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Does EuroSCORE Predict intensity of Postoperative Care and Rehabilitation Parameters? A Prospective Evaluation

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Abstract

Objective: An increasing number of elderly and multi-morbid patients undergo cardiac surgery which results in increased postoperative morbidity, prolonged Intensive Care Unit (ICU) length of stay (LOS) and higher hospital costs. We aimed to evaluate the model of the European System for Cardiac Operative Risk Evaluation (EuroSCORE) for the prediction of ICU LOS, hospital LOS, required daily nursing effort, and the type of cardiac rehabilitation.

Methods: Prospective observational evaluation of 505 consecutive adult patients (mean age 65.1 ± 12.1 years, 25.7% female) who underwent cardiac and/or thoracic aortic thoracic surgery with Cardiopulmonary Bypass (CPB).

Results: Median additive and logistic EuroSCORE was 5 (Interquartile Range (IQR) 3-7) and 5.8 (IQR 2.6-14.1), respectively. In univariate analysis both additive and logistic EuroSCORE were significantly associated with prolonged ICU LOS, prolonged hospital LOS, higher daily nursing effort, and the type of cardiac rehabilitation (inpatient versus outpatient), p<0.001 for all correlations.

Multivariate analysis including other clinically relevant variables (CPB duration, type of operation, age, Body Mass Index (BMI), urgency of surgery, Left Ventricular Ejection Fraction (LVEF)) showed higher additive EuroSCORE and higher logistic EuroSCORE, independently associated with prolonged ICU LOS, prolonged hospital LOS, and higher daily nursing effort. However, EuroSCORE did not independently predict the type of rehabilitation.

Conclusion: The EuroSCORE model can be used to identify patients with elevated risk for prolonged ICU LOS, prolonged hospital LOS and higher intensity of postoperative workload, and it is predictive for the type of rehabilitation. This conclusion may contribute to optimize the management of hospital bed capacity as well as a systematic planning of ICU resources, postoperative nursing care and cardiac rehabilitation.

Keywords: EuroSCORE, Cardiac surgery; Rehabilitation, Workload of nursing care

Abbreviations:

BMI: Body Mass Index; CABG: Coronary Artery Bypass Graft; CPB: Cardiopulmonary Bypass; EuroSCORE: European System for Cardiac Operative Risk Evaluation; IABP: Intra-aortic Balloon Pump; ICU: Intensive Care Unit; IMC: Intermediate Care Unit; LVEF: Left Ventricular Ejection Fraction; MI: Myocardial Infarction; PRN: Projet de Recherche en Nursing; SD: Standard Deviation

Introduction

Patient`s profile in cardiac surgery has considerably changed over the last 25 years [1]. Despite the increasing number of elderly and multi-morbid patients, in-hospital mortality in cardiac surgery remained unchanged or could be reduced [1]. In consequence, a higher rate of postoperative morbidity is associated with prolonged ICU LOS and, in this clinical setting, with a remarkable increase of individual health care costs per patient [2-4]. Therefore, optimal utilization of a hospital's resources becomes more and more important.

Prediction of ICU LOS and hospital LOS are decisive information for a hospital's management to allocate resources and to estimate hospital costs. In addition, estimation of intensity of postoperative nursing care during hospitalization allows calculation of required human resources for adequate nursing in a specified patient population. Patients who have undergone cardiac surgery routinely participate during hospitalization (Phase I rehabilitation) and after discharge (Phase II rehabilitation) in cardiac rehabilitation programs which are performed as inpatient or outpatient programs. Preoperative prediction of the appropriate type of rehabilitation is desirable for an optimal planning of the entire therapeutic concept.

The EuroSCORE model was first introduced in 1999 as an additive predictive system for 30-day mortality after cardiac surgery [5,6]. Several external validation studies justified the widespread use of both of the additive EuroSCORE and the logistic EuroSCORE, introduced in 2003 [7-9]. In addition, it has been demonstrated that EuroSCORE has also predictive validity for other outcome measures than operative mortality [9]. Recently, the modified EuroSCORE II has been

introduced as a further advancement of additive and logistic EuroSCORE [10].

