Influence of Diabetes Mellitus on Long-Term Survival in Systematic Off-Pump Coronary Artery Bypass Surgery

Bertrand Marcheix, MD, Frédéric Vanden Eynden, MD, Philippe Demers, MD, Denis Bouchard, MD, and Raymond Cartier, MD

Departments of Cardiovascular Surgery, Montreal Heart Institute and Université de Montréal, Montreal, Québec

Background. **Diabetic patients generally present a more diffuse and calcified coronary artery disease than nondiabetic patients that can affect long-term outcome especially if an off-pump coronary artery bybass graft (OPCABG) technique is used. The aim of this study was to compare long-term results of OPCABG surgery for diabetic and nondiabetic patients.**

Methods. **This is a retrospective analysis of prospectively gathered data over a 10-year period of 1,000 consecutive and systematic OPCABG patients operated on between September 1996 and April 2004. Average follow-up period was 66 ± 28 months and was 97% complete. Overall survival as well as occurrence of major adverse cardiac events in diabetic and nondiabetic patients were specifically studied.**

Results. **In all, 278 diabetic patients and 722 nondiabetic patients were treated. There was no difference in 30-day mortality between the two groups ($p = 0.70$). Diabetic patients had more postoperative acute renal insufficiency ($p = 0.01$) and infections (sepsis; $p = 0.002$), and deep sternal infections ($p = 0.04$) Ten-year survival ($p = 0.006$) and survival free of major adverse cardiac events ($p = 0.02$) was decreased in the diabetic group. Age (hazard ratio [HR] = 1.06), peripheral vascular disease (HR = 1.72), carotid disease (HR = 1.53), congestive heart failure (HR = 1.51), incomplete revascularization (HR = 2.37), chronic renal insufficiency (HR = 1.93), left ventricular ejection fraction (HR = 0.13), and a lesser use of multiple internal thoracic artery grafts (HR = 0.67), but not diabetes mellitus ($p = 0.13$) were significant determinants of long-term mortality. Similarly, peripheral vascular disease (HR = 1.92), chronic renal insufficiency (HR = 2.36), emergent operation (HR = 1.71), chronic obstructive pulmonary disease (HR = 1.76), previous percutaneous coronary intervention (HR = 1.66), left ventricular ejection fraction (HR = 0.26), ischemic mitral regurgitation (HR = 1.83), and a lesser use of multiple internal thoracic artery grafts (HR = 0.72) were determinants of decreased survival free of major adverse cardiac events but not diabetes ($p = 0.2$). Breaking down the major adverse cardiac events, diabetes was found an independent predictive factor of recurrent myocardial infarction (HR = 1.85) and a borderline cause of readmission for congestive heart failure ($p = 0.06$). Need for new revascularization was comparable for both population ($p = 0.37$).**

Conclusions. **In our series of OPCABG surgery patients, diabetic patients had a comparative operative mortality and perioperative myocardial infarction rate as nondiabetic patients. However, they had an increased prevalence of postoperative acute renal insufficiency and infections. They also had a worse outcome than nondiabetic patients, but that was mainly due to a higher prevalence of preoperative comorbidities and a lesser use of multiple internal thoracic artery grafts. However, diabetes itself was a potential risk factor for long-term occurrence of myocardial infarction and congestive heart failure.**

(Ann Thorac Surg 2008;86:1181–8)

Diabetes mellitus (DM) is a major public health and economic problem with dramatic increased in prevalence and incidence [1]. Coronary heart disease is highly prevalent and is the major cause of morbidity and mortality among diabetic patients [2]. Cardiovascular death doubles in men and quadruples in women who have DM compared with nondiabetic persons [3]. Patients with DM account for approximately one quarter of all patients who undergo coronary revascularization procedures each year, and DM has been recognized as a risk factor of poor outcome after both percutaneous and on-pump surgical revascularization [4]. Nevertheless, surgical revascularization remains the recommended strategy for diabetic multivessel coronary heart disease [5].

The safety and the effectiveness of off-pump coronary artery bypass graft (OPCABG) surgery have been clearly established by many groups with results comparable

Accepted for publication June 18, 2008.

