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Early Readmission of Low-Risk Patients after Coronary Surgery

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ABSTRACT

Background: Early readmission after coronary artery bypass grafting (CABG) is an expensive adverse outcome. Although the perioperative experience of high-risk CABG patients has been studied extensively, little attention has been paid to low-risk CABG patients. The primary goal of this study was to identify the preoperative characteristics and to define risk predictors of readmission and preventive factors for readmission in low-risk isolated-CABG patients.

Methods: We identified 2157 patients who underwent CABG between January 2000 and December 2005 at Washington Hospital Center, Washington, DC, and defined as low risk patients who had a Parsonnet bedside risk score lower than the 25th percentile. Patients who were rehospitalized within 30 days after surgery were compared with those who were not rehospitalized during this period.

Results: The overall readmission rate for this study cohort was 6.3%. Compared with non-readmitted patients, early-readmitted patients were more likely to have diabetes mellitus (27.94% versus 20.88%, $P = .05$) and less likely to have hypertension (42.65% versus 51.36%, $P = .05$). Blood product transfusion ($P < .01$), postoperative length of intensive care unit stay ($P = .01$), and length of hospital stay ($P = .05$) were all significantly increased in the readmitted patients. The use of β-blockers ($P = .03$) and angiotensin-converting enzyme inhibitors ($P = .04$) was significantly lower at discharge in this group of patients; however, multivariate regression analysis demonstrated diabetes (odds ratio, 1.59; 95% confidence interval, 1.08-2.42) to be the only independent predictor of early readmission.

Conclusions: For low-risk CABG patients, diabetes mellitus is the risk predictor of early readmission. Early discharge was not associated with early readmission.

INTRODUCTION

Low-risk patients, who are usually characterized as younger and male, have fewer comorbidities and major events after surgery [Cowper 1997]. Most of the attention has been paid to high-risk patients, with low-risk patients having rarely been investigated. Advances in technology, improvements in postoperative care, and economic pressures have resulted in progressively shorter hospital stays after surgery. The low-risk patient population has been the primary target for the reduction in postoperative stays. Concerns have been raised as to whether shortened hospital stays translate into increased readmission rates.

In the past decade, early readmission has become an important component of outcomes included in the Society of Thoracic Surgeons (STS) National Database. In the late 1990s, the overall readmission rate after isolated coronary artery bypass grafting (CABG) surgery was 10% to 12% at 30 days after discharge, according to the STS National Database [Society of Thoracic Surgeons 2001]. Hannan and colleagues [2003] conducted a large retrospective study on the risk factors for rehospitalization that included 16,325 patients in 1999 from the New York State database. More than 15% were readmitted for various reasons within 30 days after CABG. Hwang et al [2007] observed a 19% incidence of readmission within 30 days of discharge in their examination of the National Medicare Database from 2001 to 2003. The top 3 causes of readmission were infection (28.3%), heart failure (15.7%), and myocardial ischemia/infarction (7.9%). As mentioned above, specific studies focusing on low-risk patients have not been identified. The purpose of the present study was to identify the incidence of and the risk factors for hospital readmission in a cohort of low-risk patients who underwent isolated CABG.

MATERIALS AND METHODS

Patient Population

Preoperative, intraoperative, and postoperative clinical data were collected concurrently and entered into a computerized database of the Section of Cardiac Surgery, Washington Hospital Center, Washington, DC, USA. All data were defined according to the STS National Database [Clark 1994]. Guidelines and definitions are available at http://www.sts.org/sections/stsnationaldatabase/datamanagers. All adverse clinical events were source-documented and adjudicated. The Institutional Review Board of MedStar Research Institute/Washington Hospital Center approved the study.

Standard techniques and methods of anesthesia, surgery, extracorporeal circulation, and myocardial protection

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were used for both on-pump and off-pump CABG surgeries. The low-risk patients included in this study were derived from the group of all patients who underwent isolated CABG surgery and were discharged alive between January 2000 and December 2005. A modified 2000 Bernstein-Parsonnet bedside risk score (BD score) below the 25th percentile was the determinate that defined patients as low risk [Bernstein 2000].

