Effect of Diabetes Mellitus on Complication Rates of Coronary Artery Bypass Grafting

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Previous studies have shown that diabetes mellitus (DM) is a risk factor for postoperative coronary artery bypass grafting (CABG) complications. More contemporary studies are needed to guide revascularization decisions in DM patients. We performed a single-center study of patients who underwent CABG. Patients with no DM were compared with patients with DM, subgrouped according to whether or not DM was treated with insulin before admission (Insulin and No Insulin Groups). Multivariable logistic regression was used to determine whether DM was a significant predictor of mortality, combined postoperative events, and specific postoperative complications after controlling for other predictive clinical variables. Of 11,590 consecutive patients who underwent CABG, 5,013 (43%) had DM and 6,577 (57%) had no DM. Of the patients with DM, 3,433 (68%) were not treated with insulin and 1,580 (32%) were treated with insulin before admission. Multivariable logistic regression analyses showed that DM was not significantly associated with in-hospital mortality or combined postoperative events after considering other clinical variables. The No Insulin Group was significantly associated with stroke, and the Insulin Group was significantly associated with surgical site infection and new renal failure. In conclusion, this study of consecutively treated CABG patients shows that DM is not a predictor of in-hospital mortality or combined in-hospital postoperative events after adjusting for other clinical factors. DM is a predictor of permanent stroke, surgical site infection, and new renal failure. These findings may help with case selection and management of DM patients undergoing CABG. **(Am J Cardiol 2019;124:1389−1396)**

Diabetes mellitus (DM) is a risk factor for atherosclerotic coronary artery disease (CAD), and patients who undergo cardiac procedures for CAD frequently have DM.[1,2] DM may be a predictor for complications of coronary artery bypass grafting (CABG), although DM is also associated with other predictors for CABG complications, including obesity, hypertension, race, sex, and socioeconomic status.[3,4] Previous studies over 2 decades have revealed mixed results on whether DM is an independent predictor for CABG complications.[2,5−8] DM is a predictor of CABG complications according to the current STS online risk calculator,[9] but there is a paucity of recently published data regarding CABG complication rates in patients with DM patients. Contemporary analysis of CABG complication rates in patients with DM is needed because the prevalence, demographics, and treatment of patients with DM are changing.[3,4,10−15] Accordingly, we sought to analyze the in-hospital outcomes following CABG to determine if DM is a significant predictor of postoperative complications of CABG.

Methods

We performed an observational study of patients who underwent isolated CABG at a large cardiovascular referral center from January 1, 2001 to December 31, 2016. The study protocol was approved by the Institutional Review Board at Eastern Virginia Medical School. The study was a retrospective study using deidentified data and therefore, no informed consent was required.

We included patients who underwent both primary operations and reoperations. We excluded patients who underwent other cardiac operations simultaneously, including valvular surgery or aortic replacement. During the timeframe of the study, data were collected for the purpose of maintaining a program of continuous quality improvement and the data were internally audited monthly for accuracy and completeness. Over the 15-year period, trained data personnel prospectively collected the data using STS NCD versions 2.35, 2.41, 2.52, 2.61, 2.73, 2.81.[16]

All variables were defined according to the STS NCD data standards.[17] Accordingly, DM was defined as a history of DM diagnosed and/or treated by a healthcare provider. Patients with no DM and patients with DM were grouped into the No DM Group or the DM Group, respectively. Patients with DM were grouped according to their most aggressive DM management on admission into 2 groups: The Insulin Group, if they had taken insulin before admission, and the No Insulin Group, if their DM was controlled with either oral medications, noninsulin injectable medications, or diet.

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Baseline variables included age, gender, race, insurance payer, height, weight, body mass index (BMI), smoking history, family history of premature CAD, dyslipidemia, previous hypertension, previous cerebrovascular disease, chronic lung disease (mild, moderate, and severe), history of dialysis, peripheral arterial disease, previous myocardial infarction (MI), heart failure within 2 weeks of the operation, previous cardiac intervention, previous CABG, ejection fraction, and number of diseased coronary vessels. Procedural variables included the surgical status (elective, urgent, emergent, or salvage), whether an internal mammary artery graft was used, whether an intra-aortic balloon pump was used, the cross-clamp time, and the bypass time.

