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# Levosimendan in postcardiotomy cardiogenic shock: A single-center retrospective cohort study

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## Abstract

**Background:** Postcardiotomy cardiogenic shock remains an uncommon but highly lethal complication after cardiac surgery. Levosimendan, a calcium-sensitizing inodilator, may improve hemodynamics and organ perfusion without increasing myocardial oxygen demand. This study aimed to describe levosimendan use in our practice and to explore its association with early postoperative outcomes.

**Methods:** We conducted a single-center retrospective study in the polyvalent intensive care unit of Hassan II University Hospital, Fez, from January 2024 to January 2025. Among 86 adult cardiac surgery patients, 77 were analyzed after exclusion of 9 incomplete records. Eleven patients received levosimendan for immediate postcardiotomy cardiogenic shock; 66 non-exposed patients from the same period formed an exploratory comparator cohort. Outcomes included ventilator weaning, renal function, inotropic support evolution, arrhythmias, ICU length of stay, serial left ventricular ejection fraction (LVEF), and 30-day mortality.

**Results:** Patients receiving levosimendan had a markedly more severe baseline profile, including previous heart failure (72.7% vs 40.9%), preoperative inotropic support (27.3% vs 0%), preoperative oliguria (36.4% vs 4.5%), and a higher mean EuroSCORE II (7.01 ± 5.66 vs 3.83 ± 2.30). Within the levosimendan group, persistent oliguria decreased from 27.3% to 9.1%, and 36.4% of patients reached an LVEF > 50% at 48 hours. ICU length of stay was similar between groups (3.1 vs 2.64 days; p = 0.43). Reduction in inotropic support was less frequent in the levosimendan group (54.5% vs 93.9%; p = 0.009), while 30-day mortality was higher (45.5% vs 6.1%; p = 0.002).

**Conclusion:** In this non-randomized cohort with substantial baseline imbalance, levosimendan was preferentially used in the sickest patients and was associated with early favorable hemodynamic signals on diuresis and systolic function. However, no firm prognostic benefit can be inferred from this exploratory comparison. Prospective multicenter studies with severity adjustment are warranted.

**Keywords:** Levosimendan; Cardiogenic Shock; Postcardiotomy; Cardiac Surgery; Intensive Care; Renal Function; Left Ventricular Ejection Fraction

## 1. Introduction

Postcardiotomy cardiogenic shock is one of the most complex forms of acute circulatory failure in cardiovascular critical care. It often reflects overlapping mechanisms - left or right ventricular dysfunction, vasoplegia, pressure or volume overload, and surgery-related complications - and carries high mortality despite advances in cardiac surgery, hemodynamic monitoring, and temporary mechanical support [1-3].

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Levosimendan is an original inodilator that sensitizes troponin C to calcium and opens ATP-dependent potassium channels. Its theoretical appeal lies in improving myocardial contractility without substantially increasing oxygen consumption, while also exerting vasodilatory and potentially reno-protective and cardioprotective effects [4,5].

Clinical evidence nevertheless remains mixed. Several meta-analyses and small trials have suggested benefit on low cardiac output syndrome and selected hemodynamic endpoints, especially in patients with reduced ejection fraction. By contrast, the contemporary multicenter LICORN, CHEETAH, and LEVO-CTS trials did not confirm a clear benefit on major hard outcomes [6-11].

The aim of the present work was to transform the source thesis into a journal-style original manuscript by describing the characteristics of patients who received levosimendan in our center, the early effects observed after treatment, and the exploratory comparison with a contemporaneous non-exposed cohort.

## 2. Methods

### 2.1. Study design and population

This was a single-center retrospective descriptive and comparative study conducted in the polyvalent intensive care unit A1 of Hassan II University Hospital, Fez, from January 1, 2024 to January 31, 2025. Eighty-six adult cardiac surgery patients were initially screened. Nine records were excluded because of insufficient data, leaving a final analytical cohort of 77 patients.