Readmission Definition

Readmission was defined as the first readmission within 30 days after CABG. A telephone follow-up was conducted postoperatively to collect and confirm the data on readmission within 30 days. If attempts to contact a patient directly failed 3 times, the information was collected from family members and/or attending physicians. Patients readmitted to any hospital and facility within 30 days after surgery were compared with those not readmitted within 30 days after surgery.

Statistical Analysis

Univariate analysis. Data are expressed as a percentage, the mean ± SD, or the median (range). Normally distributed data for continuous variables were compared with the Student *t* test, and nonparametric data were evaluated with the Wilcoxon rank sum test. Data for dichotomous variables were compared with the chi-square test of general association or with the Fisher exact test when expected cell counts were <5. In all tests, *P* values ≤.05 were considered statistically significant.

Multivariable analysis. The outcome of interest analyzed with a multivariable model was readmission within 30 days after surgery versus no readmission within 30 days. Predictors of early readmission were identified in the univariate analysis or from the literatures. Variables that met a significance level of .15 in the univariate analysis or had previously been reported as important determinants of the outcome of interest were included in the multiple logistic regression analysis. The odds ratio (OR) was used as a measure of the relative risk in the final model. Model fit was evaluated with the Hosmer-Lemeshow goodness-of-fit test and analysis of residuals. The *C* statistic was reported as a measure of predictive power. All statistical analyses were performed with SAS for Windows Version 9.1 (SAS Institute, Cary, NC, USA).

RESULTS

Of the 10,770 patients who underwent isolated CABG between January 2000 and December 2005, 2157 patients (18.8%) were defined as low-risk patients (ie, a Parsonnet score below the 25th percentile), and 136 of these patients were readmitted within 30 postoperative days. The incidence of early readmission was 6.3%. The mean BD score for all CABG patients during the study period was 15.42 ± 9.90. The mean BD score for the low-risk cohort was 5.31 ± 3.02.

Baseline Characteristics

Table 1 summarizes the baseline characteristics for the readmitted and non-readmitted patients. Most of the patients were male, in both the readmitted (94.1%) and non-readmitted (93.8%) groups. The incidence of early readmission was 5.9%

Table 1. Univariate Analysis of Preoperative and Operative Characteristics of 2157 Patients*

	Early Readmission (n = 136)	No Early Readmission (n = 2021)	*P*
Age, y	61.5 ± 9.1	60.2 ± 8.7	.11†
Male sex, n (%)	128 (94.1)	1895 (93.8)	.89
Female sex, n (%)	8 (5.9)	126 (6.2)	.87
Hypertension, n (%)	58 (42.7)	1038 (51.4)	.05
Diabetes mellitus, n (%)	38 (27.9)	422 (20.9)	.05
Renal failure, n (%)	0 (0.0)	17 (0.8)	.62‡
Left main stenosis, n (%)	17 (12.5)	326 (16.1)	.26
Chronic obstructive pulmonary disease, n (%)	1 (0.7)	51 (2.5)	.25‡
Chronic heart failure, n (%)	2 (1.5)	18 (0.9)	.36‡
History of myocardial infarction, n (%)	42 (30.9)	548 (27.1)	.34
Recent myocardial infarction (within 24 h), n (%)	0 (0.0)	5 (0.3)	1.00‡
Ejection fraction (<35% versus ≥35%), n (%)	6 (4.4)	64 (3.2)	.45‡
Carotid artery disease, n (%)	0 (0.0)	12 (0.6)	1.00‡
Previous cerebral vascular accident, n (%)	2 (1.5)	11 (0.5)	.20‡
Peripheral vascular disease, n (%)	2 (1.5)	57 (2.8)	.58‡
Intra-aortic balloon pump, n (%)	0 (0.0)	6 (0.3)	1.00‡
Nonelective (versus elective), n (%)	1 (0.7)	15 (0.7)	1.00‡
On-pump (versus off-pump) CABG, n (%)	57 (41.9)	898 (44.4)	.57
4-7 Vessels grafted (versus 1-3), n (%)	76 (55.9)	1075 (53.2)	.54

*Early readmission is defined as readmission ≤30 days after surgery. Age data are expressed as the mean ± SD. A chi-square test of independence was made for all comparisons unless otherwise noted. CABG indicates coronary artery bypass grafting.

†Student *t* test.

