

Role of Surgeon in Length of Stay in ICU after Cardiac Bypass Surgery

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Received 27 June 2009; Accepted 08 October 2009

Abstract

Background: We presumed that the surgeon himself has an impact on the results after coronary artery bypass grafting (CABG) as there is no unique protocol for the discharge of post-operative cardiac patients at our institution. Therefore, we examined whether the surgeon himself has an impact on the intensive care unit (ICU) stay of isolated CABG patients.

Methods: We prospectively studied a total of 570 consecutive patients undergoing elective CABG. Length of stay in the ICU was defined as the number of days in the ICU unit post-operatively. Seven operating surgeons were classified in 3 categories on the basis of the mean hospital stay of their patients (1, 2 and 3 if the mean total patients' stay in hospital was <8 days, between 8 to 10 days, and longer than 10 days; respectively). Using a multivariable regression model, we determined the independent predictors of length of stay in the ICU (> 48 hours) and examined the role of surgeon in this regard.

Results: Incidence of post-operative arrhythmia and length of ICU stay were higher in the patients of surgeon category 3 than those of surgeon categories 1 and 2. Surgeon category 3 also operated on patients with higher EuroSCOREs than did surgeon categories 1 and 2. With the aid of a multivariable stepwise analysis, three variables were identified as independent predictors significantly associated with ICU length of stay: age, history of cerebrovascular accident, and surgeon category.

Conclusion: Surgeon category may independently predict a prolonged length of stay in the ICU. We suggest that a unique discharge protocol for post-CABG patients be considered to restrict the role of surgeon in the ICU stay of these patients.

J Teh Univ Heart Ctr 1 (2010) 9-13

Keywords: Intensive care units • Length of stay • Coronary artery bypass

Introduction

Despite major improvements in peri-operative management, a remarkable proportion of cardiac surgery patients are monitored in the intensive care unit (ICU) for a period of time longer than usual recovery period.¹ A prolonged length of stay (LOS) in the ICU following cardiac surgery is linked with poor patient outcomes and possibly restricts the overall number of performed procedures.² Prolonged hospitalization also considerably increases the expenditure of health

resources.^{3, 4} Thus, to improve care efficiency, institutions often need to identify patients that possibly need a longer period of high dependency care after cardiac surgery. Among cardiac surgeries, coronary artery bypass grafting (CABG) has received particular attention in this regard because it is an expensive and commonly performed procedure.^{4, 5}

Furthermore, increased ICU stay in cardiac surgery patients has been related to a significant reduction in long-term survival;⁶ therefore, the ability to precisely predict the duration of stay in the ICU and patient outcome is of

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essential importance.

Many studies have reported the factors affecting the length of post-operative ICU stay, but since a large number of variables could be considered,⁷ disparity in study results exists. Moreover, there is not a unique protocol for discharging the post-operative patients at our institution, so we presumed that surgeon himself has an impact on the results after CABG surgery as well as on the ICU stay and costs.

We, therefore, undertook this prospective study to determine pre-operative and intra-operative predictors contributing to prolonged LOS in the ICU with a special focus on the role of individual surgeons in influencing surgery outcomes.

Methods

From May to September 2006, we prospectively studied a total of 570 consecutive patients undergoing elective CABG at Tehran Heart Center. Patients who underwent CABG combined with a heart valve repair or replacement, resection of a ventricular aneurysm, or other surgical procedures were excluded. Written informed consent was obtained from all the patients, and the study was approved by the local hospital ethics committee.

Patient data, risk factors, operation, and outcome data were prospectively recorded on a structured paper form as described previously.⁸ Briefly, during the patient's admission by interview and physical examination the following variables were collected: age, gender, body mass index (BMI), New York Heart Association (NYHA) function class, the number of diseased vessels, and left ventricular ejection fraction (LVEF). History of myocardial infarction, smoking, diabetes, hypercholesterolemia, hypertension, peripheral vascular disease, cerebrovascular disease, respiratory failure, and renal failure were also noted. Pre-operative medical characteristics were collected by research general practitioners, and operation data were detailed by the surgeons and perfusionists. The data were entered into the SPSS software by a single operator at a later date.

LOS in the ICU was defined as the number of days in the ICU unit post-operatively. Patients who stayed in the ICU for more than 2 consecutive days on the initial admission were classified as having a prolonged ICU stay. The study outcomes were the pre-operative and intra-operative risk factors of prolonged LOS in the ICU, and the occurrence of post-operative complications in the ICU.