Address correspondence to Dr Cartier, Department of Cardiac Surgery, Montreal Heart Institute, 5000 Belanger St, Montreal, Quebec, H1T 1C8, Canada; e-mail: rc2910@aol.com.

Dr Cartier discloses that he has a financial relationship with CoroNéo.

Published by Elsevier Inc

0003-4975/08/$34.00
doi:10.1016/j.athoracsur.2008.06.063

with those of conventional coronary artery bypass graft surgery (CABG) using cardiopulmonary bypass [6–8]. Diabetic patients have been shown to display more diffuse and calcified disease than nondiabetic patients, and that could represent a greater surgical challenge during off-pump revascularization [9]. Long-term reports on OPCABG revascularization in diabetic patients are few in the literature, but it has been suggested that diabetic patients undergoing surgery off pump were more subject to iatrogenic anastomotic stenosis [10]. The objective of this study was to analyze the long-term results of OPCABG surgery in diabetic and nondiabetic patients, focusing specifically on overall survival and occurrence of major cardiac-related events.

Material and Methods

Study Design

This is a retrospective analysis of prospectively gathered data over a 10-year period (mean follow-up, 66 ± 28 months) of patients systematically undergoing OPCABG surgery by a single surgeon (R.C.) at the Montreal Heart Institute. From September 1996 to March 2004, 1,000 OPCABG operations were performed, representing 95% of all cases during the same time frame. Follow-up of the patients was 100% completed at 12 months. After this period, 3% of the patients were lost to follow-up. The general outcome of this series has already been the topic of a report [10]. The purpose of the present study is to focus on the diabetic population compared with the nondiabetic population.

Surgical Technique

The surgical technique has been quite consistent through the years and has been described elsewhere [10]. Absolute contraindications to OPCABG surgery were preoperative hemodynamic instability, and moderate to severe (3+ to 4+) mitral regurgitation. All OPCABG procedures were performed under general anesthesia with pulmonary artery pressure and transesophageal echocardiographic monitoring. Median sternotomy was used in 99% of patients. Heparin was administered at a dose of 150

Table 1. Demographic Characteristics

	Diabetes Mellitus	Nondiabetes Mellitus	*p* Value
Number	277	722	
Age (years)	65.1 ± 9.5	63.9 ± 10.2	0.11
Age >75 years (n)	33 (11.9%)	100 (13.9%)	0.51
Female	74 (26.7%)	149 (20.6%)	0.04
Hypertension	181 (65.3%)	359 (49.7%)	<0.0001
Hyperlipidemia	210 (75.8%)	524 (72.5%)	0.3
Obesity	51 (18.4%)	57 (7.9%)	<0.0001
Smoking	78 (28.2%)	210 (29%)	0.77
Chronic obstructive pulmonary disease	38 (13.7%)	80 (11.8%)	0.24
Familial history for coronary disease	181 (65.4%)	467 (64.6%)	0.46
Chronic renal failure	24 (8.7%)	24 (3.3%)	<0.0001
Pulmonary hypertension	41 (14.8%)	53 (7.3%)	<0.0001
Peripheral vascular disease	65 (23.5%)	118 (16.3%)	0.009
Stroke history	20 (7.2)	57 (7.9%)	0.72
Previous myocardial infarction	119 (43%)	279 (38.6%)	0.20
Recent MI (<30 days)	61 (22%)	136 (18.8%)	0.25
NYHA class	3.56 ± 0.66	3.56 ± 0.63	0.637
Congestive heart failure	42 (15.2)	46 (6.4%)	<0.0001
Left ventricular ejection fraction	0.51 ± 0.13	0.54 ± 0.12	0.001
Left ventricular dysfunction (n)	34 (12.3%)	71 (9.8%)	0.24
Preoperative atrial fibrillation	17 (6.1%)	20 (2.8%)	0.011
Unstable angina	198 (71.5%)	494 (68.3%)	0.35
Emergent operation	22 (7.9%)	32 (4.4%)	0.03
Preoperative intra-aortic balloon	29 (10.5%)	45 (6.2%)	0.02
Parsonnet score	16.7 ± 10.0	10.7 ± 8.8	<0.001
No. of affected vessels	2.75 ± 0.52	2.66 ± 0.57	<0.0001
Left main disease	84 (30.3%)	212 (29.3%)	0.75
One vessel	11 (4%)	38 (5.3%)	0.40
Two vessels	47 (17%)	173 (24%)	0.02
Three vessels	219 (79%)	512 (71%)	0.01
Diffuse coronary disease	91 (32.9%)	132 (18.3%)	<0.0001

MI = myocardial infarction; NYHA = New York Heart Association.

