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ORIGINAL RESEARCH

Poor Diabetic Control Marks Low Socioeconomic Status in Cardiac Surgery Patients

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Abstract

Introduction: Patients with poorly controlled diabetes mellitus (DM) have higher postoperative mortality, myocardial infarctions, and infections following cardiac surgery. Poor social determinants of health (SDH) including access to care, insurance, and medical literacy also impact postoperative outcomes. We hypothesized that poor SDH are over-represented in patients with poor diabetic control who undergo cardiac surgery.

Methods: We conducted a retrospective cohort investigation of DM patients from the Society for Thoracic Surgery Adult Cardiac Surgery Database from January 1, 2008 to June 30, 2014 at UCLA Medical Center. Bivariate and multivariate logistic regressions were used to define predictors of poorly controlled diabetes (HgbA1c≥9%).

Results: 544 diabetic patients were included in this investigation. In bivariate analysis, lack of insurance (OR 7.31, P<0.01), insulin therapy (OR 3.44, P<0.01), BMI ≥ 40 (OR 2.57, P=0.04), past smoker (OR 1.81, P=0.03), intravenous drug abuse (OR 8.47, P=0.04), and previous MI (OR 1.87, P=0.02) were independently associated with poorly controlled diabetes. In multivariate analysis, after controlling for age, gender, and race, only lack of insurance (OR 7.11, P<0.01) and insulin control of diabetes (OR 3.99, P=0.01) were associated with HgbA1c≥9%.

Conclusion: Patients with poorly controlled diabetes may have both biologic and socioeconomic factors that negatively influence outcomes after cardiac surgery. Understanding the interplay of SDH and biologic determinants of health is important for optimal outcomes from cardiac surgery.

Introduction

Although cardiac operations, most commonly coronary artery bypass grafting (CABG), significantly improve survival and quality of life,[1] the benefit comes at a price. Approximately 3-5% of the 400,000 patients (12-20,000 people) undergoing CABG in the US each year will have a major postoperative infection.[2–6] An additional 26,000 people will have a stroke, postoperative MI, or other operative complication.[7,8]

Diabetes mellitus is a risk factor for complications following cardiac surgery.[4] Patients with poorly controlled diabetes mellitus (DM) develop more deep sternal wound infection[9] and higher mortality following cardiac surgery.[10–12] A number of adverse cellular events are associated with hyperglycemia and include cytotoxicity, increased production of reactive oxygen species, impairment of immunological opsonization, hypercoagulability,[13] and increased pro-apoptotic signals.[14] Popularized by the study of Van den Berghe et al[15] on the benefits of tight perioperative blood sugar control, cardiac surgeons have focused on perioperative glycemia to improve postoperative outcomes.[16]

Despite significant improvements in hospital-based outcomes, diabetic patients still have worse outcomes following cardiac surgery. In a recent analysis of VA patients, Endicott et al.[17] demonstrated that diabetic patients had higher long-term mortality than non-diabetic patients, despite perioperative blood sugar control, and endocrinology consultation.

A potential explanation for the inferior outcomes of surgery in diabetics may lie with the social determinants of health (SDH) rather than blood sugar control itself. These factors include insurance status, medical literacy, and a lower socioeconomic status, all of which are known to impact postoperative outcomes.[18,19] We hypothesized that patients that undergo cardiac operations with poor diabetic control defined as HgbA1c≥9%,[20] also have poor SDH.

Methods: We conducted a cohort investigation of prospectively collected data from the Society for Thoracic Surgery (STS) Adult Cardiac Surgery Database from the period of January 1, 2008 to June 30, 2014 at UCLA Medical Center (IRB# 12-000805-AM-00012). Diabetic patients who underwent cardiac surgery using cardiopulmonary bypass, including robotic procedures were included. We excluded patients who had procedures involving transplantation, ventricular assist devices and additional thoracic operations, as well as those with missing data.