To resolve inconsistent subgroup labels in the source thesis, we used a simple analytical nomenclature: levosimendan group (n = 11) and no-levosimendan group (n = 66). Exposed patients received levosimendan for immediate postcardiotomy cardiogenic shock. The comparator cohort was drawn from the same period but was not strictly matched on baseline severity and could include patients with or without postoperative shock according to the source data.

Postoperative cardiogenic shock was defined in the thesis by the association of a low-output criterion, right and/or left-sided congestion, and evidence of end-organ hypoperfusion, in line with contemporary descriptions of postcardiotomy shock [1-3].

### 2.2. Data collection and treatment protocol

Data were extracted from archived medical records and the HOSIX electronic system. Collected variables included demographic characteristics, cardiovascular history, preoperative hemodynamic parameters, echocardiographic findings, surgery type, inotropic protocol, duration of mechanical ventilation, renal function, ICU length of stay, LVEF evolution, and 30-day mortality.

In the exposed group, levosimendan was administered as a continuous infusion at a fixed dose of 0.1 µg/kg/min for 24 hours through a central venous line, without a loading dose, in order to limit vasoplegia. It was used as adjunctive therapy: a levosimendan-dobutamine-norepinephrine-epinephrine combination was used in 72.7% of patients, and a levosimendan-dobutamine-norepinephrine combination in 27.3%.

### 2.3. Outcomes and statistical analysis

The outcomes retained for this manuscript were speed of ventilator weaning, urine output and renal impairment, evolution of inotropic support, arrhythmias, ICU length of stay, serial echocardiographic LVEF changes under levosimendan, and 30-day mortality. The analysis remained mainly descriptive, and the p values available in the source thesis were preserved for inotrope reduction, ICU length of stay, and 30-day mortality.

## 3. Results

### 3.1. Population characteristics

The study cohort included 77 patients, 11 of whom (14.3%) received levosimendan. All procedures were performed through median sternotomy with cardiopulmonary bypass, and surgery was predominantly valvular in both groups. Patients exposed to levosimendan had a more severe preoperative profile, with more frequent heart failure, oliguria, congestion, redo surgery, and systolic dysfunction, together with a higher EuroSCORE II.

This baseline imbalance is central to outcome interpretation. All patients in the levosimendan group had documented preoperative pulmonary hypertension, and 63.6% had preserved baseline LVEF, suggesting a complex postcardiotomy low-output phenotype not limited to classic severe left ventricular systolic failure. The preoperative LVEF distribution and selected severity markers are shown in Figure 1.

**Table 1** Main preoperative characteristics of the analyzed patients.

| Variable | No levosimendan (n = 66) | Levosimendan (n = 11) |
|---|---|---|
| Age, years, mean ± SD | 52.71 ± 12.71 | 58.09 ± 11.31 |
| Female sex, n (%) | 41 (62.1) | 7 (63.6) |
| Previous heart failure, n (%) | 27 (40.9) | 8 (72.7) |
| Atrial fibrillation/AF, n (%) | 32 (48.5) | 5 (45.5) |
| Redo surgery, n (%) | 3 (4.5) | 3 (27.3) |
| Preoperative inotropic support, n (%) | 0 | 3 (27.3) |
| Preoperative oliguria, n (%) | 3 (4.5) | 4 (36.4) |
| Clinical signs of congestion, n (%) | 7 (10.6) | 7 (63.6) |
| Preoperative LVEF < 40%, n (%) | 2 (3.0) | 4 (36.4) |
| Preoperative MAP, mmHg, mean ± SD | 78.95 ± 8.38 | 70.55 ± 25.19 |
| EuroSCORE II, mean ± SD | 3.83 ± 2.30 | 7.01 ± 5.66 |

SD: standard deviation; LVEF: left ventricular ejection fraction; MAP: mean arterial pressure. Percentages reflect an unmatched cohort with important baseline severity imbalance.