KIU/kg. A compression-type device (Cor-Vasc Retractor-Stabilizer; CoroNéo, Montreal, Quebec) was used in all cases for coronary artery stabilization. Proximal venous anastomoses were performed with side-bite clamping with systemic blood pressure lowered to 85 mm Hg. Bilateral internal thoracic artery (ITA) grafts were used either as two independent inflows or by branching off the right ITA from the left ITA (tector technique). Blood glucose level was strictly maintained at less than 11.1 mmol/L perioperatively and postoperatively. Postoperatively, patients received aspirin (80 mg orally, daily), subcutaneous heparin (5,000 KIU 3 times daily) during the entire hospital stay, and since 2002, clopidogrel (75 mg daily) for the first 3 months.

Clinical Follow-Up and Definitions

All preoperative, intraoperative, and early postoperative data were prospectively gathered. Diabetic patients were defined as being on a regimen of either oral hypoglycemic drugs or subcutaneous insulin. Perioperative myocardial infarction was defined as a new Q wave on electrocardiogram by Minnesota code criteria or myocardium-specific creatine kinase (CK-MB) levels greater than 100 ng/mL after surgery. Acute renal failure was defined as an increment of 50 mM (normal, 70 to 110 mM) of creatinine any time during the postoperative period. Clinical follow-up thereafter was completed through several means. Patients were seen for regular postoperative visits. All patients were systematically followed up by telephone interviews and chart reviews. If patients visited a different hospital, the attending physician was consulted for the consultation motive and subsequent findings. All data were systematically and prospectively entered into the database. Adverse cardiac events on follow-up were defined as cardiac death or death of unknown cause, myocardial infarction, recurrent unstable angina, hospitalization for congestive heart failure, or repeat revascularization (surgery or percutaneous coronary intervention).

Table 2. Operative Data

	Diabetes Mellitus	Nondiabetes Mellitus	*p* Value
Redo	9 (3.2%)	60 (8.3%)	0.005
No. of CABG	3.2 ± 0.85	3.15 ± 0.94	0.34
No. of CABG/territories	1.18 ± 0.28	1.18 ± 0.28	0.69
Complete revascularization	256 (92.4%)	687 (95%)	0.09
No-touch technique	24 (8.7%)	106 (14.7%)	0.012
Conversion CPB	0	4 (0.6%)	0.22
Single ITA	271 (97.8%)	699 (96.7%)	0.41
Bilateral ITAs	57 (20.6%)	259 (35.8%)	<0.0001
Sequential ITA	48 (17.5%)	122 (16.9%)	0.45
Tector ITA	75 (8.4%)	23 (10.4%)	0.41
ITA per patient	1.34 ± 0.61	1.59 ± 0.70	0.002
Radial artery	57 (20.6%)	259 (35.8%)	<0.0001

CABG = coronary artery bypass graft; CPB = cardiopulmonary bypass; ITA = internal thoracic artery.

