Incidence and predictors of readmission to the cardiac surgery intensive care unit: A retrospective cohort study in Greece

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Abstract:

INTRODUCTION: Readmission in the intensive care unit (ICU) is a significant morbidity index, which has been related to poor patient outcomes

AIM: To identify the preoperative and intraoperative risk factors for readmission in the cardiac surgery ICU.

METHODS: We conducted a retrospective cohort study of 595 consecutive patients who were admitted to the cardiac surgery ICU of a tertiary hospital of Athens — Greece during the one-year period (September 2011-September 2012). Data collection was carried out, retrospectively, by the use of a short questionnaire and based on the review of medical and nursing patient records at December 2012.

RESULTS: The incidence of ICU readmission was 3.7% (22/595). Respiratory disorders were the main reason for readmission (45.4%). Readmitted patients had a significantly higher in-hospital mortality compared to those requiring no readmission ($P < 0.001$). Multivariate analysis revealed that female gender [for males odds ratio (OR) 0.37, 95% confidence interval (CI) 0.15-0.89], high logistic EuroSCORE (OR 1.02, 95% CI 1.00-1.04), prolonged cardiopulmonary (CPB) duration (OR 1.01, 95% CI 1.00-1.02) and preoperative renal failure (OR 1.02, 95% CI 1.00-1.05) were the independent risk factors for readmission to the cardiac surgery ICU.

CONCLUSIONS: One intraoperative and three preoperative variables are associated strongly with higher probability for ICU readmission. Shorter CPB duration could contribute to lower ICU readmission incidence. In addition, the early identification of high risk patients for readmission in the cardiac surgery ICU could encourage both the more efficient healthcare planning and resources allocation.

Key words:

Cardiac surgery, intensive care units, patient readmission

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Intensive care units (ICUs) all over the world face the problem of having fewer beds in relationship to the number of patients needing intensive care.[1] Readmission to the intensive care unit (ICU) is a problem of great significance due to the current international shortage of ICUs beds in conjunction with the high healthcare cost of intensive care.

On examining cardiac surgery patients specifically, several studies were found to have associated ICU readmission with poor patient outcomes, such as high mortality and morbidity rates,[2-6] prolonged hospital stay,[6] and increased healthcare cost.[7] Various perioperative parameters have been implicated as risk factors for ICU readmission, such as older age,[6,8] history of congestive heart failure,[3] complex cardiac surgery and aortic surgery,[4] low left ventricular ejection fraction,[9] preoperative renal failure,[6,7] high EuroSCORE values,[10] increased duration of cardiopulmonary bypass (CPB) and surgery,[2] prolonged mechanical ventilation postoperatively,[7] re-exploration for bleeding,[7] and prolonged initial ICU stay.[5]

The aim of this study was to identify the preoperative and intraoperative predictors for readmission in the ICU, among cardiac surgery patients. The knowledge and the early recognition of these factors could contribute to the early identification of the high risk patients for recidivism, the more effective allocation of the limited healthcare resources, and development of preemptive strategies which target to ICU readmission avoidance. Therefore, this identification could create the necessary conditions to minimize adverse outcomes and to increase the quality of healthcare services. Our study intends to add new data to the cardiac surgery ICU readmission body of knowledge and to strengthen the importance of the knowledge of risk factors for readmission. This knowledge could lead to the early prediction and detection of high-risk patients and the more effective ICU resources allocation, a fact of great significance

for healthcare systems with limited resources and ICU-beds availability, such as the Greek one.

Methods

Study design and participants
A retrospective cohort study was conducted. During a 1-year period (September 2011-September 2012), 634 consecutive patients were admitted to the 8-bed cardiac surgery ICU of a tertiary general hospital in Athens — Greece after an open heart surgery. Patients younger than 18 years old and those who underwent off-pump surgery (without CPB) were excluded. The final sample of our study consisted of 595 patients (response rate 93.8%).