The aim of this prospective observational cohort study was to evaluate the additive and logistic EuroSCORE model for the prediction of ICU LOS, hospital LOS, and required postoperative nursing effort in patients undergoing cardiac surgery. In addition, we investigated if EuroSCORE may predict the type of cardiac rehabilitation.

Methods

Study population

In this prospective, single-center (University Hospital Bern, Switzerland) observational study, 505 consecutive adult patients were included who had undergone cardiac and/or thoracic aortic surgery with cardiopulmonary bypass (CPB) within a six month period. The initial intent of this study was to evaluate intensity of nursing care after cardiac surgery, specifically focused on nursing effort and type of cardiac rehabilitation. The study was supported by the Department of Health and Social Welfare of the Canton of Bern and was approved by the ethical review committee. All patients provided written informed consent.

Preoperative risk factors were recorded according to the EuroSCORE model [6,11]. For study purpose prolonged ICU LOS was defined as >2 subsequent nights on ICU, and prolonged hospital LOS was defined as >/=8 days of postoperative hospitalization.

To determine daily nursing effort after transfer from ICU to the regular ward, the standardized "Projet de Recherche en Nursing" (PRN) system was used [12]. The PRN system, developed for evaluation of nursing personnel requirements, had been extensively validated [13-15], and had been used in clinical routine in our hospital for more than a decade. Briefly, for standardized recording of nursing workload, 214 indicators or tasks are considered for cumulative description of patient-specific measures within a twenty-four hour period. A point value is assigned to each indicator, whereby each point represents five minutes of nursing work. This "average" time methodology is based on the average amount of time required for the measuring on an average day, by an average nurse, for an average patient [16].

For all patients after cardiac and/or thoracic aortic operations, participation in a cardiac rehabilitation was intended. Rehabilitation was performed either as inpatient or outpatient program. Inpatient rehabilitation was preferred for patients with a complicated postoperative course, distinct co-morbidities, the need for intensive medical care, the need for milieu change or a lack of homecare. Benefits of outpatient rehabilitation include the patient's possibility of part-time work, an extended time period of rehabilitation, the closeness to the patient's home, and the inclusion of relatives.

Definitions of the Society of Thoracic Surgeons Adult Database were used for data recording [www.sts.org/national-database] [17]. In addition, preoperative renal failure was defined as serum creatinine > 200 µmol/l and/or dialysis, postoperative renal failure as elevation of serum creatinine > 172 µmol/l and elevation > 50% compared to preoperative baseline creatinine. Urgent operation was defined as < 24 hours after diagnosis/indication [17].

Data analysis

In the descriptive statistics, metric variables are presented as mean and standard deviation, categories are presented as number and percentage. To investigate the relationship between PRN and EuroSCORE (additive as well as logistic), we calculated a correlation analysis (Pearson). To adjust for suspected confounders, we performed multiple regression analyses: a linear regression with mean PRN as dependent variable and several logistic regression analyses with prolonged hospital LOS, prolonged ICU LOS and type of rehabilitation (inpatient or outpatient) as dependent variables, respectively. As suspected confounders, we included CPB duration, type of cardiac operation (isolated Coronary Artery Bypass Graft (CABG) or other cardiac surgery), age, BMI, urgency of surgery (elective or urgent), and preoperative LVEF. Alternatively, we performed a separate analysis for additive and logistic EuroSCORE. All p-values and confidence intervals are 2-sided, a $p < 0.05$ is considered significant.

All statistical analyses were performed using the computerized software package SPSS for Windows Version 17.0.

Results

Mean age in the entire study population was 65.1 ± 12.1 years, 130 (25.7%) patients were female. Complete patient demographics and perioperative data are presented in the Table. Median additive EuroSCORE was 5 (IQR 3 - 7), and median logistic EuroSCORE was 5.8 (IQR 2.6 - 14.1).