We identified diabetic patients based on history of DM and a recorded HgbA1c level in the STS database. We further categorized diabetic patients as well-controlled (HgbA1c<7%)

or poorly-controlled (HgbA1c≥9%) based on previous recommendations in the literature.[20] Sociodemographic variables included gender, race, and insurance status. Race was defined as Caucasian, Black, Hispanic, or other based on patient report. Insurance status was categorized as Medicare, Medicaid, Private, and none. Diabetes treatment was defined as none, oral, or insulin based on the regimen that was prescribed or used. We had no measure of medication adherence or efficacy. Other categorical variables included other comorbidities and clinical status listed in **Table 1**.

Our primary outcome was diabetes control with HgbA1c of <7% and ≥ 9%. We used STATA/SPSS to build our bivariate and multivariate logistic regression models to define predictors of poorly controlled diabetes. Bivariate analyses were performed to determine odds ratios, 95% confidence intervals, and associated p-values. All variables with a p-value ≤0.20 in the bivariate analysis were included in a multivariable analysis. Manual backwards elimination was performed using the Likelihood Ratio test to find the best model of predictors associated with poorly controlled diabetes. Models were examined for goodness of fit using the Hosmer-Lemeshow statistic. All variables were considered significant at the $\alpha = 0.05$ level.

Results: During the study period a total of 3,800 patients underwent cardiac surgery at our institution, 745 diabetic patients were identified, and 544 met study inclusion criteria. Within our cohort, 477 patients had HgbA1c<7% and 67 had HgbA1c≥9%. Most patients were male, Caucasian, and had private insurance in both groups. Bivariate analysis identified lack of insurance (OR 7.31, P<0.01), insulin therapy for DM (OR 3.44, P<0.01), BMI ≥ 40 (OR 2.57, P=0.04), past/recent smoking (OR 1.81, P=0.03), intravenous drug abuse (OR 8.47, P=0.04), and previous MI (OR 1.87, P=0.02) to be independent risk factors associated with poorly controlled DM (**Table 1**). Using multivariate analysis to control for confounding variables, lack of insurance (OR 7.11, P<0.01), and insulin therapy (OR 3.99, P=0.01) were the only factors independently associated with poorly controlled DM (**Table 2**).

Discussion: DM is a significant medical burden growing in the United States:[21] 29.1 million people are currently diabetic in the U.S.,[22] and although emphasis has been placed on glycemic control, only an estimated 58.8% are well-controlled.[23] We hypothesized that poor diabetic control was a marker of adverse SDH in cardiac surgery patients. We found that poorly controlled diabetes was associated with prior MI, smoking, IV drug abuse, and obesity. These biologic factors can have profound implications for outcomes in our cohort. However, our research confirms our hypothesis that this biologically vulnerable population also suffers from poor SDH that are likely contributing to inferior outcomes.[18,19] Our results are of importance because ensuring optimal outcomes in this vulnerable population may require coordinated care that may not be possible without addressing issues associated with poor SDH.

Our multivariable model identified adverse SDH in poorly controlled DM undergoing cardiac surgery. Poorly controlled diabetic patients were less likely to have adequate medical insurance.[24] Lack of insurance is an important factor in postoperative recovery from cardiac surgery, particularly as insurance status may impact access to specialist endocrinology, wound care, and rehabilitation services.[19,25] In our sample, insulin therapy was independently associated with increased HgbA1c. Failure to achieve adequate diabetic control despite insulin therapy suggests limited medication compliance and poor health literacy, which both impact outcomes following cardiac surgery.[24,25]

Our study was limited in being a single center, retrospective investigation. In addition to the traditional limitations of such a design, we were unable to directly measure health literacy, availability of specialist care, and economic status. These data are not readily available in the STS datasets.[19,26] Future studies will need prospective assessment or additional adjustment for confounding variables.

Since access to healthcare in the U.S. is not uniform and is highly correlated to socioeconomic status, health systems should consider the social determinants of health in addition to established perioperative risk factors. Our research provides potential insight into the reasons for inferior outcomes in diabetics following cardiac surgery.[17] Understanding SDH has had great impact in other medical areas[27] and deserves further investigation in surgical patients.