Data collection
The data collection took place in December 2012. We used a short structured questionnaire on basic demographic and perioperative patient data for data collection proposes. The questionnaire information included patients' age, gender, height, weight, logistic EuroSCORE, the duration of surgery and CPB, comorbidity [chronic obstructive pulmonary disease (COPD), diabetes, renal failure], the cardiac patient history (previous cardiac surgery, pulmonary hypertension, recent myocardial infarction, left ventricular ejection fraction), the surgery type, the administration of red blood cells (RBC) intraoperatively, the elective or emergency character of surgery, readmission in the cardiac surgery ICU, the reason for readmission, and in-hospital mortality.

We defined as "readmission in the cardiac surgery ICU" the second or subsequent ICU admission of a patient for a problem that was directly related to his/her primary admission and required close monitoring of his/her physical condition and vital functions. We did not consider as "readmission in the cardiac surgery ICU" any other patient readmission that was not directly related to the primary admission, such as admission for a central or pulmonary catheter insertion. Aiming to ensure the reliability and validity of the data collection process, one of the researchers, the same each time, obtained the data based on medical and nursing patient records review.

Statistical analysis
Numerical data are expressed as mean (±SD) and categorical data as n (%). Bivariate analysis was performed to identify risk factors associated with readmission. The chi-square test or Fisher's exact test was used to compare the distribution of categorical variables between patients readmitted and not readmitted to the ICU and the Student's t test was used to compare continuous variables between the two groups. All tests of statistical significance were two-tailed and P-values of less than 0.05 were considered statistically significant. Variables that were significantly different in bivariate analysis were entered into the backward stepwise multivariate logistic regression analysis. The criteria for entry and removal of variables were based on the likelihood ratio test, with enter and remove limits set at $P < 0.05$ and $P > 0.05$. We estimated crude and adjusted odds ratios (ORs) with 95% confidence intervals (CIs) for the risk factors related to the re-admission. Statistical analysis was performed using SPSS 19.0 for Windows.

Ethics
The data collection was conducted after written permission from the ethics committee of the hospital. The investigation was carried out in accordance with the ethical standards of the responsible institutional committee for human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. Precautions took place to protect the privacy of research subjects and the confidentially of their personal information, including limiting the amount of personal information to the absolute minimum, assigning an identification number to each subject and attaching the identification number to the actual research information, removing the subject names as soon as data were analyzed and maintaining any identifying information and lists of identification numbers in a safe and locked file.

Results

The mean age of all patients was 65.9 (±11.5) years old and the majority of them (67.9%) were males. Twenty-two patients (3.7%) required readmission in the cardiac surgery ICU and the overall in-hospital mortality was 8.2%. The main demographic and perioperative patient characteristics are shown in Table 1.

Respiratory disorders were the most common reason for readmission in the ICU (n = 10/22, 45.4%). Six patients were readmitted due to cardiac disorders, accounting for 27.3% of the patients, while four patients (18.2%) were readmitted due to their renal function deterioration. A complete summary of reasons for readmission is given in Table 2.

Table 3 provides the main preoperative and intraoperative predictors' distribution and their relationship with the ICU readmission status (readmission or no readmission in the

Table 1: Demographic and perioperative patient characteristics

	Mean (±SD)
Age (years)	65.9 (11.5)
BMI (kg/m²)	27.7 (6.3)
Logistic EuroSCORE (%)	9.6 (12.9)
Duration of surgery (hours)	4.5 (1.3)
Duration of CPB (min)	135.9 (56.0)
	n (%)
Gender	
Males	404 (67.9)
Females	191 (32.1)
COPD	100 (16.8)
Diabetes	151 (25.4)
Renal failure	32 (5.4)
Type of surgery	
Isolated CABG	264 (44.4)
Other than isolated CABG*	331 (55.6)
Intraoperative RBC administration	116 (19.5)
Emergency status	41 (6.9)
In-hospital mortality	49 (8.2)
ICU readmission	22 (3.7)

BMI = Body mass index, CABG = Coronary artery bypass grafting, COPD = Chronic obstructive pulmonary disease, CPB = Cardiopulmonary bypass, ICU = Intensive care unit, RBC = Red blood cells, *valve surgery, CABG and valve surgery, aorta aneurysm repair ± valve surgery, closure of an atrial septal defect, atrial myxoma removal