Outcome variables included postoperative in-hospital mortality and in-hospital postoperative events. In-hospital postoperative events included permanent stroke, surgical site infection, pneumonia, prolonged ventilation, renal failure, a gastroenterology event, multisystem failure, reoperation for bleeding, atrial fibrillation, or cardiac arrest. Permanent stroke was defined as a confirmed neurologic deficit that was not resolved within 24 hours and included ischemic stroke, hemorrhagic stroke, and embolic stroke. Surgical site infections included deep sternal wound infection and superficial sternotomy wound infection for Versions 2.35, 2.41, 2.52, and 2.61, and postoperative surgical site infections for Versions 2.73 and 2.81, which included superficial and deep sternotomy infections, conduit harvest site infections, and cannulation site infections. Pneumonia was defined clinically and required the presence of appropriate clinical signs, symptoms, laboratory findings, and positive findings on 2 or more serial chest radiographs. Prolonged ventilation was defined as the need for pulmonary ventilation for >24 hours. Renal failure was defined as an acute increase in creatinine 3 times greater than baseline or ≥4 mg/dl, or a new requirement for dialysis postoperatively. Gastroenterology events included gastrointestinal bleeding requiring transfusion, pancreatitis, cholecystitis, mesenteric ischemia requiring exploration, hepatic failure, prolonged ileus, or infection with *Clostridium difficile*. Multisystem failure was defined as compromised function of 2 or more major organ systems. Postoperative atrial fibrillation was defined as new atrial fibrillation not present preoperatively, lasting longer than 1 hour and/or requiring treatment. Postoperative cardiac arrest was defined as an acute cardiac arrest documented by either ventricular fibrillation, rapid ventricular tachycardia with hemodynamic instability, asystole, or shocks from an implantable cardioverter-defibrillator.

Patients with no DM (No DM Group) were compared with DM patients not on insulin (No Insulin Group) and DM patients on insulin on admission (Insulin Group). Categorical variables were tabulated as counts and proportions (percentages), and continuous variables were tabulated as means and standard deviations (SD). The groups were compared with Chi-square analyses for categorical variables and with Student's t Test or analysis of variance for continuous variables. Simple logistic regression analyses were performed to examine the association of diabetes status with in-hospital mortality and all in-hospital events, and results were reported as odds ratios (OR) and 95% confidence intervals (CI).

Multivariable logistic regression analyses were performed to determine the effects of diabetes status and other preoperative variables on the following primary outcome variables: in-hospital mortality, all in-hospital events. Multivariable logistic regression was also performed to determine the effects of diabetes and preoperative variables on specific postoperative complications including permanent stroke, surgical site infection, pneumonia, prolonged ventilation, renal failure, a gastroenterology event, multisystem failure, reoperation for bleeding, atrial fibrillation, and cardiac arrest.

For each model, predictive variables were chosen based on previous modeling using the STS data base,[2,6] and included age, sex, race, payor, BMI, smoking status, family history of premature CAD, dyslipidemia, hypertension, cerebrovascular disease, chronic lung disease, history of dialysis, peripheral arterial disease, history of MI, congestive heart failure (CHF) within 2 weeks of CABG, previous cardiac intervention, previous CABG, ejection fraction, number of diseased vessels, surgical status, and diabetes status. Because ejection fraction data tended to cluster at 5% increments, this variable was changed to a categorical variable according to whether the reported ejection fraction was <25%, 25% to <40%, 40% to <55%, or ≥55%. Age was grouped into the following clinically meaningful categories: 0 to <50 years, 50 to <75 years, ≥75 years. BMI was also grouped into clinically meaningful categories: underweight (BMI <18.5 kg/m^2), normal (18.5≤ BMI <25 kg/m^2), overweight (25≤ BMI <30 kg/m^2), obese (30≤ BMI <35 kg/m^2), and morbid obese (35≤ BMI). Time trends were added to the model by grouping admission years into 2 time-frames with roughly equal numbers of patients: early (2001 to 2006, 5,912 patients) and late (2007 to 2016, 5,678 patients).

Statistical analysis was performed using SAS Version 9.4 and JMP Statistical Discovery Version 13.2 (SAS Institute, Cary, North Carolina). A p value of less than 0.05 was considered statistically significant.