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Figures and Tables

Figure 1.Bivariate Analysis of OR of HgbA1c≥9%

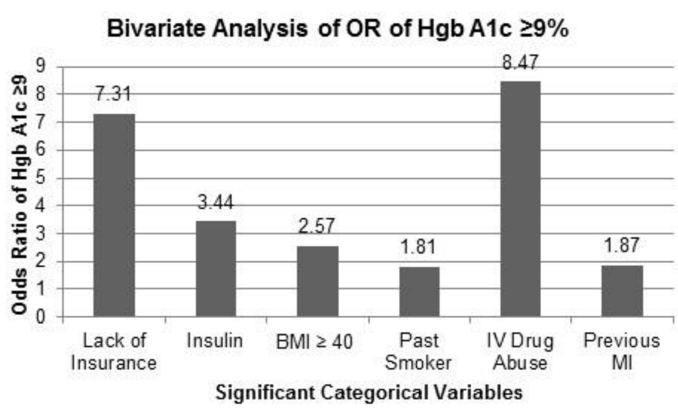

Figure 2. Multivariate Analysis of OR of HgbA1c≥9%

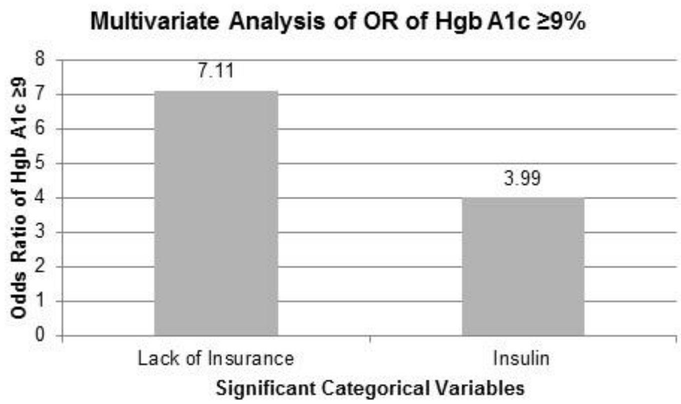

Table 1. Bivariate analysis of 544 patients with diabetes mellitus with HgbA1c<7%or HgbA1c ≥9%

Table 1. 745 diabetic patients, bivariate analysis of 544 patients with diabetes mellitus with HgbA1c<7%or HgbA1c≥9%**