Table 3. Postoperative Data

	Diabetes Mellitus	Nondiabetes Mellitus	*p* Value
Operative mortality	4 (1.4%)	13 (1.8%)	0.70
Perioperative myocardial infarction	6 (2.2%)	14 (1.9%)	0.80
NSTEMI	4 (1.4%)	9 (1.2%)	0.78
Confusion	39 (14.1%)	97 (13.4%)	0.78
Stroke	2 (0.7%)	6 (0.8%)	0.86
Transient ischemic attack	1 (0.4%)	2 (0.3%)	NS
Atrial fibrillation	75 (27.1%)	191 (26.4%)	0.83
Acute renal insufficiency	39 (14.1%)	61 (8.4%)	0.01
Infection (sepsis)	17 (6.1%)	14 (1.9%)	0.002
Deep infection	5 (1.8%)	3 (0.4%)	0.04
Sternal dehiscence	4 (1.4%)	8 (1.1%)	0.66
Respiratory complication	18 (6.5%)	68 (9.4%)	0.14
Postoperative bleeding	9 (3.2%)	32 (4.4%)	0.40
Intensive care unit stay (hours)	72.9 ± 86.8	63.5 ± 49	0.03
Mechanical ventilation (hours)	22.8 ± 57.2	17.7 ± 29.9	0.07
Hospital stay (days)	7.32 ± 9.7	6.28 ± 3.8	0.02

NS = not significant; NSTEMI = non–ST-elevation myocardial infarction.

Statistical Analysis

Data are presented as mean ± SD for continuous variables, and frequencies and percentages are presented for categorical variables. Patient population characteristics and outcomes were compared between diabetic and nondiabetic patients using the χ^2 test in case of categorical variables; continuous variables were compared using the Student *t* test or Mann-Whitney *U* test if distributional assumptions were not met. Time to mortality was presented using adjusted survival curves and compared between groups (diabetic versus nondiabetic) using the log-rank test. Cox regression analysis was used to analyze the effect of DM on mortality adjusted for the risk factors that were significant at a 0.20 level in the univariate analysis. The interaction between each risk factor and group (diabetic versus nondiabetic) was tested at a 0.05 level, to evaluate whether the effect of given risk factor was the same in the diabetic group versus the nondiabetic group. Nonsignificant interaction was dropped from the model.

Statistical analyses were performed using SPSS software (SPSS, Chicago, Illinois) and conducted at the 0.05 significance level. Univariate analysis was performed to evaluate the impact of patient characteristics and risk factors, as defined in Table 1, on long-term outcomes. All patients were considered as "intention to treat." No more than 1 variable for 10 events was considered for multivariate analysis purposes. For long-term endpoints, independent risk factors analyses are presented as hazard ratio (HR) with a 95% confidence interval. Actuarial survival was obtained using the Kaplan-Meier method. Probability values were defined by means of log-rank analysis, and *p* less than 0.05 was considered statistically significant.

ADULT CARDIAC

Table 4. Cox Regression Analysis Model for Overall Survival

	Univariate	Multivariate	
	p Value	*p* Value	HR (95% CI)
Age	<0.001	<0.001	1.06 (1.04–1.08)
Left ventricular ejection fraction	<0.001	0.001	0.13 (0.04–0.41)
Incomplete revascularization	<0.001	<0.001	2.37 (1.51–3.78)
Chronic renal insufficiency	<0.001	0.007	1.93 (1.20–3.11)
Peripheral vascular disease	<0.001	0.002	1.72 (1.23–2.40)
Cerebrovascular disease	<0.001	0.02	1.53 (1.08–2.16)
Congestive heart failure	<0.001	0.05	1.51 (1.00–2.29)
Internal thoracic artery per patient	<0.001	0.007	0.67 (0.51–0.90)
Diabetes mellitus	0.006	0.12	

CI = confidence interval; HR = hazard ratio.

Table 5. Cox Regression Analysis for Survival Free of Major Adverse Cardiac Event

	Univariate	Multivariate	
	p Value	*p* Value	HR (95% CI)
Peripheral vascular disease	<0.001	<0.001	1.92 (1.37–2.70)
Chronic renal insufficiency	<0.001	0.001	2.36 (1.40–3.99)
Chronic obstructive pulmonary disease	0.002	0.006	1.76 (1.18–2.63)
Percutaneous coronary intervention	0.06	0.02	1.66 (1.08–2.57)
Left ventricular ejection fraction	<0.001	0.02	0.26 (0.08–0.82)
Ischemic mitral regurgitation	<0.001	0.03	1.83 (1.08–3.10)
Emergency	<0.001	0.04	1.71 (0.99–2.94)
Internal thoracic artery per patient	<0.001	0.01	0.72 (0.56–0.93)
Diabetes mellitus	0.01	0.23	

CI = confidence interval; HR = hazard ratio.

