	.872
Hypertension, n	21 (44.6)	27 (39.7)	.235
Hyperlipidemia, n	24 (51.1)	32 (47.0)	.568
Smoking, n	19 (40.4)	28 (41.17)	.652
SYNTAX score	28.9 (9.4)	30.2 (±8.9)	.243
Preop. heart rate, beat/minute	80.1 (±19.3)	78.1 (±19.1)	.566
Central venous pressure, mmHg	9.1 (±2.35)	8.9 (±1.37)	.352
PCWP	15.4 (±3.65)	14.8 (±4.85)	.615
Preop systolic blood pressure, mmHg	138.4 (±31.9)	134.0 (±30.6)	.451
Preop diastolic blood pressure, mmHg	84.2 (±19.8)	77.5 (±17.1)	.054
Preop MAP	96 (±22.35)	98 (±19.35)	.356
Creatinine, mg/dL	0.97 (±0.35)	1.02 (±0.49)	.512
Potassium, mmol/L	4.2 (±0.3)	4.6 (±0.4)	.803
Preprandial blood glucose level, mg/dL	139.6 (±67.9)	153.4 (±75.3)	.319
WBC, 103/uL	9.5 (±2.8)	9.2 (±3.2)	.549
Hemoglobin, g/dL	13.1 (±1.8)	12.8 (±2.1)	.385
Thrombocyte, 103/dL	243.3 (±64.9)	238.9 (±70.8)	.738
TSH, IU/mL	1.32 (±1.88)	1.59 (±1.89)	.464
AST, IU/L	81.9 (±114.1)	76.2 (±161.7)	.206
ALAT, IU/L	32.4 (±27.0)	45.8 (±35.9)	.771

*Data are presented as the mean ± SD where indicated. PCWP indicates pulmonary capillary wedge pressure; preop, preoperative; postop, postoperative; MAP, mean arterial pressure; WBC, white blood cell; TSH, thyroid-stimulating hormone; IU/L, international unit/liter; AST, aspartate aminotransferase; ALAT, alanine aminotransferase.

time. Preoperative demographic and laboratory values of the study patients are summarized in Table 1, and the data related to the operation and the early postoperative parameters are shown in Table 2.

Echocardiographic Data

No difference was detected between the measurements of left atrium, left ventricle end-systolic and end-diastolic diameters, interventricular septum, and right ventricle in the assessment of the preoperative echocardiographic data. Left ventricle ejection fraction was calculated at 29.5 ± 3.9% in group I, and 30.2 ± 4.2% in group II (*P* = .298).

Table 2. Evaluation Regarding Outcome and Postoperative Complications*

	Group I (n = 47)	Group II (n = 68)	*P*
Number of distal anastomoses	3.72 ± 3.6 (1-4)	3.48 ± 4.2 (1-5)	.093
Cross-clamp time, min	39.6 ± 14.3	41.3 ± 24.3	.072
Perfusion time, min	72.7 ± 26.2	69.3 ± 34.6	.083
IABP, n (%)	1 (2.12)	2 (2.94)	.061
Blood transfusion	3.4 ± 2.7	3.3 ± 1.4	.04
Length of stay in ICU, d	1.2 ± 2.3	1.6 ± 2.1	.004
Length of hospital stay, d	5.2 ± 5.8	6.1 ± 3.6	.001
Intubation time, h	8.67 ± 4.8	9.86 ± 9.2	.001
Reoperation for bleeding, %	1 (2.12)	2 (0.6)	.06
Arrhythmia required treatment, n (%)	2 (4.25)	11 (16.17)	.0001
CVD, n (%)	0 (0.0)	1 (1.47)	.001
Total in-hospital mortality, n, first 30 days (%)	0 (0.0)	2 (2.94)	.0001

*Data are presented as the mean ± SD where indicated. Statistically significant values appear in bold. IABP indicates intraaortic balloon pump; CVD, cerebrovascular disease; IUC, intensive care unit.

Before hospital discharge, ejection fraction values were calculated at 36.2 ± 4% in group I, and 33.4 ± 3.7% in group II (*P* = .043).

