

# In-Hospital Mortality in Cardiac Surgery Patients After Readmission to the Intensive Care Unit: A Single-Center Experience with 10,992 Patients

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**Objectives:** Determine if readmission to the intensive care unit (ICU) after cardiac surgery procedures is associated with increased mortality.

**Design:** This was a retrospective non-randomized study to evaluate the cause of readmission and mortality rate in patients readmitted to the ICU after cardiac surgery and to compare the clinical variables of patients readmitted to the ICU who died and those who survived.

**Setting:** The study was performed in a single university hospital.

**Participants:** This was an analysis of 10,992 consecutive adult patients. Readmission rate to the ICU, mortality rate, the reason for readmission to the ICU, type of surgery, length of stay, cause of mortality, and day of the week of ICU readmission were analyzed.

**Interventions:** All patients underwent cardiac surgery at a single center and were discharged after primary stay from the ICU.

**Measurements and Main Results:** A total of 197 (1.8%) of 10,992 patients were readmitted to the ICU. In-hospital

mortality rate for patients readmitted and not readmitted to the ICU was 23.9% and 4.7%, respectively. The main causes of ICU readmission were cardiac (40%) and respiratory (37%) complications. The mortality rate in readmitted patients who underwent coronary artery bypass graft (CABG) or valve surgery was 26% and 19%, respectively.

**Conclusions:** Patient readmission to the ICU following cardiac surgery was associated with a 5-fold increase in hospital mortality rate compared to non-readmitted patients. The highest mortality rate was observed among readmitted patients who underwent CABG. Older age, previous myocardial infarction, and initial long length of stay in the post-operative ward were independent risk factors for death after readmission to the ICU.

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**KEY WORDS:** cardiac surgery, ICU mortality, mortality after cardiac surgery

**P**ROPER CARE in the intensive care unit (ICU) after cardiac surgery is an integral part of effective treatment of cardiac patients. However, prolonged stay in the ICU is associated with increased mortality, morbidity, and worse long-term survival,<sup>1-3</sup> and it increases the cost of treatment.<sup>4,5</sup> Early discharge from the ICU, on the other hand, increases the risk of subsequent patient readmission to the ICU,<sup>6,7</sup> which is associated with increased adverse outcomes compared with other types of ICU admissions.<sup>8,9</sup>

On average, patient readmission to the ICU after cardiac surgery procedures ranges from 2.3% to 5.9%.<sup>10-13</sup> Unfortunately, there still is very limited literature available on this topic. Previous studies mainly have focused on etiology and risk factors for readmission, and most studies focused on selected groups of patients such as those after coronary artery bypass graft (CABG) or valve surgery. Currently, there are no studies that identify the predictors of mortality for cardiac surgery patients readmitted to the ICU.

The aim of this study was to identify the risk factors for patient mortality after ICU readmission following cardiac

surgery and to evaluate the influence of the type of cardiac surgery procedure on ICU readmission and subsequent mortality. Furthermore, the authors sought to determine the cause of readmission and assess the effect of the following on patient survival after readmission: Type of hospital admission, length of hospital stay, initial ICU and postoperative department stay, and day of the week (working days v non-working days) of admission or readmission to the ICU or to the postoperative department. To their knowledge, the current patient cohort represented the largest study population of postoperative cardiac surgery patients who were readmitted to the ICU.

## METHODS

The authors conducted a retrospective analysis of 11,537 consecutive adult patients who underwent cardiac surgery procedures between January 1, 2009, and December 31, 2013, in a single, university-based cardiac surgery unit. Five hundred forty-five (4.7 %) patients who died in the operating room or during their initial stay in the ICU were excluded from the study. Patients who underwent heart transplantation (HTX) also were excluded. The remaining 10,992 patients who were discharged alive from the initial cardiac ICU admission were analyzed retrospectively.

## ICU Discharge Criteria

The discharge of patients from the ICU to the postoperative ward was determined by the patient's health status (as assessed by the Therapeutic Intervention Scoring System (score between 0 and 19 points; TISS-28) of cardiac surgical postoperative intensive care and by clinical judgment of the physician discharging the patient from the ICU. No fast-track or early extubation anesthetic techniques were used.

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## ICU Readmission Criteria and Definition

“ICU readmission” was defined as a second ICU admission of a patient for a problem that was related directly to his/her primary admission and required close monitoring of his/her physical condition and vital functions. “Cause of readmission” was defined as all complications that were observed during the first 48 hours of ICU stay after readmission. The decision to transfer patients from the postoperative ward to the ICU was up to the discretion and clinical judgment of the ward physician and the physician readmitting the patient to the ICU.