	(n = 505)
Age, years	65.1 ± 12.1
Female sex, n (%)	130 (25.7)
Cardiovascular risk factors	
Diabetes mellitus, n (%)	129 (25.5)
Hypertension, n (%)	380 (75.4)
Adiposity, n (%)	229 (45.3)
Dyslipidemia, n (%)	300 (59.5)
Smoker, n (%)	245 (48.6)
Body Mass Index, kg/m^2	26.9 ± 4.6
Family history, n (%)	121 (24.0)
Left ventricular ejection fraction	
≥ 50, n (%)	375 (74.3)
30-49, n (%)	99 (19.6)
≤ 29, n (%)	31 (6.1)
EuroSCORE	
Additive, median [IQR]	5 [3 - 7]
Logistic, median [IQR]	5.8 [2.6 - 14.1]
Peripheral artery disease, n (%)	73 (14.5)
Chronic lung disease, n (%)	77 (15.4)

Previous cardiac operation, n (%)	58 (11.5)
Previous stroke, n (%)	55 (10.9)
Previous myocardial infarction	
< 6 - 24 hours before operation, n (%)	22 (4.4)
1 -21 days before operation, n (%)	88 (17.4)
> 22 days before operation, n (%)	65 (12.9)
none, n (%)	281 (55.6)
Unknown, n (%)	49 (9.7)
Preoperative IABP, n (%)	7 (1.4)
Preoperative renal failure, n (%)	15 (3.0)
Urgent operation, n (%)	143 (28.3)
Type of operation	
CABG only, n (%)	231 (45.7)
CABG and valve, n (%)	69 (13.7)
CABG and other, n (%)	38 (7.5)
CABG and valve and other, n (%)	24 (4.8)
Valve only, n (%)	52 (10.3)
Valve and other, n (%)	61 (12.1)
Other, n (%)	30 (5.9)
CPB duration, min	88.6 ± 40.6
Off-pump, n (%)	6 (1.9)
Time of operation, min	190.4 ± 63.3
Cross-clamp time, min	57.6 ± 27.8
Intraoperative / early postoperative IABP, n (%)	8 (1.6)
Postoperative complications	
Bleeding or tamponade, n (%)	30 (5.9)
Stroke, n (%)	8 (1.6)
Renal failure, n (%)	46 (9.1)
30-day mortality, n (%)	17 (3.4)
Length of hospital stay, days, median [IQR]	9 [8 - 13]
Length of ICU stay, nights, median [IQR]	1 [1 - 2]
Length of IMC stay, days, median [IQR]	1 [0 - 2]
PRN	
Daily, points, median [IQR]	63.8 [54.3 - 77.7]
Total, points, median [IQR]	437 [311 - 668]
First day on ward, points, median [IQR]	131 [86 - 143]
Rehabilitation program	
Inpatient, n (%)	349 (69.1)

Outpatient, n (%)	113 (22.4)
None, n (%)	12 (2.4)
Neurologic Rehabilitation, n (%)	4 (0.8)
Unknown, n (%)	10 (2.0)
Data are mean ± SD unless otherwise specified	

Table 1: Patient demographics and clinical characteristics

In the univariate analysis, both additive and logistic EuroSCORE were significantly associated with prolonged ICU LOS (p<0.001 for both correlations, Figure 1), prolonged hospital LOS (p<0.001 for both correlations, Figure 1), increase in daily nursing effort (p<0.001 for both correlations, Figure 2), and the type of rehabilitation (inpatient versus outpatient; p<0.001 for both correlations).
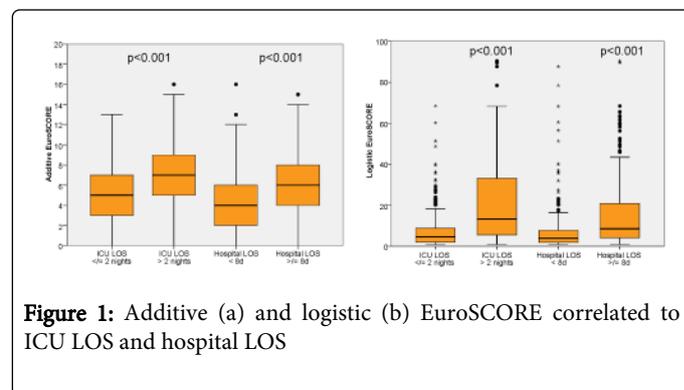