Results

During the 15-year study period, a total of 11,590 patients underwent isolated CABG surgery at our institution. Of those, 5,013 patients (43%) had the diagnosis of diabetes (DM Group) and 6,577 patients (57%) had no diabetes (No DM Group). Of the patients with DM, 3,433 (68%) were in the No Insulin Group and 1,580 (32%) were in the Insulin Group. Over the time of the study, the number of patients in the No DM Group per year decreased, whereas the number of DM patients per year remained constant. Thus, the proportion of patients with DM per year increased from 38% in 2002 to 56% in 2016.

There were substantial differences in the baseline characteristics in the No DM, No Insulin, and Insulin Groups, as shown in Table 1. Patients in both DM groups (No Insulin and Insulin Groups) were more likely to be female, Black or Asian, have Medicaid, have a higher BMI, have dyslipidemia, hypertension, cerebrovascular disease, history of dialysis, peripheral arterial disease, previous MI, CHF within 2 weeks, previous percutaneous coronary intervention (PCI), a lower ejection fraction, or 3 vessel disease,

Table 1
Baseline demographics, co-morbid illnesses, and procedural variables by diabetes group

Baseline variable	No DM (n = 6577)	DM (n = 5013)	No insulin (n = 3433)	Insulin (n = 1580)	All patients (n = 11,590)	p Value No DM versus No insulin	p Value No DM versus insulin	p Value No DM versus DM
Age (years)	63.9 (SD = 10.9)	64.0 (SD = 9.9)	64.9 (SD = 9.6)	62.0 (SD = 10.3)	63.9 (SD = 10.5)	<0.001	<0.001	<0.001
Women	1,607 (24.4%)	1,660 (33.1%)	1,005 (29.3%)	655 (41.5%)	3,267 (28.2%)	<0.001	<0.001	<0.001
Race						<0.001	<0.001	<0.001
Black	1,205 (18.3%)	1,419 (28.3%)	882 (25.7%)	537 (34.0%)	2,625 (22.7%)			
White	5,099 (77.5%)	3,281 (65.4%)	2,331 (67.9%)	950 (60.1%)	8,384 (72.3%)			
Asian	150 (2.3%)	180 (3.4%)	129 (3.8%)	51 (3.2%)	510 (4.4%)			
Hispanic	47 (0.7%)	60 (1.2%)	41 (1.2%)	19 (1.2%)	107 (0.9%)			
Other	76 (1.2%)	77 (1.5%)	50 (1.5%)	27 (1.7%)	220 (1.9%)			
Insurance status						<0.001	<0.001	<0.001
Commercial	2,613 (39.7%)	1,821 (36.3%)	1,269 (37.0%)	552 (35.0%)	4,134 (38.3%)			
Medicaid	128 (2.0%)	185 (3.7%)	100 (2.9%)	85 (5.4%)	313 (2.7%)			
Medicare	3,126 (47.5%)	2,533 (50.5%)	1,749 (51.0%)	784 (49.7%)	5,659 (48.8%)			
Other Government	142 (2.2%)	105 (2.1%)	77 (2.2%)	28 (1.8%)	247 (2.1%)			
Other	340 (5.2%)	258 (51.5%)	158 (4.6%)	100 (6.3%)	598 (5.2%)			
Uninsured	442 (6.7%)	110 (2.2%)	80 (2.3%)	30 (1.9%)	337 (2.9%)			
Height (cm)	172.7 (SD = 10.5)	171.2 (SD = 11.0)	171.7 (SD = 11.2)	170.2 (SD = 10.6)	172.1 (SD = 10.8)	<0.001	<0.001	<0.001
Weight (kg)	85.1 (SD = 18.3)	91.3 (SD = 20.2)	90.9 (SD = 20.1)	92.1 (SD = 20.3)	87.6 (SD = 19.4)	<0.001	<0.001	<0.001
BMI (kg/m^2)	28.4 (SD = 5.8)	31.0 (SD=6.2)	30.6 (SD=5.9)	31.7 (SD=6.5)	29.5 (SD=6.1)	<0.001	<0.001	<0.001
Smoker	3,424 (52.1%)	2,180 (43.5%)	1,553 (45.2%)	627 (39.7%)	5,604 (48.4%)	<0.001	<0.001	<0.001
Family history of CAD	1,498 (22.8%)	908 (18.1%)	636 (18.5%)	272 (17.2%)	2,406 (20.8%)	<0.001	<0.001	<0.001
Dyslipidemia	4,978 (75.7%)	4,183 (83.4%)	2,836 (82.6%)	1,347 (85.3%)	9,161 (79.0%)	<0.001	<0.001	<0.001
Hypertension	5,140 (78.2%)	4,555 (90.9%)	3,090 (90%)	1,465 (92.7%)	9,295 (83.6%)	<0.001	<0.001	<0.001
Cerebrovascular disease	771 (11.7%)	816 (16.3%)	512 (14.9%)	304 (19.2%)	1,587 (13.7%)	<0.001	<0.001	<0.001
Chronic lung disease						0.046	<0.001	<0.001
Mild	432 (6.6%)	432 (8.6%)	261 (7.6%)	171 (10.8%)	1,296 (11.2%)			
Moderate	190 (2.9%)	176 (3.5%)	115 (3.4%)	61 (3.9%)	366 (3.2%)			
Severe	161 (2.5%)	149 (3.0%)	94 (2.7%)	55 (3.5%)	310 (2.7%)			
None	5,773 (87.8%)	4,226 (84.30%)	2,942 (85.7%)	1,284 (81.3%)	9,999 (86.3%)			
Dialysis	92 (1.4%)	239 (4.8%)	92 (2.7%)	147 (9.3%)	331 (2.9%)	<0.001	<0.001	<0.001
Peripheral arterial disease	788 (12.0%)	849 (16.9%)	529 (15.4%)	320 (20.3%)	1,637 (14.1%)	<0.001	<0.001	<0.001
Prior cardiac history								
Myocardial infarction	2,527 (38.4%)	2,031 (40.5%)	1,327 (38.7%)	704 (44.6%)	4,558 (39.3%)	0.821	<0.001	<0.001
CHF within 2 weeks	781 (11.9%)	1120 (22.3%)	660 (19.2%)	460 (29.1%)	1901 (16.4%)	<0.001	<0.001	<0.001
Prior cardiac intervention	1,744 (26.5%)	1417 (28.3%)	940 (27.4%)	477 (30.2%)	3161 (27.3%)	0.354	0.004	0.014
Prior CABG	254 (3.9%)	213 (4.2%)	154 (4.5%)	59 (3.7%)	467 (4.0%)	0.137	0.812	0.268
Prior PCI	990 (15.1%)	922 (19.8%)	588 (17.1%)	334 (21.1%)	1912 (16.5%)	0.007	<0.001	<0.001
Ejection fraction (%)	52.4 (SD = 12.8)	50.2 (SD = 13.8)	50.6 (SD = 13.6)	49.4 (SD = 14.2)	51.5 (SD = 13.3)	<0.001	<0.001	<0.001
Number of narrowed coronary arteries						<0.001	<0.001	<0.001
One	340 (5.2%)	137 (2.7%)	97 (2.8%)	40 (2.5%)	477 (4.12%)			
Two	1,272 (19.4%)	848 (16.9%)	568 (16.6%)	280 (17.8%)	2,120 (18.3%)			
Three	4,954 (75.4%)	4,020 (80.2%)	2,764 (80.6%)	1,256 (79.6%)	8,974 (77.5%)			