Patients who currently smoked cigarettes or who had quit smoking for less than 1 month were considered smokers. Any cerebral neurological deficit induced by both cerebrovascular accident (CVA) and transient ischemic attacks or previous cerebral surgery was defined as cerebrovascular disease. Peripheral vascular disease (PVD) was defined as history or any evidence of aneurysm or occlusive peripheral vascular disease on physical examination.

The amount of inotropic support and arterial blood gas parameters (base excess and pH in plasma) were recorded within and up to 24 hours after surgery. A wound infection was any wound infection in the sternum or leg incision following surgery. Post-operative arrhythmia was defined as all observed rhythms except for normal sinus rhythm.

The operations were performed by seven surgeons. Surgeons, in terms of mean total in-hospital duration of stay for patients of each individual surgeon, were classified into 3 groups as follows:

1, if mean total patients' stay in hospital was <8 days; 2, if mean total patients' stay in hospital ranged between 8 to 10 days; and 3, if mean total patients' stay in hospital was longer than 10 days.

The numerical variables were presented as mean \pm SD and were compared using the One-Way ANOVA test, while the categorized variables were summarized by absolute frequencies and percentages and were compared using the chi-square test. A multivariable stepwise logistic regression models for risk factors predicting LOS in ICU was constructed. Variables were included into the multivariable model if the *p* value was found to be less than or equal to 0.20 in the univariable analysis as well as their clinical significance. The associations of the independent predictors of LOS in ICU in the final model were expressed as odds ratios (OR) with 95% confidence intervals (CIs). Model discrimination was measured using the *c* statistic, which is equal to the area under the ROC (Receiver Operating Characteristic) curve. Model calibration was estimated using the Hosmer-Lemeshow (HL) goodness-of-fit statistic (higher *p* values imply that the model fit the observed data better). For the statistical analysis, the statistical software SPSS version 13.0 for Windows (SPSS Inc., Chicago, IL) and the statistical package SAS version 9.1 for Windows (SAS Institute Inc., Cary, NC, USA) were used. All the *p* values were 2-tailed, with statistical significance considered as *p* value \leq 0.05.

Results

The baseline characteristics and pre-operative data of the CABG patients according to individual surgeon categories are presented in Table 1. There were 7 operating surgeons classified in 3 categories on the basis of the mean hospital stay of their patients as explained in the method section.

Surgeon category 3 operated on patients with higher EuroSCOREs than did surgeon categories 1 and 2. There were also some differences noted between surgeon categories with respect to the number of grafts performed, inotropic drug use, and time on pump.

The overall in-hospital mortality rate was 0.5%. As seen in Table 2, all 3 deaths occurred in surgeon category 3 operations (2.9% compared to no mortality for patients in surgeon categories 1 and 2; *p* value = 0.001). Incidence



Table 1. Pre-operative risk factors and operative characteristics of patients for individual surgeon categories*

	Category 1	Category 2	Category 3	p value
Number of patients	320 (56.1)	145 (25.4)	105 (18.5)	-
Age (y)	59.23±8.92	58.04±8.86	59.80±9.22	0.260
Male	246 (76.9)	115 (79.3)	68 (64.8)	0.019
Body mass index (Kg/m ²)	27.33±4.13	27.40±3.81	27.51±4.28	0.924
Creatinine (mg/dl)	1.27±0.28	1.24±0.23	1.26±0.30	0.517
LVEF (%)	48.22±10.12	48.57±11.05	49.34±10.14	0.627
EuroSCORE	2.19±0.11	2.28±0.18	3.06±0.25	0.002
Cardiac risk factors				
Diabetes	125 (39.1)	60 (41.4)	48 (45.7)	0.480
Hypertension	156 (48.8)	72 (49.7)	54 (51.4)	0.892
Hyperlipidemia	229 (71.6)	96 (66.2)	75 (71.4)	0.481
Cigarette smoking	110 (34.4)	61 (42.1)	35 (33.3)	0.223
Family history of CAD	146 (45.6)	68 (46.9)	56 (53.3)	0.386
Prior MI	155 (48.9)	80 (55.2)	52 (49.5)	0.443
Prior CVA	10 (3.1)	9 (6.2)	3 (2.9)	0.234
History of PVD	78 (24.4)	47 (32.4)	33 (31.4)	0.129
Number of grafts	3.55±0.94	3.89±0.95	4.08±0.87	<0.001
Inotropic drug use	138 (43.1)	49 (33.8)	51 (48.6)	0.049
IABP-support	5 (1.6)	6 (4.1)	1 (1.0)	0.133
Pump time (min)	62.82±20.70	74.54±20.09	85.79±19.58	<0.001
NYHA function class III-IV	214 (66.9)	88 (60.7)	67 (63.8)	0.423