Table 2: Reasons for readmission

Cause	n (%)
Respiratory disorder	10 (45.4)
No clear etiology	3
Pleural effusions	2
Atelektasis	2
Pneumothorax	1
Exacerbation of COPD	1
Aspiration	1
Cardiac disorder	6 (27.3)
Hemodynamic instability—Hypotension	2
Cardiac arrest	2
Arrhytmia	1
Cardiac tamponade	1
Renal insufficiency	4 (18.2)
Requiring hemodialysis	3
Cerebrovascular accident	2 (9.1)
Total	22 (100)

COPD = Chronic obstructive pulmonary disease

Table 3: Bivariate analysis between ICU readmission and independent variables

Variables	ICU Readmission		P-value
	No	Yes	
	Mean (±SD)	Mean (±SD)	
Age (years)	67.75 (11.6)	70.09 (8.4)	0.082
BMI (kg/m²)	27.68 (6.3)	27.61 (5.0)	0.950
EuroSCORE (%)	9.34 (12.7)	15.38 (15.0)	0.030
Duration of surgery (hours)	4.52 (1.3)	5.10 (1.75)	0.049
Duration of CPB (min)	134.69 (55.2)	166.82 (67.7)	0.008
	n (%)	n (%)	
Gender			0.02
Males	394 (97.5)	10 (2.5)	
Females	179 (93.7)	12 (6.3)	
COPD			0.05
No	480 (97.0)	15 (3.0)	
Yes	93 (93.0)	7 (7.0)	
Diabetes			0.77
No	427 (96.2)	17 (3.8)	
Yes	146 (96.7)	5 (3.3)	
Renal failure			0.43
No	543 (96.4)	20 (3.6)	
Yes	30 (93.75)	2 (6.25)	
Type of surgery			0.23
Isolated CABG	257 (97.3)	7 (2.7)	
Other than isolated CABG	316 (95.5)	15 (4.5)	
Intraoperative RBC administration			0.70
No	462 (96.5)	17 (3.5)	
Yes	111 (95.7)	5 (4.3)	
Emergency status			0.68
No	534 (96.4)	20 (3.6)	
Yes	39 (95.1)	2 (4.9)	

BMI = Body mass index, CABG = Coronary artery bypass grafting,
COPD = Chronic obstructive pulmonary disease, CPB = Cardiopulmonary
bypass, RBC = Red blood cells, *P* < 0.001

ICU). Female gender, high logistic EuroSCORE values, longer duration of surgery and CPB, and a history of COPD were associated with higher probability for readmission at the level of 5% ($P \leq 0.05$) in bivariate analysis.

The main findings of multivariate analysis are summarized in Table 4. We found that high logistic EuroSCORE values (OR 1.02, 95% CI 1.00-1.04), longer CPB time (OR 1.01, 95% CI 1.00-1.02), and a history of renal failure (OR 1.02, 95% CI 1.00-1.05) were among the independent predictors of ICU readmission. In addition to the above, females had an almost 40% greater probability to be readmitted in the cardiac surgery ICU (for males: OR 0.37, 95% CI: 0.15-0.89). We also observed a positive association between duration of surgery and ICU readmission (OR 1.29, 95% CI 1.00-1.67), but this association did not remain statistically significant (OR 0.94, 95% CI 0.54-1.61) after adjusting to age, body mass index, gender, logistic EuroSCORE, duration of CPB, history of COPD, diabetes and renal failure, type of surgery, intraoperative RBC administration, and emergency status.

Finally, as depicted in Diagram 1, patients who were readmitted to the cardiac surgery ICU had significantly higher in-hospital mortality rates compared to those who were not readmitted (36.4% vs 7.15%, *P* < 0.001).

Discussion

The incidence of readmission to the ICU for the present series of 595 consecutive patients who underwent cardiac surgery was 3.7%, while respiratory disorders were the main cause for readmission. Patients who required readmission had significantly greater probability to die during their hospitalization compared to non-readmitted patients. In addition, among the main findings of this study was the identification of the independent predictors of ICU readmission. In particular, female subjects and patients with high perioperative risk, preoperative renal failure and long duration of CPB had a greater probability for readmission to the cardiac surgery ICU.