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Table 1 (*Continued*)

Baseline variable	No DM (n = 6577)	DM (n = 5013)	No insulin (n = 3433)	Insulin (n = 1580)	All patients (n = 11,590)	p Value No DM versus No insulin	p Value No DM versus insulin	p Value No DM versus DM
Surgical status						0.015	0.005	0.001
Elective	3,258 (49.5%)	2,482 (49.5%)	1,751 (51.0%)	732 (46.33%)	5,741 (49.5%)			
Urgent	3,074 (46.7%)	2,384 (47.6%)	1,580 (46.0%)	804 (50.9%)	5,458 (47.1%)			
Emergent	238 (3.6%)	145 (2.9%)	101 (2.9%)	44 (2.8%)	383 (3.3%)			
Salvage	0	1 (0.02%)	1 (0.03%)	0	1 (0.01%)			
LIMA use	5,532 (84.1%)	4,124 (82.3%)	2,843 (82.8%)	1,281 (81.1%)	9,656 (83.3%)	0.007	0.011	0.003
Intra-aortic balloon pump	709 (10.8%)	427 (8.5%)	298 (8.7%)	129 (8.2%)	1,136 (9.8%)	0.001	0.002	<0.001
Cross-clamp time (minutes)	60.7 (SD = 23.0)	62.8 (SD = 23.0)	62.9 (SD = 23.0)	62.4 (SD = 23.0)	61.6 (SD = 23.1)	<0.001	0.009	<0.001
Bypass time (minutes)	85.4 (SD = 29.7)	88.6 (SD = 33.5)	89.1 (SD = 34.6)	88.2 (SD = 31.0)	86.9 (SD = 31.5)	<0.001	0.001	<0.001