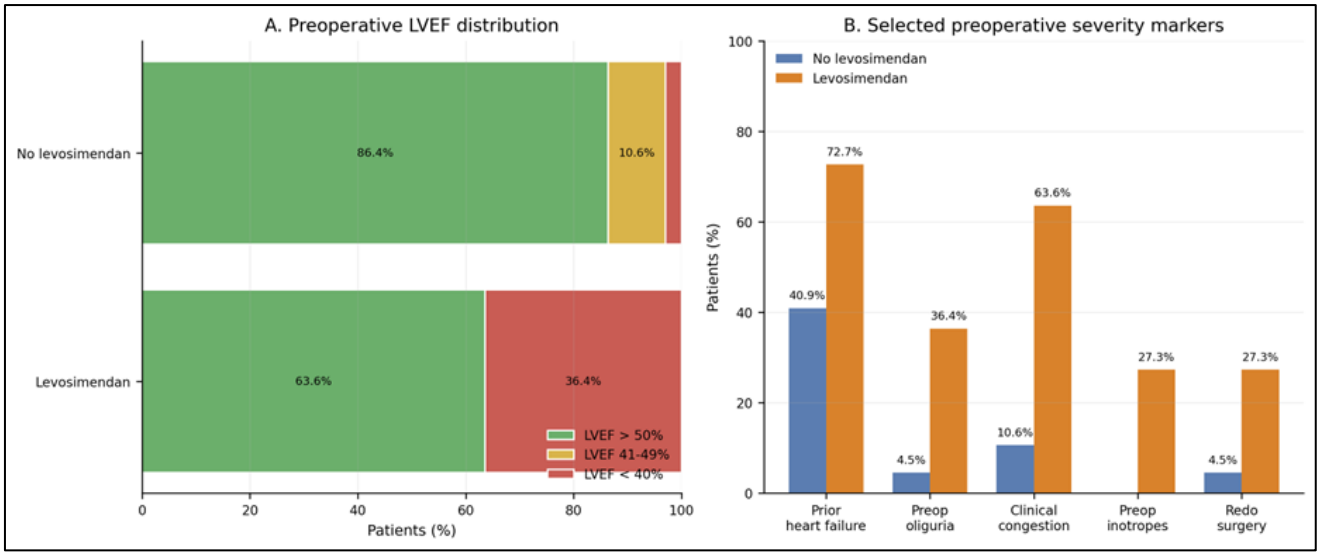


**Figure 1** Baseline severity profile. (A) Preoperative LVEF distribution in both groups. (B) Selected preoperative severity markers derived from the source thesis

### 3.2. Early postoperative course

Ventilator weaning was faster in the non-exposed cohort: 95.5% of patients were extubated within 6 hours versus 63.6% in the levosimendan group. In exposed patients, 18.2% required 6 to 24 hours before weaning and 9.1% could not be weaned from mechanical ventilation.

Renal trends appeared more favorable under levosimendan. The proportion of patients remaining oliguric decreased from 27.3% before treatment to 9.1% after treatment, while 81.8% recovered or maintained satisfactory diuresis. By contrast, in the non-exposed cohort, postoperative oliguria remained uncommon and essentially stable, moving from 6.1% preoperatively to 7.6% postoperatively. These diuretic and renal-function changes are detailed in Figure 2.

Inotropic support reduction was less frequent in the levosimendan group: only 54.5% of exposed patients showed a reduction in inotropic requirements, versus 93.9% in the non-exposed cohort (p = 0.009). Arrhythmias remained common under levosimendan, with a post-treatment prevalence of 63.6%, compared with 54.5% in the non-exposed postoperative cohort. Median ICU length of stay was 3.1 days with levosimendan versus 2.64 days without levosimendan, without a statistically significant difference (p = 0.43). Changes in inotropic support and 30-day vital status are summarized in Figure 3.

**Table 2** Early postoperative outcomes and main study endpoints**.**

| **Outcome** | **No levosimendan (n = 66)** | **Levosimendan (n = 11)** |
|---|---|---|
| Ventilator weaning < 6 h, n (%) | 63 (95.5) | 7 (63.6) |
| Persistent oliguria at postoperative/post-treatment assessment, n (%) | 5 (7.6) | 1 (9.1) |
| Reduction in inotropic support, n (%) | 62 (93.9) | 6 (54.5); p = 0.009 |
| Postoperative/post-treatment arrhythmia, n (%) | 36 (54.5) | 7 (63.6) |
| ICU stay, median days | 2.64 | 3.1; p = 0.43 |
| 30-day mortality, n (%) | 4 (6.1) | 5 (45.5); p = 0.002 |

Renal and rhythm evaluations were not strictly symmetrical between groups in the source document and should therefore be interpreted as exploratory.