The ICU readmission rate of our study is close to the findings of others studies,[3,5,6,10-12] which refer rates from 2.2% to 3.7% among
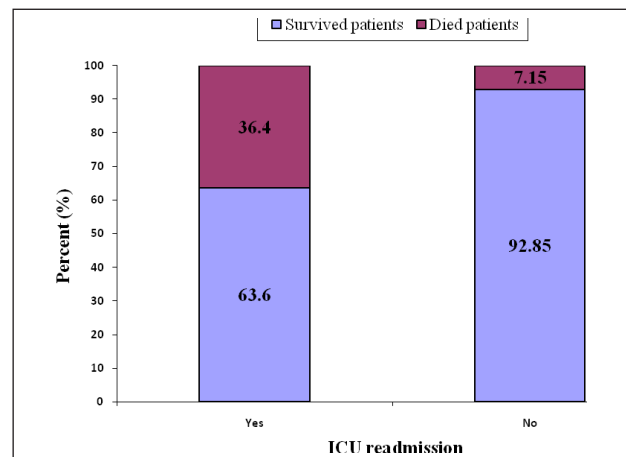

Diagram 1: In-hospital mortality in patients requiring and not requiring ICU readmission

Table 4: Predictors of readmission in the cardiac surgery ICU

Variables	Univariate analysis	Multivariate analysis
	OR (95% CI)	OR (95% CI)
Age (years)	1.04 (0.99-1.09)	1.03 (0.98-1.08)
BMI (kg/m²)	0.99 (0.93-1.07)	1.00 (0.94-1.07)
EuroSCORE (%)	1.02 (1.00-1.05)	1.02 (1.00-1.04)
Duration of surgery (hours)	1.29 (1.00-1.67)	0.94 (0.54-1.61)
Duration of CPB (min)	1.01 (1.00-1.01)	1.01 (1.00- 1.02)
Gender		
Females	1.00	1.00
Males	0.38 (0.16-0.89)	0.37 (0.15-0.89)
COPD		
No	1.00	1.00
Yes	2.41 (0.96-6.07)	2.50 (0.94-6.60)
Diabetes		
No	1.00	1.00
Yes	0.86 (0.31-2.37)	0.69 (0.24-2.00)
Renal failure		
No	1.00	1.00
Yes	1.81 (0.40-8.11)	1.02 (1.00 -1.05)
Type of surgery		
Isolated CABG	1.00	1.00
Other than isolated CABG	1.74 (0.70-4.34)	0.74 (0.25-2.19)
Intraoperative RBC administration		
No	1.00	1.00
Yes	1.22 (0.44-3.39)	0.93 (0.32-2.65)
Emergency status		
No	1.00	1.00
Yes	1.37 (0.31-6.07)	0.62 (0.11-3.41)

BMI = Body mass index, CABG = Coronary artery bypass grafting, COPD = Chronic obstructive pulmonary disease, CPB = Cardiopulmonary bypass, RBC = Red blood cells, ICU = Intensive care unit

cardiac surgery patients. However, Benetis *et al*.,[2] Limathe *et al*.,[7] Joskowiak *et al*.,[4] and Celkan *et al*.[8] reveal in their studies ICU readmission incidence 5%, 5.9%, 7.8%, and 8.75%, respectively. The higher readmission rates than our findings could be justified by the fact that these data come from one-center studies from different countries and cardiac surgery centers, which probably apply different therapeutic and surgical protocols.

Respiratory disorders were the most frequent reason for readmission in the cardiac surgery ICU in our study. Various authors reported the same finding in their studies.[3-7,9,11,12] Respiratory dusfunction remains a leading cause of postcardiac surgical morbidity[13,14] due to factors such as general anesthesia, median sternotomy incision, use of the internal thoracic artery, postoperative analgesia and sedation protocols, and effects of CPB.[15-17]

As aforementioned, female gender was the strongest predictor of readmission in the ICU in our study. Although Vaccarino *et al*.[18] reported that the rates of hospital readmission were significantly higher in women who underwent coronary artery bypass grafting (CABG), from the literature review, we did not find studies investigated the "ICU readmission" outcome. Female gender is possibly a risk factor for poor outcomes

in cardiac surgery patients, such as higher intraoperative complications[19] and longer ICU length of stay.[20] In addition, female gender is among the variables which are included in EuroSCORE model and reflects higher perioperative risk for cardiac surgery patients and women have more comorbidities at surgical presentation compared with men.[19] Consequently, the higher clinical severity in conjunction with the poor outcomes associated with females could justify why these patients are at higher risk for ICU readmission.