Preop and postop S and SR values obtained using TTE were considered more favorable in group I with levosimendan administration compared to group II (Table 3). Global longitudinal S and SR analyses were similar in the preoperative measurements between the two groups (*P* = .267), whereas better mean values were obtained in group I in the early postoperative period (*P* = .024) at hour 12 and 24 measurements than taken before CPB. No significant differences were attained between preop group I and group II in terms of S and SR means. However, statistically significant differences were achieved in the postoperative period. The segmental and global longitudinal S and SR analyses within the postoperative term were significantly better compared to group II (Table 4).

Data Related to CABG and Hemodynamics

In the comparison of the hemodynamic data, the initial values of heart rate (HR), MAP, central venous pressure (CVP), and pulmonary capillary wedge pressure (PCWP) were similar between the groups (P >.05). Following separation from CPB, HR, CVP, and PCWP, values were significantly higher in group II in comparison to group I (P < .05). Following the initiation of levosimendan infusion, MAP and urine output levels of the patients were higher and the lactate levels were lower compared to their initial measurements.

Table 3. Transthoracic Echocardiographic Evaluations*

	Preop			Postop		
	Group I	Group II	*P*	Group I	Group II	*P*
General Measurements						
Left atrium, mm	38.9 (±4.0)	37.9 (±4.3)	.165	37.8 (±5.6)	37.5 (±3.3)	.453
LV end-systolic diameter, mm	41.9 (±7.8)	40.3 (±7.1)	.087	40.8 (±9.2)	40.6 (±6.8)	.765
LV end-diastolic diameter, mm	59.9 (±5.7)	56.3 (±6.4)	.127	58.0 (±6.6)	57.2 (±6.1)	.235
Interventricular septum, mm	9.9 (±1.5)	10.3 (±1.8)	.426	10.1 (±1.2)	9.7 (±1.1)	.329
Posterior wall thickness, mm	9.7 (±1.3)	9.9 (±1.9)	.061	10.1 (±1.2)	9.4 (±2.1)	.087
LV ejection fraction (%)	29.5 (±3.9)	30.2 (±4.2)	.298	36.2 (±4.4)	33.4 (±3.7)	.043
Right ventricle, mm	26.2 (±5.4)	25.4 (±6.4)	.364	25.7 (±7.0)	26.1 (±5.1)	.548
Strain Analyses						
Septal wall apical	12.1 (±3.3)	11.1 (±2.1)	.063	13.7 (±3.1)	11.7 (±2.4)	<.001
Septal wall mid	12.7 (±4.3)	12.4 (±3.8)	.134	15.4 (±4.2)	13.3 (±3.9)	<.001
Septal wall basal	12.8 (±4.1)	11.7 (±3.6)	.057	15.3 (±3.2)	12.9 (±3.6)	<.001
Lateral wall apical	10.2 (±3.5)	10.7 (±4.4)	.245	12.9 (±3.6)	12.1 (±2.9)	.102
Lateral wall mid	11.9 (±3.2)	11.4 (±1.9)	.327	13.9 (±2.8)	12.3 (±2.2)	.045
Lateral wall basal	11.5 (±4.1)	11.1 (±3.7)	.312	14.2 (±4.3)	13.0 (±3.6)	.048
Global longitudinal strain	11.7 (±3.8)	11.2 (±3.3)	.267	14.2 (±3.5)	12.6 (±3.1)	.024
Strain Rate (S-1) Analyses						
Septal wall apical	1.10 (±0.32)	1.03 (±0.28)	.147	1.48 (±0.38)	1.28 (±0.33)	<.001
Septal wall mid	1.18 (±0.53)	1.14 (±0.39)	.243	1.50 (±0.41)	1.36 (±0.38)	<.001
Septal wall basal	1.16 (±0.44)	1.21 (±0.22)	.231	1.51 (±0.47)	1.37 (±0.38)	<.001
Lateral wall apical	1.10 (±0.32)	1.10 (±0.43)	.934	1.33 (±0.42)	1.27 (±0.35)	.213
Lateral wall mid	1.16 (±0.28)	1.06 (±0.27)	.176	1.40 (±0.38)	1.26 (±0.32)	.019
Lateral wall basal	0.99 (±0.41)	1.04 (±0.27)	.039	1.38 (±0.46)	1.36 (±0.37)	.452
Strain rate mean (1/s)	1.11 (±0.38)	1.09 (±0.31)	.568	1.43 (±0.42)	1.30 (±0.41)	.024