Data are presented as n (%) or mean±SD

*Category 1: Mean total patient's stay in hospital < 8 days

Category 2: Mean total patient's stay in hospital > 10 days

Category 3: Mean total patient's stay in hospital 8-10 days

CAD, Coronary artery disease; MI, Myocardial infarction; CVA, Cerebrovascular accident; PVD, Peripheral vascular disease; IABP, Intra-aortic balloon pump; NYHA, New York heart association classification

Table 2. Patients' mortality, outcome, and adverse events for individual surgeon categories*

	Category 1	Category 2	Category 3	p value
Mortality	0	0	3 (2.9)	0.001
Arrhythmia	118 (36.9)	52 (35.9)	54 (51.4)	0.018
Peri-operative MI	2 (0.6)	2 (1.4)	0	0.422
Peri-operative CVA	2 (0.6)	1 (0.7)	1 (1.0)	0.941
Respiratory failure	52 (16.3)	29 (20.0)	23 (21.9)	0.351
Wound infection	1 (0.3)	2 (1.4)	0	0.240
LOS in the ICU (hr)	44.40±31.19	45.02±38.05	56.84±39.59	0.005
Arterial blood gas parameters				
Mean BE within 6 hours after surgery	-5.78±2.57	-5.35±2.33	-5.84±2.90	0.198
Mean pH < 7.34 within 6 hours after surgery	78 (24.4)	30 (20.7)	25 (23.8)	0.679

Data are presented as n (%) or mean±SD

*Category 1: Mean total patient's stay in hospital < 8 days

Category 2: Mean total patient's stay in hospital > 10 days

Category 3: Mean total patient's stay in hospital 8-10 days

MI, Myocardial infarction; CVA, Cerebrovascular accident; LOS, Length of stay; ICU, Intensive care unit; BE, Base excess

of post-operative arrhythmia and length of ICU stay were higher in patients of surgeon category 3 than those of surgeon categories 1 and 2 (Table 2).

Age, sex, BMI, surgeon category, EuroSCORE, hypertension, diabetes, prior CVA, history of PVD, prior MI, NYHA function class, LVEF, number of diseased vessels, and creatinine were the variables entered into the logistic regression model based on their statistical significance in univariable analyses (entering criterion p value ≤ 0.20) as well as their clinical significance.

Table 3 shows the independent predictors of LOS at ICU in patients undergoing CABG. The multivariable stepwise analysis helped identify three variables as independent predictors significantly associated with ICU length of stay:

Table 3. Determinants of length of stay at intensive care unit

Predictors	OR	95% CI	P value
Surgeon category*			0.017
1**	1	-	-
2	0.831	0.537-1.288	
3	1.729	1.097-2.725	
Age	1.020	1.000-1.041	0.048
Prior CVA	2.593	1.082-6.215	0.027

Hosmer-Lemeshow goodness-of-fit test: p value=0.86

Area under the ROC curve (AUC): c=0.64

*Category 1: Mean total patient's stay in hospital < 8 days

Category 2: Mean total patient's stay in hospital > 10 days

Category 3: Mean total patient's stay in hospital 8-10 days

**Reference category

CVA, Cerebrovascular accident; OR, Odds ratio; CI, Confidence interval

age, history of CVA, and surgeon category. The table also shows that the predictive performance of the risk model assessed by using the area under the ROC curve (AUC) was acceptable ($c = 0.64$), and so was the calibration of the risk model.

Discussion

We studied pre-operative and intra-operative variables in a multivariable regression model to predict LOS in the ICU after bypass surgery for 570 CABG patients at our center. Three variables, namely age, prior CVA, and surgeon category, were found to be the independent predictors of an ICU length of stay greater than 48 hours.

Over the past 2 decades, a considerable number of reports have been published on the predictors of LOS in ICU following CABG surgery. However, a great disparity in type and number of independent variables analyzed has been reported.