BMI = body mass index; CABG = coronary artery bypass graft surgery; CHF = congestive heart failure; CAD = coronary artery disease; DM = diabetes mellitus; LIMA = left internal mammary artery; PCI = percutaneous coronary intervention; SD = standard deviation.

as compared with the No DM Group. Patients in the No Insulin Group were older, more likely to have Medicare and less likely to have no insurance, as compared with the No DM Group. Patients in the Insulin Group were younger, more likely to have chronic obstructive pulmonary disease, and have previous cardiac intervention, as compared with the No DM Group.

Hemoglobin A1C levels were available in 1,327 (21.2%) patients in the No DM Group, 1438 (41.9%) patients in the No Insulin Group, and 816 (51.6%) patients in the Insulin Group. The hemoglobin A1C levels were 5.8% (SD = 0.4), 7.3% (SD = 1.5), and 8.3% (SD = 1.8), respectively. Patients in both DM groups (No Insulin and Insulin Groups) were less likely to receive a left internal mammary artery graft, be treated with an intra-aortic balloon pump and had longer cross-clamp times and bypass times. Patients in the Insulin Group were more likely to have the surgical status of urgent CABG. Overall, internal mammary graft use increased in all groups over the timeframe of the study, from 75.4% in 2001 to 95.9% in 2016.

The unadjusted analysis showed that there were significant differences in the complication rates in the No DM, No Insulin, and Insulin Groups, as shown in Table 2. Simple regression analysis showed significant unadjusted associations between diabetes status and in-hospital mortality and combined in-hospital events. Using the No DM Group as the reference, unadjusted analysis showed that the Insulin Group was a significant predictor of in-hospital mortality (OR = 1.70, CI = 1.15 to 2.51), and combined in-hospital events (OR = 1.26, CI = 1.12 to 1.41). The No Insulin Group was a significant predictor of combined in-hospital events (OR = 1.10, CI = 1.01 to 1.20), but not of mortality (OR = 1.12, CI = 0.79 to 1.58).

Results of the multivariable logistic regression analysis for in-hospital mortality are shown in Table 3. Diabetes status was not a significant predictor for in-hospital mortality. Significant predictors of in-hospital mortality were surgical status, age, previous CABG, peripheral arterial disease, history of dialysis, sex, chronic lung disease, CHF within 2 weeks, history of previous MI, and ejection fraction.

Results of the multivariable logistic regression analysis for combined in-hospital events are shown in Table 4. Diabetes status was not a significant predictor for combined in-hospital events. Significant predictors were surgical status, age, payor, chronic lung disease, BMI, ejection fraction, history of dialysis, CHF within 2 weeks, history of MI, race, history of dyslipidemia, history of hypertension, peripheral arterial disease, and number of diseased vessels.

Summary results showing the associations of diabetes status with specific postoperative complications are shown in Table 5. Using the No DM Group as a reference, the No Insulin group was a significant predictor of permanent stroke and the Insulin Group was a significant predictor of surgical site infection and new renal failure.

Discussion

In this large contemporary study, DM patients represented 43% of patients who underwent CABG, which is a higher proportion than previously reported.[2] By the end of the study timeframe, 56% of CABG patients had DM,