## Study Databases

Data for the study were obtained from medical records, hospital data, and the local KROK database (National Register of Cardiac Surgery). The following data were recorded: Age, gender, angina status, hypertension, diabetes, history of chronic lung disease (COPD), renal function, atrial fibrillation (AF), hyperlipidemia, history of stroke, extracardiac arteriopathy, urgency of the procedure (“urgent” was defined as a procedure performed <24 hours from the time of hospital admission), reoperation, active endocarditis, EuroSCORE, type of surgery, principal cause of readmission to the ICU, length of stay, and admission or readmission day of the week (weekends *v* weekdays). Patients readmitted to the ICU who died constituted group I, whereas readmitted patients who survived made up group II. In-hospital mortality rate of readmitted patients was compared with non-readmitted patients.

## Statistical Analysis

Values are given as mean  $\pm$  standard deviation. The probability of an event given certain risk factors was calculated using logistic regression analysis, including odds ratio (OR) and its confidence interval (95% CI). A *p* value of less than 0.05 was considered statistically significant. Statistical analysis was performed using Statistica 10 software (StatSoft Inc., Tulsa, OK).

## RESULTS

Among 10,992 patients who underwent cardiac surgery during the study period and were discharged alive from the cardiac ICU, 197 (1.8%) required readmission to the ICU. The main demographic and perioperative patient characteristics are shown in Table 1. The highest readmission rate was 3.4% and was observed in patients after cardiac tumor surgery. A complete summary of readmission rates and type of cardiac surgery is given in Table 2.

## Causes of Readmission to the ICU, Types of Surgery, Mortality

Thirty-six patients were readmitted to the ICU more than once. In these cases, the causes for first readmission were analyzed. Multiple complications were observed in 19 patients, and in these cases, all causes of readmission were analyzed. The most common causes of readmission to the ICU were cardiac ( $n = 78/197$ , 40%) and respiratory ( $n = 72/197$ , 37%) complications. The highest mortality rate was observed in patients readmitted with renal complications (46%). Mortality due to cardiovascular and respiratory complications was noted to be 31% and 22%, respectively. A complete summary of reasons for readmission and type of cardiac surgery is given in Table 3.

**Table 1. Demographic, Perioperative, and Postoperative Patient Characteristics of Readmitted Patients**

Characteristic		n
Age [years]	68,18 $\pm$ SD 10,89	—
Female	35%	69
Male	65%	128
EuroSCORE	6 $\pm$ SD 3,12	—
CAD	54%	106
MI	41%	80
PCI	19%	38
Hypertension	82%	161
Diabetes type 2	31%	61
COPD	16%	31
CKD	23%	46
AF	29%	58
Hyperlipidemia	53%	104
Extracardiac arteriopathy	11%	21
Previous cardiac surgery	9%	18
Active endocarditis	6%	12
Previous stroke	9%	18
Urgent	21%	21
ICU length of stay (day)	5 $\pm$ SD 7	—
Postoperative department admission		
Day	86%	170
Weekends	14%	27
Weekday		
Stay on postoperative department (day)	6 $\pm$ SD 7	—
ICU readmission day		
Weekends	76%	150
Weekday	24%	47

Abbreviations: AF, atrial fibrillation; CAD, coronary artery disease; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; EuroSCORE, European System for Cardiac Operative Risk Evaluation; ICU, intensive care unit; MI, myocardial infarction; PCI, percutaneous coronary intervention.

## Determinants of Mortality After Readmission

Of the 197 patients (male 65%, female 35%) readmitted to the ICU, 47 (23.9%) patients died; these data are summarized in Figure 1. Only 7 patients out of 10,992 investigated patients were readmitted to the ICU directly from home or a nursing/rehabilitation facility. Sixteen patients (8.1%) were discharged from the cardiac ICU to another hospital ICU for various reasons. These cases were not included in the authors' survival analysis. Older age, myocardial infarction, and longer initial stay in the postoperative department were independent risk factors for patient death after readmission to the ICU (Table 4).

## DISCUSSION

According to published data, there is a large variability of readmission rates to the ICU after cardiac surgery which range from 2.2% to nearly 8.75%.<sup>6,9,10,12–16</sup> The rate of ICU readmission in the authors' study was 1.8% and is the lowest in published literature. The higher readmission rates reported in the literature may be due to several underlying reasons. Firstly, these data come from different countries and cardiac surgery centers where different therapeutic methods and surgical protocols are used. Secondly, previous studies included only

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