Variable	7≤HgbA1c<9 n (%) (*n*=201)	HgbA1c<7 n (%) (*n*=477)	HgbA1c≥9 n (%) (*n*=67)	Simple Logistic Regression OR* (95% CI)	P-value
Age, y					
Mean ± SD (Median)	63 ± 11 (63)	65 ± 12 (66)	60 ± 11 (60)	0.97 (0.95-.99)	0.002
Gender					
Male	137 (68)	329 (69)	52 (77)	Reference	
Female	63(31)	145 (31)	15 (22)	0.65 (0.36-1.20)	0.17
Race/Ethnicity					
Caucasian	122 (60)	246 (55)	33 (52)	Reference	
Black	15 (7)	30 (7)	6 (9)	1.49 (0.58-3.85)	0.41
Hispanic	29 (14)	77 (17)	16 (25)	1.55 (0.81-2.97)	0.19
Other	40 (20)	96 (22)	9 (14)	0.70 (0.32-1.52)	0.36
Payor					
Medicare	110 (54)	21 (6)	1 (3)	Reference	
Medicaid	12 (6)	25 (7)	1 (3)	0.29 (0.04-2.03)	0.24
Private	113 (46)	289 (85)	32 (80)	0.81 (0.36-1.06)	0.52
None	**8 (4)**	**6 (2)**	**6 (15)**	**7.31 (2.01-25.4)**	**0.002**
Diabetes Therapy					
None/Diet	15 (7)	99 (22)	7 (11)	Reference	
Oral	78 (39)	206 (46)	20 (32)	1.37 (0.56-3.36)	0.49
Insulin	**101 (50)**	**148 (33)**	**36 (57)**	**3.44 (1.47-8.04)**	**0.004**
Admit Source					
Elective	43 (21)	125 (69)	13 (57)	Reference	
Emergency Dept.	9 (4)	23 (13)	6 (26)	2.51 (0.86-7.27)	0.09
Transfer ACF	10 (5)	25 (14)	4 (17)	1.54 (0.46-5.11)	0.48
Other	0 (0)	8 (4)	0 (0)	---	0.98
BMI (kg/m²)					
< 30	130 (65)	331 (69)	43 (64)	Reference	
30≤BMI<40	55 (27)	125 (26)	17 (25)	1.05 (0.58-1.90)	0.88
>= 40	**16 (8)**	**21 (4)**	**7 (10)**	**2.57 (1.04-6.39)**	**0.04**
Past Smoker	**43 (21)**	**116 (25)**	**24 (38)**	**1.81 (1.05-3.14)**	**0.03**
FHCAD	70 (34)	133 (30)	19 (31)	1.04 (0.58-1.85)	0.89
Alcohol					
<=1 drink/week	51 (25)	135 (96)	15 (94)	Reference	
2-7 drinks/week	0 (0)	4 (3)	1 (6)	2.25 (0.23-21.5)	0.48
>=8 drinks/week	0 (0)	2 (1)	0 (0)	---	0.09
IV Drug Abuse	**0 (0)**	**2 (1)**	**2 (11)**	**8.47 (1.12-64.1)**	**0.04**
Dyslipidemia	147 (73)	349 (75)	51 (79)	1.22 (0.65-2.29)	0.53
Dialysis	21 (10)	67 (15)	6 (10)	0.61 (0.25-1.47)	0.27
Hypertension	168 (84)	387 (82)	56 (85)	1.23 (0.60-2.51)	0.57
PVD	18 (9)	60 (14)	5 (8)	0.56 (0.22-1.46)	0.23
CVD	31 (15)	58 (13)	8 (13)	1.00 (0.45-2.20)	0.99
Immune Suppression	28 (14)	70 (16)	9 (15)	0.90 (0.42-1.91)	0.78
Liver Disease	5 (2)	9 (6)	1 (5)	0.88 (0.10-7.38)	0.91
PCI	98 (49)	236 (52)	33 (52)	0.99 (0.59-1.67)	0.98
Previous MI	**77 (38)**	**130 (29)**	**27 (43)**	**1.87 (1.09-3.21)**	**0.02**
CHF	105 (52)	258 (55)	41 (62)	1.32 (0.78-2.24)	0.30
Cardiogenic Shock	4 (2)	20 (5)	3 (5)	1.05 (0.30-3.66)	0.93
Status					
Elective	98 (49)	250 (53)	29 (44)	Reference	
Urgent	97 (48)	198 (42)	33 (50)	1.44 (0.84-2.44)	0.18
Emergent	3 (1)	22 (5)	4 (6)	1.57 (0.50-4.86)	0.44

*OR, Odds Ratio, CI, Confidence Interval, ACF, Acute Care Facility, BMI, Body Mass Index, FHCAD, Family History of Coronary Artery Disease, PVD, Peripheral Vascular Disease, CVD, Cerebrovascular Disease, PCI, Previous Cardiac Intervention, MI, Myocardial Infarction, CHF, Congestive Heart Failure. **In some circumstances data was unavailable for some patients, column percentages are presented. Diabetic patients 7≤HgbA1c<9 were not included in bivariate analysis.

Table 2. Multivariable Logistic Regression analysis of 544 patients with diabetes mellitus with HgbA1c<7% or HgbA1c≥9%

Table 2. Multivariable Logistic Regression analysis of 544 patients with diabetes mellitus with HgbA1c<7% or HgbA1c≥9%

Variable	Multivariate Logistic Regression OR* (95% CI)	P-Value
Payor		
Medicare	Reference	
Medicaid	0.34 (0.04-2.83)	0.32
Private	0.79 (0.39-1.61)	0.52
None	**7.11 (1.68-30.02)**	**0.008**
Diabetes Therapy		
None/Diet	Reference	
Oral	2.33 (0.78-6.93)	0.13
Insulin	**3.99 (1.40-11.4)**	**0.01**
Past Smoker	1.92 (0.97-3.77)	0.06

*OR, Odds Ratio, CI, Confidence Interval,

**Analysis controls for age, gender and race/ethnicity

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