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Can EuroSCORE predict direct costs of cardiac surgery?[☆]

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Abstract

Objective: The aim of this study is to determine if a preoperative risk stratification model can identify different surgical costs. **Methods:** Four hundred and eighty-eight patients undergoing open heart surgery between March 2000 and March 2001 were classified with the EuroSCORE model. Direct variable costs were prospectively collected, surgical team costs excluded. The multivariate analysis was used to find variables independently associated with costs. **Results:** Of the 488 patients enrolled 342 (70%) were males, mean age 65 ± 10 years, 57 (12%) had myocardial infarction, 20 (4%) had ejection fraction $< 30\%$, 56 (11%) were operated in emergency, 26 (5%) had a re-operation. 113 (23.2%) were operated for valvular disease, 30 (6.1%) were operated for thoracic aortic surgery, one (0.2%) was operated for interatrial septal defect, 79 (16.2%) were operated for other intervention in addition to coronary bypass and 265 (54.3%) for isolated coronary bypass. The mean intensive care unit length of stay (ICU-LOS) was 2.3 ± 4.1 days and the postoperative LOS was 8.2 ± 5.3 days. According to EuroSCORE, 117 patients (24%) were at low, 187 (38%) at medium, and 184 (38%) at high risk. Costs were significantly and directly correlated with preoperative risk model with a correlation coefficient of 0.47 and an increase of costs of 3.5% (95% CI 2.3–4.7, $P < 0.0001$) for each single rise of risk score. The relationship EuroSCORE vs. direct costs is, respectively: EuroSCORE 0–2 $\Rightarrow 6863 \pm 861$ €; 3–4 $\Rightarrow 8292 \pm 3714$ €; 5–6 $\Rightarrow 8908 \pm 3480$ €; 7–8 $\Rightarrow 10,462 \pm 6123$ €; 9–10 $\Rightarrow 13,711 \pm 12,634$ €; $> 10 \Rightarrow 21,353 \pm 18,507$ €. Excluding EuroSCORE from the preoperative logistic model, age, preoperative creatinine, critical condition, ejection fraction, re-operation and sex were independently correlated with costs. **Conclusions:** From our data the EuroSCORE model developed to predict (30-day postoperative) hospital mortality could be used to predict direct operative costs and identify patients with different levels of resource consumption. © 2003 Elsevier Science B.V. All rights reserved.

Keywords: Costs; Risk models; Cardiac surgery

1. Introduction

During the last two decades a major case-mix evolution has been observed in cardiac surgery [1], both in North America and in Europe.

Despite an increase of average perioperative mortality risk^{1,2}, since older patients, more acute, and with more co-

morbidity, are referred to cardiac surgery³, the hospital mortality was unchanged or slightly reduced¹ [2,3]. Meanwhile an increase of postoperative complications led to an increase of surviving patients, but at the cost of a higher rate of complications [4], of prolonged intensive care unit (ICU) length of stay (LOS) [5–7] and of a remarkable increase of individual costs [8,9].

The identification of candidates to cardiac surgery at risk of prolonged stay in ICU and relative higher costs may be useful in order to allocate limited resources both for budgetary reasons and for negotiating the prospective charges with public and private financing institutions. At present there are no available statistical models, specifically validated, to predict individual costs in cardiac surgery.

In order to assess whether a preoperative predictive

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¹ From <http://www.clevelandclinic.org/heartcenter/pub/about/default.asp>

² From <http://www.scts.org/doc/5483>

³ From <http://space.tin.it/salute/ppinnapi/symp2000/edwards.htm>

model, designed to identify the mortality risk in cardiac surgery, can also be applied to predict costs, we compared in our population the preoperative risk stratification obtained using the EuroSCORE model [10], or the single variables of the EuroSCORE model, with costs.

2. Materials and methods

From March 2000 to March 2001 488 patients underwent cardiac surgery at our institution. For each patient selected, demographic and clinical preoperative characteristics were used to calculate the EuroSCORE: a risk stratification model, widely validated on the European population and already diffused and used in the cardiac surgery centers also in Italy [11] for quality assurance of outcome.

The direct variable costs (disposable materials, diagnostic tests, drugs, laboratory test and blood components) were prospectively collected. We decided to exclude hospital fixed costs and surgical team costs because they are related to specific activities and it is not possible to generalize them to other Institutions. The EuroSCORE subdivides patients in three main risk groups (low, medium, and high risk). In order to have a more detailed analysis of the relationship between costs and the EuroSCORE we decided to divide the preoperative mortality risk of patients in six groups of increasing risk and then we calculated the mean costs.