‡Fisher exact test.

for women and 6.3% for men ($P > .05$). More patients in the readmitted group had diabetes mellitus ($P = .05$), and fewer were hypertensive ($P = .05$). The 2 groups did not differ in frequency for any of the following variables: age, comorbid renal disease, preoperative surgical emergency or not, left main artery disease, heart function, chronic obstructive pulmonary disease, peripheral vascular disease, carotid artery disease, preoperative intra-aortic balloon pump placement, myocardial infarction, and cerebral vascular accident ($P > .05$). All of these variables are risk factors often associated with adverse outcomes after CABG. Off-pump or on-pump CABG procedures were performed at similar frequencies in the 2 groups (41.9% versus 44.4%, $P = .57$).

Postoperative Outcomes

Table 2 presents the univariate analyses of the postoperative events. There was no 30-day mortality in the low-risk patients, but the overall postoperative 30-day mortality rate during the study period was 2.3% (273 of the 9888 isolated-CABG patients). Readmitted patients were more likely to have had longer intensive care unit stays ($P = .01$), hospital stays ($P = .05$), and blood product transfusions ($P < .01$) than non-readmitted patients. More patients in the readmitted group stayed in the hospital more than 5 days after surgery (25% versus 17.4%, $P = .03$). Fewer readmitted patients received β-blockers (41.2% versus 50.7%, $P = .03$) and angiotensin-converting enzyme (ACE) inhibitors at discharge (8.1% versus 14.5%, $P = .04$).

Independent Risk Factors of Readmission

Multiple logistic regression analysis (Table 3) identified preoperative diabetes as an independent risk factor for early readmission, with a 59% increase in incidence (OR, 1.59; 95% confidence interval, 1.07-2.36; $P = .02$). Operative blood loss appeared to be a weak risk factor of early readmission (OR, 1.00; 95% confidence interval, 1.00-1.00; $P = .05$). Hypertension was associated with a marginally decreased risk of readmission ($P = .08$, Table 3). Patients with hypertension in the non-readmitted group more frequently received β-blockers and ACE inhibitors at discharge, but no statistically significant difference was noted for any single prescription or combination of prescriptions ($P > .05$, Table 4).

Reasons for Early Readmission

The most frequent reasons for early readmission recorded in our database were arrhythmia (23.1%), respiratory complications/pneumonia (18%), deep sternum incisional infection (10.3%), myocardial infarction and/or recurrent angina (10.3%), and pericardial drainage/tamponade (7.7%).

COMMENT

The readmission rate within 30 days after CABG was 6.3% for patients in our low-risk study cohort. This rate is much lower than the rates reported without risk stratification for patients who underwent CABG surgery in the 1980s and

Table 2. Univariate Analysis of the Postoperative Characteristics of the Patients (n = 2157)*

	Early Readmission (n = 136)	No Early Readmission (n = 2021)	*P*
Bypass time, min	72 (31-134)	66 (20-158)	.34†
Cross-clamp time, min	50 (22-114)	46 (15-610)	.43†
Postoperative stroke, n (%)	0 (0.0)	7 (0.4)	1.00‡
Postoperative myocardial infarction, n (%)	0 (0.0)	21 (1.0)	.64‡
Postoperative atrial fibrillation, n (%)	31 (22.8)	398 (19.7)	.38
Postoperative renal insufficiency, n (%)	0 (0.0)	9 (0.5)	1.00‡
Prolonged ventilation, n (%)	3 (2.2)	38 (1.9)	.74‡
Reoperation during hospitalization, n (%)	4 (2.9)	45 (2.2)	.55‡
Minor infections, n (%)	0 (0.0)	36 (1.8)	.17‡
Major infections, n (%)	0 (0.0)	3 (0.2)	1.00‡
Estimated blood loss, mL	400 (100-5000)	400 (10-2150)	.10†
Total PRBC transfused, mL	750 (250-4250)	500 (250-6500)	<.01†
Postoperative LOS, d	4 (3-21)	4 (1-120)	.05†
Postoperative LOS >5 d (versus ≤5 d), n (%)	34 (25.0)	352 (17.4)	.03
Length of ICU stay, d	1.00 (0.5-8.0)	1.00 (0.29-38.3)	.01†
Postoperative ICU stay >1 d (versus ≤1 d), n (%)	17 (12.5)	221 (10.9)	.57
β-Blockers at discharge, n (%)	56 (41.2)	1025 (50.7)	.03
ACE inhibitors at discharge, n (%)	11 (8.1)	292 (14.5)	.04
Discharge hematocrit levels, %	29.2 ± 3.6	29.5 ± 3.9	.35§

*Data are expressed as the number of patients (percent), the median (range), or the mean ± SD as indicated. A chi-square test of independence was used for all comparisons unless otherwise noted. PRBC indicates red blood cell products; LOS, length of hospital stay; ICU, intensive care unit; ACE, angiotensin-converting enzyme.