Results

There were 278 diabetic patients (28%), and of them, 30 (10.2%) were on insulin therapy.

Patient Demographics and Risk Factors

Hypertension, obesity, chronic renal failure, pulmonary hypertension, atrial fibrillation, peripheral vascular disease, and congestive heart failure were significantly more frequent among the diabetic population (Table 1). Prevalence of diffuse coronary disease, emergency interventions, and triple-vessel disease were also increased among diabetic patients compared with nondiabetic patients. Their Parsonnet score was also significantly higher ($p < 0.001$).

Operative Data

Table 2 depicts operative data from the whole cohort and compares the diabetic and nondiabetic populations. More redo surgery and bilateral internal thoracic artery bypasses were performed in the nondiabetic group. The number of performed bypass grafts was similar in both groups but the "no touch" technique was used less frequently in the diabetic group. On average, more ITA

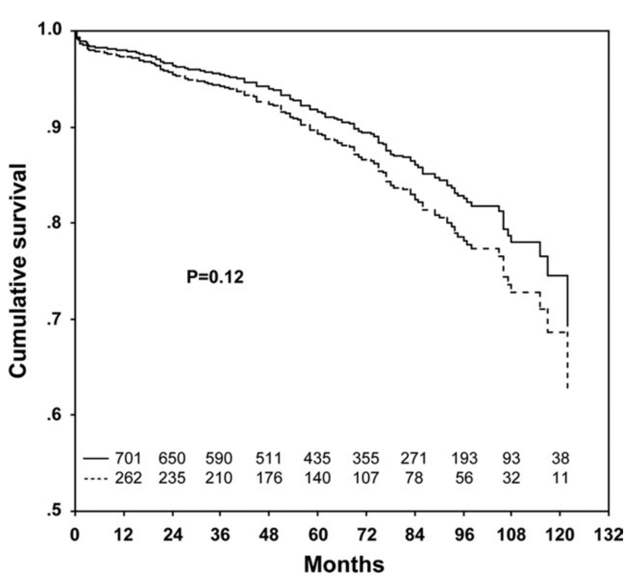

Fig 1. Survival curve comparing patients with diabetes mellitus (dashed line) and without diabetes (solid line) after correcting for risk factors.

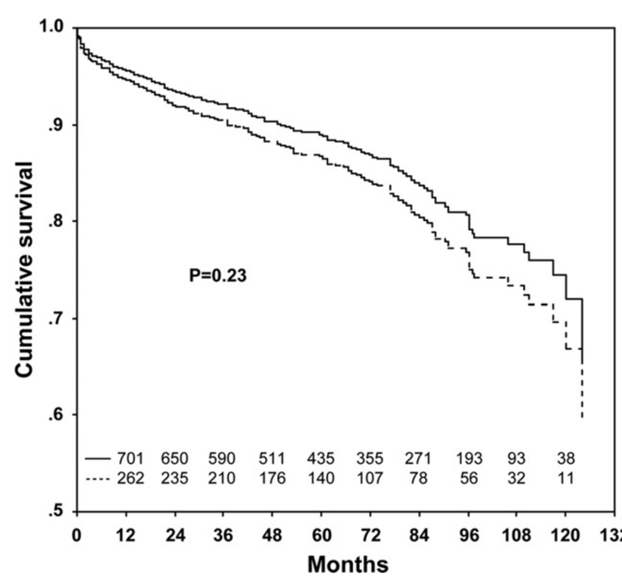

Fig 2. Major adverse cardiac event–free survival curve comparing patients with diabetes mellitus (dashed line) and without diabetes (solid line) after correcting for risk factors.

Table 6. Cox Regression Analysis for Survival Free of Myocardial Infarction

	Univariate	Multivariate	
	p Value	*p* Value	HR (95% CI)
Peripheral vascular disease	0.008	0.03	1.96 (0.99–3.86)
Congestive heart failure	0.006	0.04	2.47 (1.05–5.83)
Diabetes mellitus	0.02	0.05	1.96 (0.99–3.86)
Cerebrovascular disease	0.02	0.11	

CI = confidence interval; HR = hazard ratio.