A linear regression analysis with the log-transformed direct costs was used to explore the association of the EuroSCORE model and its variables with costs. A covariance analysis (ANCOVA) using direct costs as dependent variable was used with two models: the first one including only clinical and operative variables in the explanatory model and the second including also the EuroSCORE.

3. Results

Of the 488 patients enrolled 342 (70%) were males, mean age 65 ± 10 years, 113 (23.2%) were operated for valvular disease, 30 (6.1%) were operated for thoracic aortic surgery, one (0.2%) was operated for interatrial septal defect, 79 (16.2%) were operated for other intervention in addition to coronary bypass and 265 (54.3%) for isolated coronary artery bypass graft (CABG).

Table 1 describes the variables used to calculate the EuroSCORE of our population and the operating and follow-up characteristics. According to EuroSCORE 117 (24%) were at low, 187 (38%) at medium, and 184 (38%) at high risk. The mean ICU-LOS was 2.3 ± 4.1 days and the postoperative LOS was 8.2 ± 5.3 days. The overall crude 30 day mortality was 4.7% (23 patients).

In Table 2 are summarized the association between the six groups of increasing mortality risk and costs.

First of all in a linear regression analysis EuroSCORE

Table 1
Patients' clinical, operating and follow-up characteristics

Variables	# Pts	%
EuroSCORE variables		
Male	342	70
Mean age (years)	65 ± 10	
COPD	18	4
Vascular peripheral disease	58	12
Cerebrovascular disease	2	0.4
Infectious endocarditis	3	0.6
Critical state	6	1.2
Unstable angina	39	8
Pulmonary artery pressure (>60 mmHg)	2	0.4
Intervention other than or in addition to bypass	79	16.2
Thoracic aortic surgery	42	8.5
Postinfarctual septal disease	0	-
Previous AMI	57	12
EF (<30%)	20	4
Emergency	56	11
Re-operation	26	5
Creatinine (>2.0 mg/dl)	21	4
EuroSCORE classes		
Low risk (<3)	117	24
Medium risk (3 ± 6)	187	38
High risk (>6)	184	38
Follow-up		
Mean ICU-LOS (days)	2.3 ± 4.1	
Mean postoperative-LOS (days)	8.2 ± 5.3	
30 days crude mortality	23	4.7

was significantly associated with the log-transformed direct costs, with a correlation coefficient of 0.47 and an increase of costs of 3.5% (95% CI 2.3–4.7, $P < 0.0001$) for each single rise of risk score (Fig. 1).

Finally, we performed a covariance analysis using direct costs as dependent variable and including only clinical and operative variables in the explanatory model. If the EuroSCORE was excluded variables like age, preoperative serum creatinine, critical preoperative state, left ventricular (LV) dysfunction, previous cardiac surgery, surgery on thoracic aorta, interventions other than or in addition to CABG, and sex were independently associated with costs (Table 3).

Table 2
Direct costs for each group of mortality risk

EuroSCORE	Number of patients	Costs (mean ± DS) in €
0–2	117	6863 ± 861
3–4	124	8292 ± 3714
5–6	121	8908 ± 3480
7–8	81	$10,462 \pm 6123$
9–10	31	$13,711 \pm 12,634$
>10	14	$21,353 \pm 18,507$