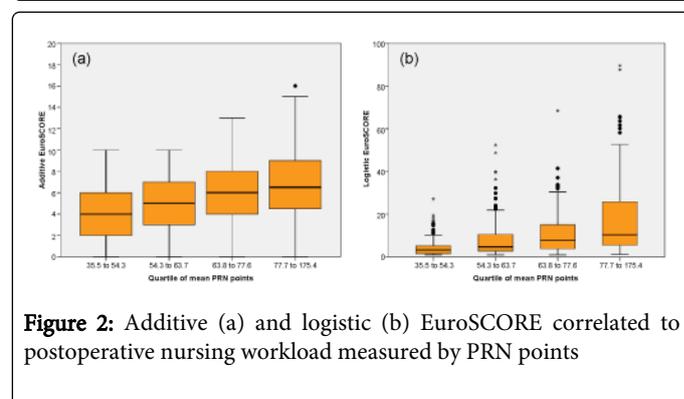**Figure 1:** Additive (a) and logistic (b) EuroSCORE correlated to ICU LOS and hospital LOS

Figure 2: Additive (a) and logistic (b) EuroSCORE correlated to postoperative nursing workload measured by PRN points

Longer CPB duration (p<0.001), status of urgent operation (p<0.001), lower LVEF (p=0.015) and both higher additive EuroSCORE (p<0.001) and higher logistic EuroSCORE (p=0.003) were independently associated with prolonged ICU LOS. Type of operation, age and BMI were not significantly associated with ICU LOS.

The type of cardiac operation, other than isolated CABG, higher age and both higher additive and higher logistic EuroSCORE were independently associated with prolonged hospital LOS. CPB duration, BMI, status of urgent operation and lower LVEF were not significantly associated with hospital LOS.

In linear regression analysis, mean daily nursing effort was significantly higher in patients with longer CPB duration (p=0.005), higher age (p=0.016) and higher EuroSCORE both additive (p=0.002)

and logistic (p<0.001). The type of cardiac operation, BMI, status of urgent operation and lower LVEF were not significantly associated with mean daily nursing effort.

In the multivariate regression analysis, neither additive nor logistic EuroSCORE showed independent association with the type of rehabilitation. The only remaining independent association was detected for the age of the patient: higher age was found to be predictive for inpatient rehabilitation (p<0.001, odds ratio 1.051 with 95% confidence interval 1.026 to 1.076).

Discussion

Risk stratification models, created for patients undergoing cardiac surgery, are clinically helpful tools in various aspects. Prediction of outcome variables is useful to clinicians in individual patient treatment (e.g. indication for surgery, preoperative counselling) and is, in a more general aspect, the basis for quality monitoring of a hospital's process flow. In addition, risk stratification may be used to estimate needed hospital resources and the amount of overall health care costs for specific treatments [18].

The EuroSCORE model is the most widely evaluated and validated risk stratification system in cardiac surgery [6,11]]. Initially developed as an additive scoring system for the prediction of the 30-day mortality, it has been modified later by a logistic regression model [19]. The logistic model shows better individual risk prediction, especially in high-risk patients, whereas the additive EuroSCORE underestimates the risk [20-22].

Besides prediction of 30-day mortality, it has been demonstrated that the EuroSCORE model is also predictive for long-term mortality, specific postoperative complications, long-term health-related quality of life, as well as direct operative costs in patients undergoing cardiac surgery [3,9,23,24]. Furthermore, the EuroSCORE model has been used to estimate changes in patients risk profile over time [25].

In the present study we demonstrated that both the additive and the logistic EuroSCORE model independently predict prolonged ICU LOS, prolonged hospital LOS, and postoperative nursing workload. Higher EuroSCORE was associated with inpatient rehabilitation after surgery, but was not independently predictive for the type of cardiac rehabilitation (inpatient versus outpatient).