*Data are presented as the mean ± SD where indicated. Measurements from patients before (preop) CABG operation and after the operation in the discharging term from the hospital are displayed. In the postoperative term, it was determined that the mean values of strain and strain rate were better in the group administered levosimendan. CABG indicates coronary artery bypass graft operation; preop, preoperative; postop, postoperative; LV, left ventricle.

45 cases in group I were weaned from CPB on the first attempt (95.7%), whereas just 53 cases in group II were separated on the first attempt (77.9%). In a total of 3 cases, the placement of an intraaortic balloon pump was required after the separation from CPB due to the development of unresponsive hypotension despite the administration of elevated doses of inotropic agents. A need for the use of a mechanical support device arose in only one patient in group I on the first postoperative day (2.12%). There were two cases with a similar requirement in group II (2.94%). Amiodarone infusion was administered for intractable tachyarrhythmias in only 2 patients in group I (4.25%), and 11 patients in group II (16.17%). The infusion dose of parenteral antiarrhythmics was also higher in group II compared to group I.

Patient mortality within the first 30 days was considered as in-hospital mortality. Within this period, a total of 2 patients died, both of whom were in group II. The cause of deaths was multiple organ dysfunction syndrome subsequent to acute renal failure. The main problem behind the organ failures seen in both patients was heart failure, indeed caused by left ventricular dysfunction.

DISCUSSION

Plenty of studies have been conducted regarding levosimendan. In those studies, effects of levosimendan on cardiac output, cardiac index, and other hemodynamic parameters have been evaluated. A study testing ventricular functions following levosimendan use via TT method has not been performed to the best of our knowledge. Levosimendan was shown to alter myocardial function more favorably than other conventional inotropic agents during

Table 4. Transesophageal Echocardiographic (TEE) Evaluations*

	Preop†			Postop‡		
	Group I	Group II	*P*	Group I	Group II	*P*
Strain Analyses (%)						
2-chamber (%)	-9.5 (±3.1)	9.7 (±3.7)	.782	-12.2 (±4.3)	-11.0 (±3.6)	.021
4-chamber (%)	-10.2 (±4.4)	-10.4 (±3.3)	.824	-13.2 (±4.8)	-12,3 (±4.6)	.036
Long axis, LAX (%)	-11.8 (±3.4)	-11.1 (±4.0)	.180	-14.6 (±5.1)	-12.5 (±4.7)	<.001
Global longitudinal strain (%)	-10.5 (±3.3)	-10.5 (±2.1)	.863	-13.7 (±3.1)	-11.9 (±2.4)	<.001
Strain Rate (S-1) Analyses						
2-chamber strain rate-sm (1/s)	-0.96 (±0.36)	-0.89 (±0.37)	.139	-1.38 (±0.41)	-1.20 (±0.34)	.032
4-chamber strain rate-sm (1/s)	-1.09 (±0.41)	-1.05 (±0.27)	.094	-1.48 (±0.46)	-1.40 (±0.37)	.094
Long axis, LAX strain rate (1/s)	-1.11 (±0.41)	-1.06 (±0.38)	.085	-1.41 (±0.35)	-1.26 (±0.44)	.035
Strain rate mean (1/s)	-1.05 (±0.39)	-1.00 (±0.34)	.078	-1.42 (±0.41)	-1.29 (±0.39)	.048

*Data are presented as the mean ± SD where indicated. Preop indicates preoperative; postop, postoperative; LV, left ventricle; LAX, midesophageal long axis.
†Initial TEE measurement was taken immediately before the cardiopulmonary bypass just after the general anesthesia induction.
‡The mean of postoperative measurements at hour 12 and hour 24 is depicted. Determined strain and strain rate values were better in the group administered levosimendan.

the early postoperative period and at the time of discharge from the hospital.