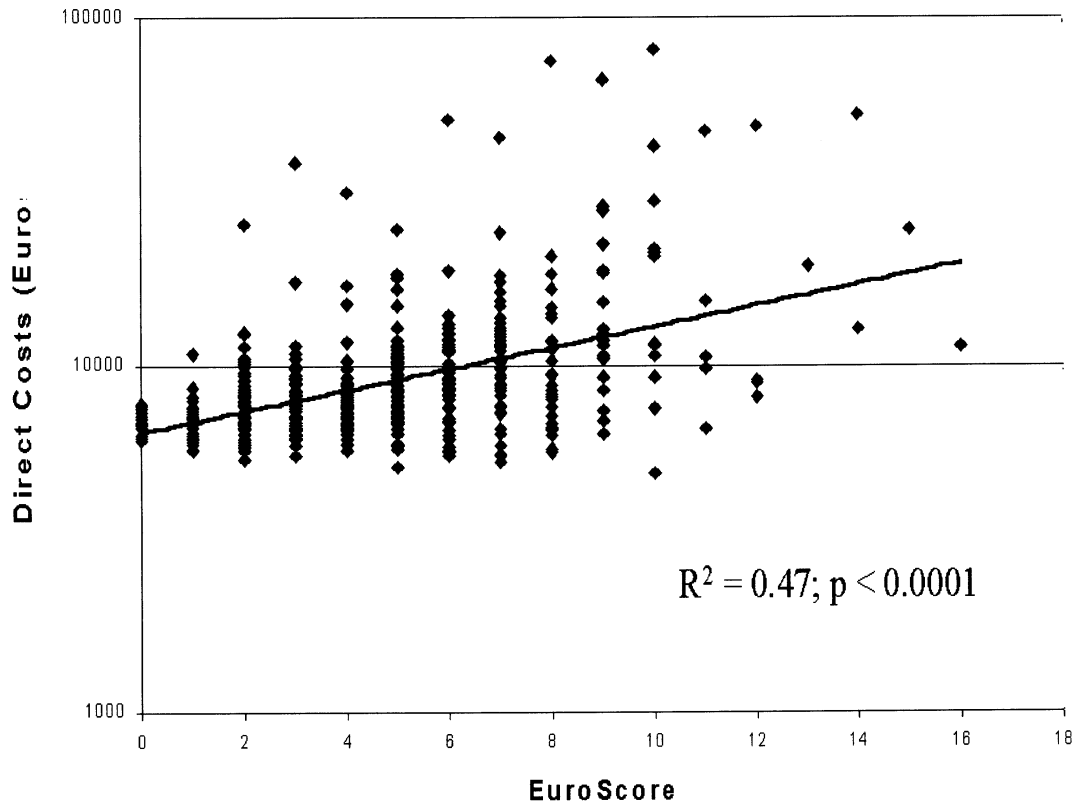


Fig. 1. Linear regression analysis: Euroscore vs. log-transformed direct costs; increase of costs 3.5% (95% CI 2.3–4.7), $P < 0.0001$ for each single rise of risk score.

4. Discussion

Charges were used in several economic evaluations of cardiac surgery but in this study we performed a thoughtful analysis of direct variable costs. From our data the EuroSCORE model, developed to predict (30-day post-operative) hospital mortality, could be used to predict direct variable costs and to identify patients with different levels of resource consumption. Similar results were recently obtained in a retrospective analysis by Sokolovic et al. [12].

Furthermore, some of the variables included in the EuroSCORE model showed an independent association

with costs. This should be kept in mind when it should be decided whether to refer a patient to cardiac surgery, because patients with these risk factors, alone or differently combined, could have higher costs, lower cost-benefit relation and probably longer ICU-LOS in addition to higher mortality risk. Thus, it would be desirable that another form of medical or surgical treatment will be suggested in this subset of higher risk patients. If our data are confirmed by other investigations, cardiologists, and cardiac surgeons will have more information to include into the decision model. We should be aware that the decision to refer a patient to cardiac surgery should not be confined only to the risk of

Table 3
Clinical and operative variables independently associated with costs

Variables	% Cost increase	95% CI	P
Age (years)	0.5 per year	0.2–0.8	0.0028
Serum creatinine (>2.0 mg/dl)	9.4	1.4–18.1	<0.0001
Critical preoperative state	78.3	32.2–140.3	0.0001
LV dysfunction (EF < 30%)	36.6	16.1–60.8	0.0001
LV dysfunction (EF = 30–50%)	22.9	4.5–44.6	0.0113
Previous cardiac surgery	49.7	30.5–71.7	<0.0001
Surgery on thoracic aorta	20.6	7.8–34.8	0.0009
Other than isolated CABG	36.6	27.3–46.6	<0.0001
Sex (female)	12.1	4.5–20.1	0.0012

death, but also to the risk of long and costly hospital stays that are translated into a painful anguish for either the patient or his/her relatives. Shortly, all European centers will be able to automatically calculate the preoperative EuroSCORE of each patient, so that surgeons will have a simple tool to check their performance and to improve their outcome not only in terms of mortality but also of quality of life for their own patients.

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Appendix A. Conference discussion

Dr T. Wahlers (Jena, Germany): I think it is a very important study concerning the changing pattern of patients we are dealing with, and, in our opinion, you can identify the costs mostly on the length of the ICU stay. So my question is, have you looked with a mean of 2.6 days ICU stay whether you find a direct correlation with the ICU stay in this model with regard to the costs, because the costs, in my opinion, mainly depend, aside from the surgery, on the ICU performance of the patient?

Dr Pintor: Is it a comment or a question?

Dr Wahlers: The length of the ICU stay, because you have given only the mean of all your patients, and the relation to the EuroSCORE.

Dr Pintor: The length of stay is 2.5 days.

Dr Wahlers: Right, and my question is whether you have looked up if the ICU stay is proportional, longer, in the patients with the higher EuroSCORE.

Dr Pintor: Yes, in another study, that was not presented here, we found a statistically significant correlation between the EuroSCORE and the ICU and postoperative length of stay.

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