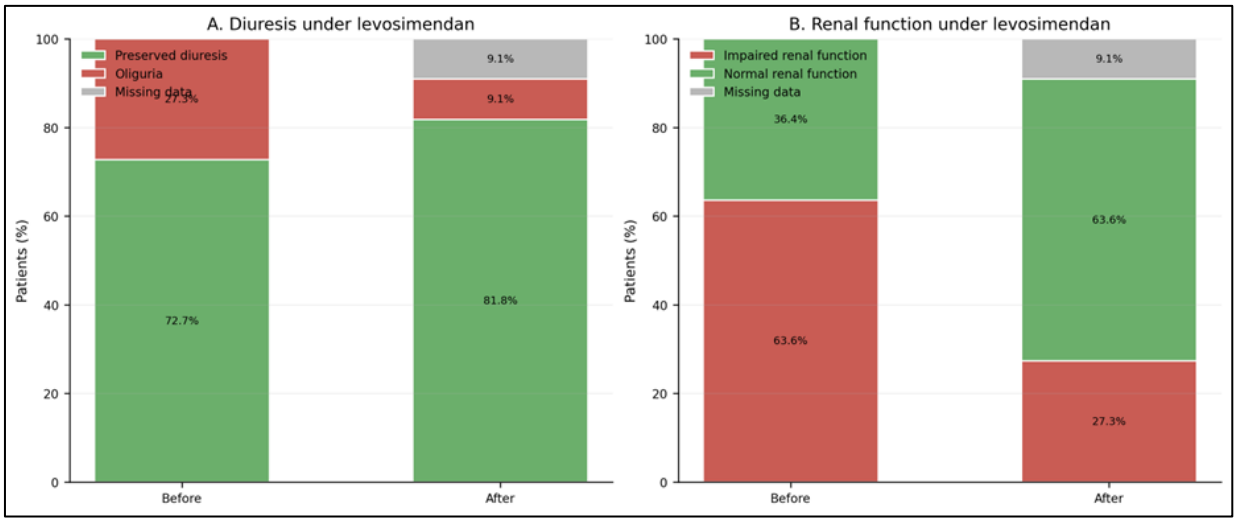


**Figure 2** Renal response under levosimendan. (A) Diuresis before and after treatment. (B) Renal-function status before and after treatment. Missing data are displayed when they were not documented in the source thesis