†Wilcoxon signed rank test.

‡Fisher exact test.

§Student *t* test.

Table 3. Multiple Logistic Regression Analysis to Determine Risk Factors for Readmission to the Hospital within 30 Days of Surgery (n = 2157)*

	Odd Ratio (95% Confidence Interval)	*P*
Age	1.01 (0.99-1.04)	.20
Estimated blood loss	1.00 (1.000-1.001)	.05
Diabetes mellitus	1.61 (1.08-2.42)	.02
Hypertension	0.72 (0.50-1.04)	.08
Female sex	1.08 (0.51-2.29)	.84
Postoperative atrial fibrillation	1.12 (0.72-1.74)	.63
Postoperative LOS >5 d (versus ≤5 d)	1.38 (0.89-2.13)	.15
β-Blockers at discharge	0.81 (0.56-1.18)	.27
ACE inhibitors at discharge	0.59 (0.31-1.13)	.11

*Hosmer-Lemeshow goodness-of-fit test: χ^2 (8) = 7.00; *P* = .54; *C* statistic = 0.61. LOS indicates length of hospital stay; ACE, angiotensin-converting enzyme.

1990s [Cowper 1997; Society of Thoracic Surgeons 2001; Hannan 2003; Hwang 2007].

In recent years, there has been growing interest in the use of risk-adjusted models for analyzing outcomes in cardiac surgery. Currently, there are more than 15 different scoring systems for risk assessment, including the American Society of Thoracic Surgeons risk program, the 2000 Bernstein-Parsonnet score [Bernstein 2000], the EuroSCORE [Nashef 1999], and the American College of Cardiology/American Heart Association (ACC/AHA) model [Eagle 2004]. The development of the modified 2000 BD score system was based mainly on CABG or valve surgeries and has shown good performance with respect to predicted versus observed outcomes of CABG surgery (on- and off-pump) [Doering 2000; Berman 2006]. Berman and colleagues [2006] compared this system with the EuroSCORE system and confirmed that it remains a simple, objective, and efficient model for risk evaluation, especially for a heterogeneous source population. In our institution, a significant percentage of our patients are drawn not only from a large and diverse metropolitan area but also from a rural and suburban demographic. With a Parsonnet score of 15, the expected mortality rate is approximately 2.3%; our observed mortality rate for all CABG patients was 2.3%. The mortality rate is approximately 0.9% for an estimated score of 5; the mortality was zero in our cohort of low-risk patients.

Table 4. Comparison of the Hypertension Treatments for the 2 Groups at Discharge*

	Early Readmission (n = 58), n (%)	No Early Readmission (n = 1038), n (%)	*P*†
β-Blockers	31 (53.5)	592 (57)	.1
ACE inhibitors	7 (12.1)	199 (19.2)	.06
β-Blockers + ACE inhibitors	38 (65.5)	791 (76.4)	.06

*Early readmission is defined as readmission ≤30 days after surgery. ACE indicates angiotensin-converting enzyme.

†Student *t* test.

Diabetes mellitus is one of the strongest independent risk factors associated with readmission in this group of low-risk patients. This finding was consistent with the findings for studies of CABG patients with diabetes without risk stratification [Hannan 2003; Cowper 2007]. Stewart et al [2000] has shown a significant association between diabetes and 30-day readmission in general CABG patients. Similarly, Whang and Bigger found diabetes to be associated with a 44% increase in rehospitalization within 12 months in patients with concurrent diabetes and severe left ventricular dysfunction [Whang 2000]. The Society of Thoracic Surgeons National Adult Cardiac Database showed an increasing trend of diabetic patients referred for CABG (21% in 1990, 33% in 1999) [Ferguson 2002]. The long-term results of CABG in diabetic patients have been disappointing compared with nondiabetic patients [Luciani 2003]. Unfortunately, to date there has been no consensus on the perioperative management strategy for diabetic patients. Although our study provides no observations on the control of blood glucose level, there is now evidence to suggest that achieving tight glucose control in diabetes patients improves outcomes and decreases recurrent ischemic events [Lazar 2004]. Our results warrant a large study with effective targets for blood glucose levels aimed at reducing adverse outcomes, especially readmission rates.