Intracellular calcium level is quite important for the inotropic effect [Fabiato 1979]. Unlike many inotropic agents used in many hospitals, levosimendan generates its inotropic effect via increasing the calcium sensitivity of the myocardial cells, the contractile elements of the myocardium. Adrenergic drugs elevate intracellular calcium levels [Figgitt 2001]. Adrenergic inotropic agents typically cause vasoconstriction via sensitizing the alpha receptors in the peripheral vascular bed, whereas levosimendan creates coronary and systemic vasodilatation affecting ATP-dependent potassium channels [Lehmann 2004; Labriola 2004]. Levosimendan causes less arrhythmias as opposed to other inotropes due to not increasing the oxygen consumption of the myocardium [Follath 2002; Liileberg 1998]. Various hemodynamic problems are faced following separation from CPB, and in these cases, inotropic agents are to be preferred. Adrenaline and dopamine are mixed-receptor agonists manifesting their effects on alpha, beta-1, and beta-2 receptors. However, dobutamine has more selective beta-1 agonist features with less effect on the alteration of peripheral resistance. There are many studies regarding such effects of dopamine and dobutamine [Gray 1981; Salomon 1981; Yağar 2012; Romson 1999]. In our study, only 2 cases under levosimendan treatment had intractable tachyarrhythmias (4.25%), while the intractable tachyarrhythmias requiring long-term antiarrhythmic drug infusion (amiodarone) were seen in 11 cases in group II (16.17%).

In our study, no difference in global longitudinal S and SR values was detected between the two groups by TTE in the preoperative term (*P* = .568). In the postoperative term before the hospital discharge, though, S and SR values of group I with levosimendan treatment were significantly better compared to the other group (*P* = .024). In the measurements performed by our group using TEE, mean S and SR values measured before CPB were determined to be lower than previously reported measurement values by Goebel et al (Group I: S, -10.5%; SR, -1.05; and Group II: S, -10.5%; SR, -1.00) [Goebel 2007]. The study by Goebel et al was on healthy adult patients; however ejection fraction levels of our study population were less than 35%. Our results in correlation with the other studies suggest that TT calculations are the worst measurement results in patients with significant coronary artery disease [Pan 2001; Sogaard 2002]. S and SR values were significantly increased in group I (S, -13.7%; SR, -1.42) compared to group II (S, -11.9%, SR, -1.29) (*P* < .001). As is widely known, vasodilator and inotropic effects of levosimendan last longer than other inotropic agents. The reason for this is due to its active metabolite, OR-1898. It was reported that levosimendan's effect is maintained longer as the infusion doses of adrenergic inotropes were lessened [De Hert 2007; Alvarez 2006]. In our study, the reason for better results obtained from group I in the discharge period may be related to the prolonged effect time of levosimendan.

In our study, although the two groups were similar in terms of preoperative demographic data and operative parameters, the length of stay in the hospital and intensive care unit was significantly lower in patients in group I. The length of hospital stay was 5.1 ± 5.8 days in group I and 6.2 ± 3.6 in group II (*P* = .001). No mortality was seen in the cases in group I during 30-day monitoring. The mortality rate was 2.94% in group II in 30 days. Any end-organ damage was not detected in group I patients during their stay in the intensive care unit. No case had lactate levels more than 4 mmol/L, six hours after the operation.

There is no consensus regarding the initiation time of levosimendan in the literature. In many studies, levosimendan administration was started in patients having difficulties in the separation from CPB or after the development of problems with low cardiac output [Alvarez 2006; Aksun 2009]. On the other hand, there are some authors suggesting that it is more effective to start levosimendan therapy in the preoperative period [Liileberg 1998]. In this study, we started the levosimendan administration 6 hours before the operation. 95.7% of the patients in group I were successfully separated from CPB at the initial attempt, whereas the rate was only 77.9% in group II (P = .001).

In conclusion, for better postoperative results, we propose initiation of levosimendan administration 6 hours before the operation in patients with systolic dysfunction undergoing electively planned CABG.

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