Table 2
Unadjusted analysis of outcome variables by diabetes group

Outcome variables	No DM (n = 6,577)	DM (n = 5,013)	No insulin (n = 3,433)	Insulin (n = 1,580)	All patients (n = 11,590)	p Value No DM versus No Insulin	p Value No DM versus Insulin	p Value No DM versus no insulin and insulin
Mortality	89 (1.4%)	88 (1.8%)	52 (1.5%)	36 (2.3%)	177 (1.5%)	0.518	0.011	0.038
Length of stay from surgery to discharge	6.8 (SD = 6.4)	8.2 (SD = 9.9)	8.0 (SD = 10.2)	8.8 (SD = 9.2)	7.4 (SD = 8.1)	<0.001	<0.001	<0.001
All in-hospital postoperative events	2,218 (33.7%)	1,847 (36.8%)	1,230 (35.8%)	617 (39.1%)	4,065 (35.1%)	0.036	<0.001	<0.001
Any permanent stroke	76 (1.2%)	106 (2.1%)	71 (2.1%)	35 (2.2%)	182 (1.6%)	<0.001	0.002	<0.001
Surgical site infection	53 (0.8%)	70 (1.4%)	34 (1.0%)	36 (2.3%)	123 (1.1%)	0.350	<0.001	<0.001
Pneumonia	217 (3.3)	167 (3.3)	111 (3.2)	56 (3.5)	384 (3.3)	0.860	0.629	0.848
Prolonged ventilation	732 (11.1%)	704 (14.0%)	440 (12.8%)	264 (16.7%)	1,436 (12.4%)	0.0133	<0.001	<0.001
Renal failure	125 (1.9%)	177 (3.5%)	89 (2.6%)	88 (5.6%)	302 (2.6%)	0.0251	<0.001	<0.001
Gastroenterology event	133 (2.0%)	150 (3.0%)	97 (2.8%)	53 (3.4%)	283 (2.4%)	0.0121	0.002	0.002
Multisystem failure	49 (0.8%)	47 (0.9%)	28 (0.8%)	19 (1.2%)	96 (0.8%)	0.7025	0.087	0.229
Reoperation bleeding	126 (1.9%)	86 (1.7%)	60 (1.8%)	26 (1.7%)	212 (1.8%)	0.5526	0.469	0.703
Postoperative atrial fibrillation	1,243 (18.9%)	906 (18.1%)	653 (19.0%)	253 (16.0%)	2,149 (18.5%)	0.882	0.007	0.018
Postoperative cardiac arrest	80 (1.2%)	67 (1.3%)	37 (1.1%)	30 (1.9%)	147 (1.3%)	0.538	0.043	0.063

DM = diabetes mellitus; SD = standard deviation.

Table 3
Multivariable logistic regression model showing associations of preoperative variables with mortality

Variable	Odds ratio (95% confidence interval)	p Value
Surgical status		<0.001
Emergent	9.49 (5.59-16.09)	<0.001
Urgent	1.23 (0.848-1.83)	0.261
Elective	Reference	
Patient age (years)		<0.001
75-100	9.18 (2.84-29.67)	<0.001
50-75	3.12 (1.02-9.53)	0.045
0-50	Reference	
Previous coronary bypass	4.07 (2.18-7.60)	<0.001
Peripheral arterial disease	1.97 (1.35-2.86)	0.002
Prior dialysis	3.14 (1.65-5.97)	0.002
Sex (Male=reference)	1.70 (1.20-2.40)	0.003
Chronic lung disease		0.025
Severe	2.37 (1.26-4.47)	0.008
Moderate	1.82 (0.90-3.67)	0.097
Mild	1.2 (1.03-2.87)	0.037
None	Reference	
Heart failure within 2 weeks	1.69 (1.15-2.47)	0.027
Prior myocardial infarction	1.47 (1.02-2.12)	0.039
Ejection fraction category (%)		0.044
<25	1.73 (0.88-3.39)	0.112
25-40	1.80 (1.15-2.81)	0.010
40-55	1.08 (0.71-1.64)	0.709
>=55	Reference	
Family history of coronary artery disease	0.74 (0.45-1.20)	0.166
Payor		0.195
Medicare	1.34 (0.84-2.13)	0.216
Medicaid	2.03 0(.84-4.93)	0.116
Uninsured	1.77 (0.56-5.34)	0.312
Commercial	Reference	
Diabetes status		0.206
Insulin group	1.46 (0.92-2.33)	0.108
No insulin group	0.99 (0.67-1.45)	0.941
No DM group	Reference	
Previous cardiac intervention	0.79 (0.53-1.21)	0.281
Number of narrowed coronary arteries		0.360
3	2.13 (0.51-8.84)	0.300
2	1.46 (0.33-6.38)	0.616
1	Reference	
Body mass index category (kg/m^2)		0.375
≥35	1.05 (0.62-1.78)	0.863
30-34	0.82 (0.51-1.33)	0.432
25-29	0.73 (0.48-1.10)	0.134
18.5-24	Reference	
Cerebrovascular disease	1.31 (0.89-1.94)	0.395
Race		0.605
Hispanic	1.32 (0.30-5.87)	0.715
Asian	0.56 (0.16-2.02)	0.378
White	1.26 (0.83-1.89)	0.275
Black	Reference	
Timeframe (early=reference)	0.92 (0.61-1.36)	0.666
Hypertension	0.82 (0.51-1.30)	0.696
Smoker	1.06 (0.78-1.53)	0.778
Dyslipidemia	0.98 (0.66-1.47)	1.000