Tuman et al.⁷ found 11 pre-operative variables to be significantly associated with LOS in the ICU, including emergency surgery, age, pre-operative renal dysfunction, prior MI, cerebrovascular disease, type of surgery, congestive heart failure, and left ventricular dysfunction. Although they developed a model for predicting illness after cardiac surgery, the study has been shown to predict only the mean LOS in the ICU.

In a similar study on pre-operative variables, Tu et al.⁹ suggested that LOS following cardiac surgery could be predicted by a multivariate predictive index. Five variables were found to be the independent predictors of prolonged LOS in the ICU (age, female sex, left ventricular function, urgency of surgery, and type of surgery). Nonetheless, the authors accepted that the model had a poor predictive ability and LOS in the ICU could not be predicted with certainty.

Mounsey et al.¹⁰ found only left ventricular end diastolic pressure and number of diseased coronary vessels to be beneficial in predicting LOS in ICU. Michalopoulos et al.¹¹ studied elective procedures taking into account not only pre-operative variables, but also significant variables related to both the operative and immediate post-operative period such as number of inotropes administered and blood transfusion. They found that age, pre-operative left ventricular ejection fraction, bypass time, aortic cross-clamp time, number of inotropic agents used, and blood transfusions to be predictors of an extended LOS in the ICU.

Deoring et al.² suggested that a significant portion of the variance in the ICU length of stay following CABG could be attributed to five variables, including pre-operative mortality risk (Parsonnet score), intubation hours, presence of arrhythmias, early hemodynamic instability, and 12-hour fluid balance. Finally, in a newly published study, Rosenfeld and co-workers¹² found age > 70 years, urgency of surgery,

pump time, and chronic obstructive pulmonary disease to be the independent pre-operative predictors for a prolonged ICU stay in CABG patients.

Such disparity in study results may be due to the fact that the majority of these studies have not included the operative or immediate post-operative variables and have just taken into account events which affect patient outcome during the pre-operative period. Other explanations for the differences in study findings may be due to various study populations and treatment protocols, different cut-off used to define a prolonged stay in the ICU (from ≥ 2 to 10 days),^{9, 10, 13, 14} differences in variables definitions, and the large number of variables that can be considered.⁷

Chiming with other studies that have suggested age to be an independent predictor of the ICU stay ≥ 48 hours, ≥ 3 days, and ≥ 6 days,¹⁵⁻¹⁷ age was also a significant predictor of LOS in ICU in our study. A longer stay in the ICU in older patients may be justified by higher pre-operative comorbidity rates and severity of illness.¹⁸⁻²⁰ However, because of improvements in operative and anesthetic techniques, mortality and morbidity in the elderly have been declined in recent years.^{18, 19, 21} Gender was not a significant predictor in our study. In a recently published study, Ranucci et al.²² also reported that female gender was not an independent risk factor for mortality or prolonged ICU stay, which is consistent with our results.

In a previous study,²³ the variable of 'previous history of CVA' was independently associated with atrial fibrillation after cardiac surgery. It can be assumed that prior CVA may prolong LOS following CABG surgery by increasing the risk of atrial fibrillation arrhythmia as suggested by our current study.

The main difference between our study and those described above is that we took into account surgeon category as a variable. We found that the surgeon could potentially influence the duration of a patient's ICU stay and that there were differences in the average LOS in ICU between surgeons at our hospital. Particularly, we found that patients in surgeon category one as a reference, had higher LOS compared to category 2 and lower LOS compared to category 3. It may indicate the necessity of using a unique protocol for discharging post-operative patients.

This study was observational and limited by its inherent restrictions and by the fact that we did not evaluate the contribution of individual intra-operative variables such as blood transfusion and cross-clamp time. However, it has previously been shown that compared with pre-operative and post-operative variables, intra-operative factors are less indicative of ICU duration of stay when all factors are considered together.^{10, 24} Moreover, as all our patients were elective, the conclusions are limited to this study population and do not include emergent patients.



Conclusion

Detection of high-risk patients may help in more careful peri-operative management to decrease the possibility of prolonged hospitalization and its related morbidity and mortality. More studies with larger sample sizes are warranted to identify other factors contributing to ICU stay in CABG which have not been studied to date. In addition to age and other pre-operative variables, surgeon category may predict an extended LOS in the ICU. We suggest that a unique protocol for discharging post-operative patients be considered to restrict the role of surgeon in ICU stay after bypass surgery.

Acknowledgment

This research project was supported by the Endocrine and Metabolism Research Center grant. We are indebted to the Tehran Heart Center Research Department for technical assistance.

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