Not surprisingly, we noted that high EuroSCORE values were associated with significantly higher probability for ICU readmission. In line with our finding, Chung *et al*.[10] in their retrospective study of 130 cardiac surgery patients concluded that patients with increased EuroSCORE had an almost 14% higher probability to required readmission. In addition, Kogan *et al*.[11] conducting a prospective follow up study in a large patient series report significantly strong association between high EuroSCORE and readmission to the cardiac surgery ICU. Another important finding of this study was the significant association between the preoperative renal failure and the greater rates of readmission in the ICU. Similar to our result, as highlighted by the studies of Bardell *et al*.,[6] and Limathe *et al*.,[7] the history of renal failure is an independent predictor for readmission in the ICU among patients who underwent open heart surgery.

Patients of high perioperative risk and those with preexisting renal failure are characterized as high-risk surgical patients with higher severity and increased incidence of postoperative complications, such as hemorrhage and strokes.[21,22] Consequently, the readmission of these patients in the ICU in order to achieve clinical stability and safety is rather reasonable.

Duration of CPB was the only intraoperative variable which was associated with readmission in the ICU. In line with our results, Benetis *et al*.[2] in a recent case control study of 169 patients who underwent isolated CABG found that prolonged CPB time (>103 min) is among the independent predictors for readmission to the ICU. It is known that the use of CPB has been associated with a systematic inflammatory response, abnormal heart rhythm, pulmonary complications, disruption of the coagulation system, postoperative bleeding, adverse cerebral effects, and renal dysfunction.[15,23-27] These circumstances could compose the clinical profile of a critically ill patient who is possibly going to require readmission to the ICU for more effective therapeutic management. If CPB time reduction can prevent readmission to the ICU, it is an even more important issue in cardiac surgery patients.

Finally, we found that readmitted patients had significantly greater in-hospital mortality rates compared to patients who did not require ICU readmission during their hospital stay. Numerous studies on cardiac operated patients are in accordance with our finding.[2-6,10,12] Obviously, the clinical instability and severity of patients required readmission to the ICU for critical and intensive care could interpret the higher mortality rates among this patient group. The readmission to the ICU is a well known indicator of poor prognosis[28,29] and comes as a result of severe postoperative complications.[4,5,7]

Our study allows us to reach significant conclusions regarding the preoperative and intraoperative predictors of readmission to the ICU following cardiac surgery. In addition, to the best of our knowledge, the present study is the first Greek study aiming to investigate parameters that could predict the ICU readmission and consequently to contribute to administrative decisions regarding the provided care and the ICU resources' allocation. However, this study has some limitations, such as retrospective design, small sample size, and the fact that data were collected by one cardiac surgery centre. These limitations limit the generalization of the findings to the general cardiac surgical population and affect the validity of the study.

Conclusions

One intraoperative and three preoperative variables were the independent predictors of readmission in the cardiac surgery ICU. The knowledge of these parameters allows the early identification of high risk patients for readmission following open heart surgery. Female subjects, patients with a history of renal failure, and those with increased perioperative risk (high EuroSCORE values) could be targeted due to their significantly higher probability for requiring ICU readmission, ensuring both the safe initial discharge from ICU and receiving of care that these patient require on the ward by highly skilled and experienced healthcare professionals, who are capable to recognize and manage rapidly and effectively severe and life threatening conditions and complications. Moreover, the identification of a modifiable risk factor has great significance for clinicians since decreasing the length of CPB could achieve lower incidence of ICU readmission for cardiac surgery patients.

Further research is needed based on multicentre studies, prospective design and investigation of new areas, such as the patient management after the initial discharge from ICU to a general ward, the impact of ward medical and nursing staff levels and expertise on the care of critically ill patients received, the development of a tool for the early identification of high-risk cardiac surgery patients and the healthcare cost of ICU readmission.

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