Table 4
Multivariable logistic regression model showing associations of preoperative variables with combined in-hospital events

Variable	Odds ratio (95% confidence interval)	p Value
Surgical status		<0.001
Emergent	3.71 (2.91-4.72)	<0.001
Urgent	1.28 (0.867-1.88)	0.001
Elective	Reference	
Patient age (years)		<0.001
75-100	2.78 (2.27-3.39)	<0.001
50-75	1.64 (1.38-1.93)	<0.001
0-50	Reference	
Payor		<0.001
Medicare	1.60 (1.45-1.77)	<0.001
Medicaid	1.34 (1.04-1.73)	0.024
Uninsured	1.05 (0.80-1.37)	0.733
Commercial	Reference	
Chronic lung disease		<0.001
Severe	2.17 (1.69-2.78)	<0.001
Moderate	1.28 (1.03-1.60)	0.030
Mild	1.47 (1.26-1.70)	<0.001
None	Reference	
Body mass index category (kg/m^2)		<0.001
≥35	1.52 (1.32-1.75)	<0.001
30-34	1.12 (0.99-1.26)	0.084
25-29	1.03 (0.92-1.15)	0.649
18.5-24	Reference	
Ejection fraction category (%)		<0.001
<25	1.83 (1.46-2.31)	<0.001
25-40	1.24 (1.09-1.41)	0.001
40-55	1.13 (1.02-1.24)	0.014
>=55	Reference	
Prior dialysis	1.76 (1.38-2.23)	<0.001
Heart failure within 2 weeks	1.23 (1.11-1.41)	0.001
Prior myocardial infarction	1.15 (1.05-1.26)	0.003
Race		0.005
Hispanic	1.56 (1.03-2.36)	0.035
Asian	0.40 (1.09-1.80)	0.009
White	1.17 (1.06-1.30)	0.003
Black	Reference	
Dyslipidemia	0.86 (0.77-0.95)	0.013
Hypertension	1.81 (1.05-1.33)	0.024
Peripheral arterial disease	1.17 (1.04-1.32)	0.030
Number of narrowed coronary arteries		0.041
3	1.21 (0.97-1.51)	0.091
2	1.07 (0.85-1.36)	0.568
1	Reference	
Family history of coronary artery disease	0.89 (0.80-0.99)	0.059
Sex (Male=reference)	0.92 (0.84-1.01)	0.081
Timeframe (early=reference)	1.09 (0.98-1.20)	0.101
Cerebrovascular disease	1.12 (1.00-1.26)	0.156
Smoker	1.06 (0.97-1.16)	.192
Previous cardiac intervention	1.06 (0.96-1.17)	0.241
Diabetes status		0.545
Insulin group	1.05 (0.93-1.20)	0.427
No insulin group	0.98 (0.89-1.08)	0.644
No DM group	Reference	
Previous coronary bypass	0.96 (0.77-1.19)	0.711

reflecting a steady reduction in No DM patients treated with CABG.

The unadjusted analysis showed that DM was associated with several CABG complications; however, analysis of baseline variables also showed that DM was associated with other potential predictors of CABG complications. After adjusting for other potential predictors including age category, gender, race, payer status, BMI category, ejection fraction category, surgical status, and various co-morbid illnesses, DM was not a significant predictor of in-hospital mortality or combined in-hospital postoperative events. This finding is new, as compared with the findings in the late 1990s and early 2000s,[5–7] the more recent findings from the STS NCD registry,[2] and the California CABG Outcomes Reporting Program.[8]

Our study showed that diabetes status in the No Insulin Group was a significant predictor for permanent stroke, and diabetes status in the Insulin Group was a significant predictor for surgical site infections and new renal failure, but DM status was not a significant predictor of other postoperative complications. These findings are consistent with several previous reports[2,5–7] and are more affirmative for CABG than the findings reported in 2015 by Li et al.[8] Interdisciplinary care of CABG patients with DM has been an area of focus for our institution and it is possible that this single-center focus on glycemic control accounts for the more affirmative findings in our study.[18]