With respect to the outcome measures ICU LOS and hospital LOS, our study confirms previous findings [5,26]: Ettema and associates validated several prediction models for prolonged ICU stay after cardiac surgery and found that both Parsonnet score and EuroSCORE had superior discrimination compared to other predictive scores [27]. Interestingly, both models widely implemented in clinical practice, were originally derived and validated only for the prediction of mortality after cardiac surgery.

A valid tool for the prediction of ICU LOS und hospital LOS, such as EuroSCORE, is important for clinicians, patients and a hospital's management: Clinicians weigh up the risks and benefits of an indicated operation and perform counselling of patients and relatives in an optimal manner. Patients with predicted lower risk for postoperative complications and estimated short stay on ICU may be planned in the daily operating program before other patients, in order to improve efficiency in the use of operating room and ICU resources [27]. Based on the prediction of ICU LOS and hospital LOS, a hospital's management is enabled to implement strategies for the planning of capacity utilization, the allocation of resources and the estimation of costs.

Nursing workload is a relevant determinant of adequate postoperative care on ICU and regular ward, and a cornerstone in the planning of human resources and the calculation of hospital costs. We were able to demonstrate that EuroSCORE is independently associated with nursing workload on the regular ward. No previous investigations have been focused on this outcome measure. Our findings suggest that patients with higher EuroSCORE do not only have a higher probability for prolonged hospital stay but also for more intense nursing care. For that reason, EuroSCORE seems to be a valid tool for administrative planning of nursing. As a conclusion, surgical units where patients with higher EuroSCORE level are operated need a higher nurse/patient ratio.

Both inpatient and outpatient cardiac rehabilitation programs are evidence-based methods for secondary prophylaxis and reintegration of patients into daily life after cardiac surgery. Information about the anticipated in-hospital postoperative course and further treatment after discharge is essential for patients and their relatives. An early planning of a patient's transfer following hospitalization is wishful for an optimal utilization of a hospital's infrastructure and therefore of hospital costs. To our knowledge, no other study has been focused so far on the association between EuroSCORE and the type of cardiac rehabilitation. Our data demonstrate that EuroSCORE predicts the type of postoperative cardiac rehabilitation in the univariate analysis but not in the multivariate analysis. Out of all tested clinical variables (CPB duration, type of operation, age, BMI, urgency of surgery, LVEF), only higher age was independently associated with inpatient rehabilitation.

Limitations of this trial include the single center design of our investigation. Since inpatient rehabilitation is established only in a few European countries, prediction of the type of rehabilitation is limited to these countries. Furthermore, our institution is a tertiary care university hospital, not having an inpatient rehabilitation center at its disposal. This fact may have led to longer hospital stay. The predictive validity of EuroSCORE for the type of rehabilitation may be limited, because EuroSCORE only weighs up medical variables. However, there are strong social reasons influencing the decision for either inpatient or outpatient rehabilitation. In addition, the availability of appropriate rehabilitation programs as well as the patient's requests may confound our results.

Since the time frame of our study was set before the presentation of the modified EuroSCORE II, we were not able to implement this new version of the predictive model in our study [10]. Further studies are needed to evaluate predictive validity of the new EuroSCORE II regarding other outcome parameters than operative mortality.

A close collaboration between centers for cardiac surgery and rehabilitation facilities is essential for patients, in order to be integrated into a rehabilitation program according to their physical abilities and for early reintegration into daily life.

In conclusion, our prospective observational study confirms that both additive and logistic EuroSCORE are predictive for ICU LOS and hospital LOS after cardiac surgery. We were able to demonstrate the very new aspect that additive and logistic EuroSCORE are also predictive for nursing workload after surgery and for the appropriate type of rehabilitation. EuroSCORE is a widely implemented model for preoperative risk prediction of mortality in cardiac surgery. Therefore, our findings support the use of the EuroSCORE model to detect

patients with elevated risk for prolonged ICU stay and prolonged hospital stay as well as to identify patients who need more intense postoperative nursing care. These latest scientific findings may contribute to optimize the management of hospital bed capacity as well as a systematic planning of ICU resources, postoperative nursing care and cardiac rehabilitation.

Acknowledgements

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