Table 7. Cox Regression Analysis for Survival Free of Congestive Heart Failure

	Univariate	Multivariate	
	p Value	*p* Value	HR (95% CI)
Left ventricular ejection fraction	<0.001	0.001	0.14 (0.001–0.17)
Myocardial infarction (< 4 weeks)	<0.001	0.02	2.47 (1.05–5.83)
Diabetes mellitus	0.005	0.06	1.85 (0.98–3.46)
Unstable angina	0.01	0.20	
Congestive heart failure	<0.001	0.10	

CI = confidence interval; HR = hazard ratio.

grafts per patient were performed in the nondiabetic patients.

Early Clinical Outcome

Perioperative morbidity and mortality is described in Table 3. Operative mortality (30 days) was lower in the diabetic group but did not reach statistical significance ($p = 0.7$). Moreover, prevalence of postoperative acute renal insufficiency, deep sternal infections, and sepsis were more frequently encountered in the diabetic population. They also had longer hospital and intensive care unit lengths of stay.

Late Clinical Outcome

LONG-TERM SURVIVAL. The overall actuarial survival was significantly decreased in the diabetic population at 1 year (95% ± 1.3% versus 97% ± 0.6%), 5 years (83% ± 2.4% versus 89% ± 1.3%), and 10 years (58.4% ± 6.2% versus 74% ± 2.6%) of follow-up ($p = 0.005$) compared with the nondiabetic population. The Cox regression analysis model revealed that age, incomplete revascularization, low left ventricular ejection fraction, chronic renal insufficiency, peripheral vascular disease, cerebral vascular disease, number of ITA grafts per patient (negative correlation), and history of congestive heart failure were significant determinants of long-term mortality (Table 4). After correcting for these risk factors, DM was not recognized as a significant detrimental cause of long-term survival (Fig 1).

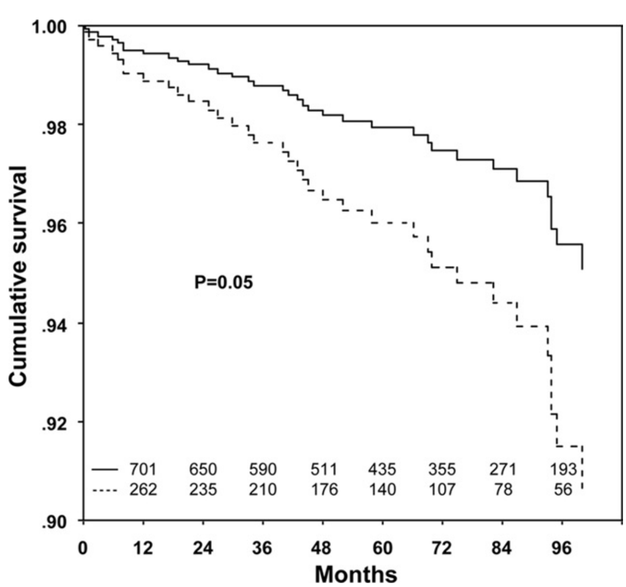

Fig 3. Myocardial infarction–free survival curve comparing patients with diabetes mellitus (dashed line) and without diabetes (full line) after correcting for risk factors.