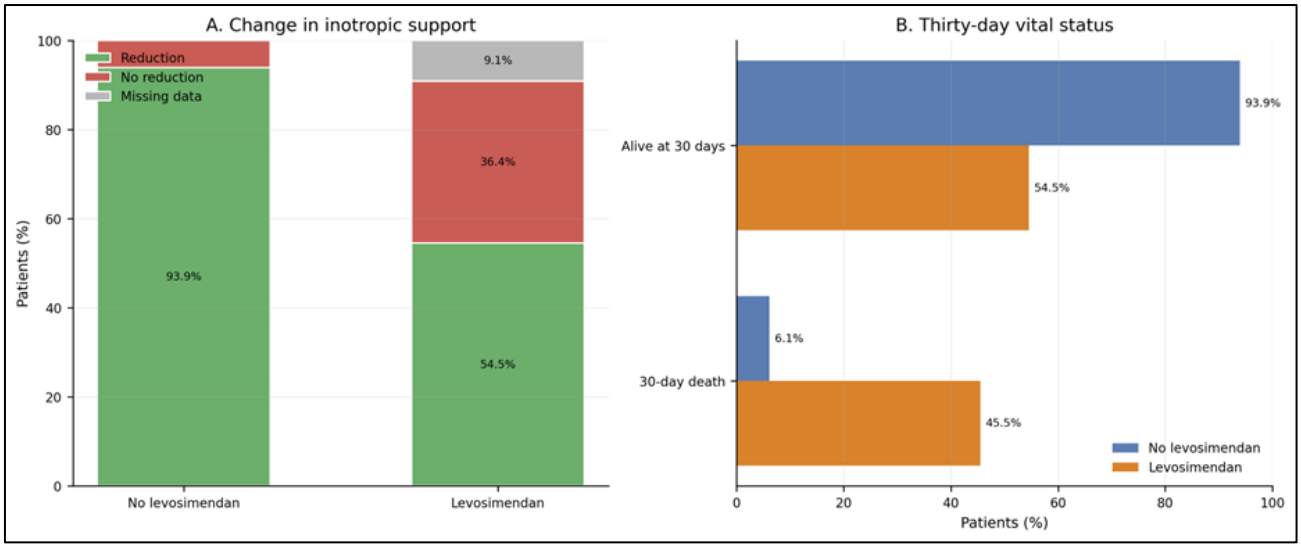


**Figure 3** Early postoperative course. (A) Change in inotropic support. (B) Thirty-day vital status

### 3.3. Serial echocardiographic evolution under levosimendan

Within the levosimendan group, serial LVEF measurements suggested progressive improvement in systolic function. The proportion of patients with LVEF < 40% fell from 45.5% at 1 hour to 18.2% at 48 hours. Conversely, the proportion reaching LVEF > 50% rose to 9.1% at 6 hours, 27.3% at 24 hours, and 36.4% at 48 hours. The detailed LVEF kinetics, including missing measurements from the source data, are presented in Figure 4.

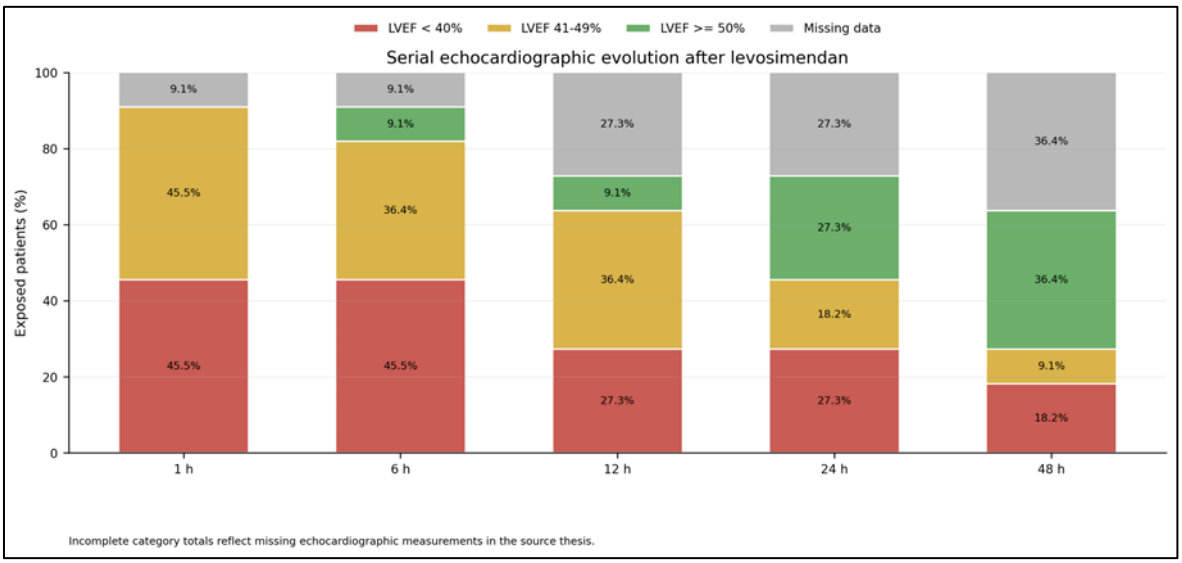


**Figure 4** Serial LVEF evolution after levosimendan in the exposed group. Incomplete totals reflect missing echocardiographic measurements in the source document