Our findings regarding postoperative mortality are in agreement with the current STS on-line risk calculator, which can be used to calculate the predicted risk for a single patient who underwent CABG. Exploring the STS on-line risk calculator reveals that the postoperative risk changes minimally when DM or insulin are added to the calculation.[9] The information provided by the STS risk calculator is very useful for clinicians who are motivated to use it, however, it is not readily obvious to most practicing clinicians who may still be laboring under the assumption based on previous published studies that DM carries a substantially increased risk for mortality following CABG. Our study of contemporary surgical practice clearly shows that DM is not a significant risk factor for mortality or combined in-hospital postoperative events, and this important information could influence the case selection of CABG patients. Our findings regarding postoperative stroke, surgical site infection, and new renal failure suggest the need for early detection and treatment of these complications in CABG patients with DM.

The Freedom Trial recently reported that CABG was superior to PCI in reducing death and MI and is preferred for DM patients requiring revascularization for multivessel CAD.[12] Nevertheless, current American College of Cardiology/American Heart Association guidelines state that diabetes patients have higher rates of perioperative mortality and morbidity.[19] Furthermore, some commentators have raised concerns about the increased stroke rate in diabetes patients undergoing CABG and question whether the Freedom Trial has settled the issue that patients with diabetes and multivessel disease should be uniformly referred for CABG.[20] Our contemporary analysis should provide reassurance that the complication rate of CABG is only minimally increased in DM patients, and should support the recommendations for choosing CABG for DM patients with multivessel disease, given the long-term survival benefit of CABG over PCI that was seen in the Freedom Trial.[21]

Our study is not without limitations. The STS definition of DM has limitations in defining specific types of DM.

Table 5
Results of multivariable logistic regression models showing associations of diabetes status with in-hospital mortality, any postoperative event, and specific postoperative complications

Complication	No insulin group*	p Value	Insulin group*	p Value
In-hospital mortality	0.99 (0.67-1.44)	0.941	1.46 (0.92-2.33)	0.108
Any postoperative event	0.98 (0.89-1.08)	0.644	1.05 (0.93-1.20)	0.427
Cerebrovascular accident	1.54 (1.08-2.18)	0.016	1.49 (0.95-2.33)	0.081
Surgical site infection	1.01 (0.64-1.59)	0.964	1.70 (1.04-2.78)	0.036
Pneumonia	0.89 (0.69-1.14)	0.359	0.93 (0.66-1.29)	0.651
Prolonged ventilation	0.98 (0.85-1.13)	0.795	1.15 (0.96-1.38)	0.123
New renal failure	1.02 (0.76-1.38)	0.870	2.27 (1.66-3.13)	<0.001
Gastroenterology event	1.20 (0.91-1.60)	0.200	1.37 (0.95-1.95)	0.088
Multisystem failure	1.00 (0.60-1.67)	1.000	1.54 (0.82-2.86)	0.178
Postoperative reoperation for bleeding	1.02 (0.73-1.42)	0.904	1.00 (0.63-1.58)	0.998
Postoperative atrial fibrillation	0.93 (0.83-1.04)	0.229	0.80 (0.68-0.95)	0.009
Postoperative cardiac arrest	0.77 (0.51-1.17)	0.228	1.13 (0.70-1.81)	0.624

* Odds ratio (95% confidence interval).

We do not have information about the duration of DM in our patients, which may have been informative. Hemoglobin A1C levels could have helped define the DM patients[22,23] but were not uniformly measured in all study patients. Our study is from a single center and the results may not be generalizable to other centers, although our hospital is fairly typical of a large urban hospital in the United States. An analysis of a single hospital's results may lack the statistical power of an analysis of the nation-wide STS database; however, our analysis is a realistic contemporary appraisal of current practice in a hospital setting that may be more meaningful for practicing clinicians.

In summary, this large observational study of contemporary CABG shows that DM is not a significant predictor of in-hospital mortality or combined in-hospital postoperative events after adjusting for other factors including surgical status, age, previous CABG, peripheral arterial disease, female sex, CHF, lung disease, dialysis, ejection fraction, and previous MI. DM is a predictor of permanent stroke, surgical site infection, and new renal failure.

Disclosures

None of the authors have any relevant financial, personal or professional relationships with other people or organizations to disclose.

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