In the early to mid 1980s, the average length of hospital stay after CABG was 10 to 11 days [Wagner 1983; Roberts 1985]. Cowper et al [2006] documented a downward trend in postoperative hospital stay from 1992 to 1998. The length of stay decreased from 6 days to 4 days in low-risk patients and decreased from 12 days to 10 days in high-risk patients. We had similar observations, with a trend toward a decreased readmission rate in patients with shorter hospital stays compared with those with longer hospital stays. This difference did not reach statistical significance, however. These observations are consistent with studies of CABG patients carried out in the 1990s [Bernstein 2000; Hannan 2003], which found that patients with the shortest hospital stays had the lowest readmission rates.

In post-CABG patients, medical therapy has been one of the important measures for preventing adverse clinical outcomes. A few studies have documented that administration of β-blockers can reduce postoperative mortality [Chen 2000], decrease the incidence of atrial fibrillation [Halonen 2006], and reduce cardiac events [Osman 2005]; however, according to the American College of Cardiology and American Heart Association guidelines for CABG [Eagle 2004], early administration of β-blockers was recommended only to reduce the incidence of postoperative atrial fibrillation in patients without contraindications. The use of ACE inhibitors was not discussed. Only a single randomized controlled trial has examined the use of ACE inhibitors in post-CABG patients [Oosterga 2001]. Therefore, the use of β-blockers and ACE inhibitors in CABG patients at discharge remains understudied.

Hypertension usually confers an increased risk for cardiovascular events, but the present study showed hypertension to be a borderline-independent factor associated with a lower rate of early readmission. This result may be related to the different treatments with medicines at discharge. More patients in the non-readmission group had been prescribed β-blockers and ACE inhibitors than patients in the readmission group. Few randomized controlled trials have been conducted to investigate the impact of β-blocker and ACE-inhibitor treatment on outcomes after CABG. Our results indicate that further studies should investigate the benefits of routine or patient-targeted prescription of β-blockers and ACE inhibitors at discharge.

Concerns about blood loss and potential sequelae are not new, and perioperative bleeding remains an important postoperative complication, despite improvements in operative and anesthesiological techniques and postoperative management [Brown 2008]. Blood loss usually is associated with increased transfusion of blood products, organ dysfunction, reexploration, longer hospital stays, higher costs, and increased mortality. We found blood loss to be a strong predictor of readmission. We emphasize that the risk profile of perioperative bleeding in CABG patients has changed. Many patients undergo surgery while they are still taking oral antiplatelet agents, which may increase transfusions and the risk of bleeding [Kapetanakis 2006].

Female sex is a predictor of early readmission and higher mortality [Hannan 2003; Cowper 2007]; however, we did not find female sex to be associated with a higher rate of early readmission. This finding is probably due to the low-risk cohort having a lower percentage of women (5.9% in the early-readmission group and 6.2% in the entire group). Older age has also been reported as an independent risk predictor for early readmission [Cowper 2007]. Age as a predictor of high risk is usually defined as older than 70 years [Kurki 1996] or older than 80 years according to the BD score definition [Bernstein 2000]. The patients in our groups were younger (61.46 ± 9.11 and 60.21 ± 8.67 years) and were younger than the mean age of 64 years for patients undergoing CABG.

This study has several limitations. First, because the data were collected from a single center, the results may not be generalized to the entire CABG population in the United States. Second, the low percentage of patients discharged with ACE inhibitors and β-blockers may compromise the study's predictive strength.

In conclusion, this study shows a lower incidence of early readmission for low-risk patients than for the entire cohort of patients who underwent isolated CABG. Only diabetes mellitus was identified as independent risk factor for early readmission in low-risk patients undergoing isolated CABG. Future study may indicate that the incidence of early readmission can indeed be lowered further by prescribing ACE inhibitors and β-blockers at discharge.

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