## 4. Discussion

This manuscript highlights three main messages. First, in our practice, levosimendan was reserved for a small subgroup of more severely ill patients characterized by more frequent preexisting heart failure, greater preoperative oliguria and congestion, earlier need for inotropes, and a higher EuroSCORE II. Second, despite this baseline severity, early favorable physiological signals were observed on diuresis and systolic function. Third, no robust conclusion regarding prognostic benefit is possible because of the strong imbalance between groups, and the higher mortality observed under levosimendan should be interpreted as a marker of severity rather than a signal of harm.

The improvement in diuresis and LVEF under levosimendan is consistent with the drug's pharmacology. Levosimendan enhances inotropy without markedly increasing myocardial oxygen consumption, reduces afterload, and may favor

renal perfusion [4,5]. Randomized physiological studies have shown increased renal blood flow and glomerular filtration after cardiac surgery, with improved renal oxygenation and no major metabolic penalty [12,13]. A recent randomized trial in postoperative acute heart failure likewise suggested benefit on hemodynamic stability and ventricular function at 48 hours [14].

By contrast, our comparative results show neither shorter ICU stay nor lower 30-day mortality. This is in keeping with the cautious tone of contemporary trials. LICORN did not demonstrate a significant reduction in low cardiac output syndrome [8]. CHEETAH did not show lower 30-day mortality [9]. LEVO-CTS failed to confirm major benefit on severe postoperative events [10]. An expert update published after these trials emphasized the importance of patient selection and timing of administration [11].

The distinctive feature of our cohort lies in the phenotype of exposed patients. Unlike many trials focused on coronary artery bypass grafting and severe left ventricular systolic dysfunction, our levosimendan group mainly consisted of valvular surgery patients, all with documented pulmonary hypertension, and with preserved baseline LVEF in 63.6% of cases. This profile, more commonly marked by right-sided overload, congestion, and mixed low output, might theoretically benefit from inodilator effects and reduced pulmonary afterload, yet remains underrepresented in contemporary randomized studies.

The frequency of arrhythmias observed in the levosimendan group nevertheless warrants caution. Even if the comparison remains fragile, persistent rhythm disorders in nearly two thirds of exposed patients remind us that levosimendan is usually embedded in complex hemodynamic strategies, often combined with other inotropes and used in particularly unstable patients, where close rhythm surveillance remains essential.

This study has major limitations: its retrospective, single-center, non-randomized design; the very small size of the levosimendan group; the clinical heterogeneity of the comparator cohort; the lack of statistical adjustment for baseline severity; the limited availability of p values; and incomplete follow-up beyond 30 days. In addition, subgroup labeling was inconsistent in the original thesis and had to be standardized for the present manuscript.

## 5. Conclusion

In this single-center experience, levosimendan was used in the sickest patients with postcardiotomy cardiogenic shock, often on a valvular, congestive, and high-risk hemodynamic background. The data suggest early favorable signals on diuresis and systolic function, but do not support any firm conclusion regarding hard outcomes. The main message of this work is therefore not one of demonstrated efficacy, but rather that levosimendan may have rescue interest in a severe phenotype that is imperfectly represented in the large trials. Prospective multicenter studies with matched comparators and severity adjustment are needed before broader generalization.

## Compliance with ethical standards

### *Disclosure of conflict of interest*

The authors declare no conflicts of interest.

### *Statement of ethical approval*

The ethics approval number was not reported in the source thesis. The exact regulatory status of this retrospective analysis should be confirmed according to local institutional and journal requirements before final submission.

### *Funding*

No specific funding was received.

### *Author contributions*

All authors contributed substantially to the conception of the work or interpretation of data, critically revised the manuscript, approved the final version, and agree to be accountable for all aspects of the work.

*Data availability*

The analyzed clinical data derive from medical records and the HOSIX system at Hassan II University Hospital, Fez. Data may be discussed upon reasonable request, subject to institutional confidentiality rules.

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