MACE-FREE SURVIVAL. Survival free of major adverse cardiac events (MACE) at 1 year (93.5% ± 1.5% versus 95.5% ± 0.8%), 5 years (80% ± 2.6% versus 89% ± 1.2%), and 9 years (57.5% ± 6.8% versus 76.4% ± 2.4%) was also decreased in the diabetic population ($p = 0.02$). Chronic obstructive pulmonary disease, peripheral vascular disease, chronic renal insufficiency, previous percutaneous coronary intervention, ischemic mitral regurgitation, low left ventricular ejection fraction, emergency operation, and number of ITA grafts per patient (protector effect) were determinants of decreased MACE-free survival (Table 5). After correcting for these factors, DM did not appear as a significant cause of MACE (($p = 0.23$); Fig 2). Breaking down the MACE, DM (HR = 1.96) was found to be an independent predictive factor of readmission for recurrent myocardial infarction (Table 6, Fig 3) and a borderline predictive factor of readmission for congestive heart failure ($p = 0.06$; HR = 1.85) (Table 7) and death of cardiac cause ($p = 0.07$). Readmission for unstable angina ($p = 0.63$) or new subsequent procedures ($p = 0.37$), either surgical or percutaneous coronary intervention, were comparable for both the diabetic and nondiabetic populations. More specifically, freedom of revascularization for non-DM and DM was 96% ± 0.8% and 94% ± 1.7% at 5 years and 90% ± 1.7% versus 86% ± 4.2% at 10 years, respectively.

Comment

Previous studies have reported conflicting results regarding the adverse effect of DM on surgical outcomes after CABG [11–16]. These equivocal data may be due to several factors, such as the extent of coronary artery disease, adequacy of DM control, strategy of conduit selection, and surgical techniques including cardiopulmonary bypass [13, 16–22].

The short-term safety and effectiveness of OPCABG have been clearly established by many groups with results comparable with those of conventional CABG using cardiopulmonary bypass [6–8]. Reports of long-term results after OPCABG are few in the literature. We especially focused our attention on the impact of DM on long-term results compared with the non-DM population.

In the current study, the diabetic population represented 27.8% of the entire cohort, which was comparable with other series [22–26]. A small subset (30 patients, 10%) had type 1 (insulin-dependent) DM. This cohort of diabetic patients is known to have a less favorable outcome [27], and that was difficult to put in perspective in our series owing to their small representation among the cohort. Patients with DM were more likely to have higher body mass index, history of congestive heart failure, chronic renal failure, peripheral vascular disease, and more extensive coronary artery disease than the nondiabetic group. The operative mortality (30 days) was comparable for both groups, even though the diabetic population was sicker. This point is consistent with other recent reports [11, 14, 28, 29]. Rajakaruna and coworkers [28] recently reported a series of 877 diabetic patients (17% of the whole studied cohort) with an in-hospital mortality of 2.2% (1% in the nondiabetic group). Diabetes was not identified as an in-hospital mortality risk factor. Kubal and colleagues [30] reported similar observations although they found higher perioperative morbidity among insulin-dependent diabetic patients [30]. Others have reported higher mortality rates at large among diabetic patients [17, 31–33]. Thourani and associates [31], reporting 2,278 diabetic patients, observed an operative mortality of 3.9%. Cohen and colleagues [17] had similar findings, reporting mortality rates as high as 5%. The North American multicenter registry data on 41,663 diabetic patients reported, in 1997, a 30-day mortality of 3.7% [34]. In agreement with Rajakaruna and colleagues [28], our study failed to isolate DM as an independent predictor for operative mortality [11]. As suggested by Calafiore and colleagues [23], the 30-day mortality may be more influenced by technical details of the surgery than by the disease itself. Nonetheless, rigorous screening of the patients and optimization of metabolic control in the perioperative period can reduce the postoperative morbidities [18, 35].

Most series report higher incidences of renal, neurologic, and gastrointestinal complications among diabetic patients [29]. In the current series, postoperative acute renal failure, sepsis, and deep sternal infection were more frequently encountered in the diabetic population. This clinically translated to longer lengths of intensive care unit and hospital stay. In our series, postoperative acute renal failure is linked with the higher prevalence of chronic renal failure in the diabetic population. Despite active perioperative blood glucose control in diabetic patients during the perioperative period, postoperative infections were still more frequent in the diabetic population. The predisposition of diabetic patients to infective complications after cardiac surgery has been often suggested [16, 36–40]. Angiopathy, neuropathy, and hyperglycemia associated with DM are identified as the main reasons for predisposition to infections [41].

Overall actuarial survival and MACE-free survival were lower in the diabetic population. This finding is in agreement with other reports [12, 14, 17, 34, 38, 42, 43]. Weintraub and colleagues [42] studied the long-term outcome of a nonselected and nonrandomized cohort of diabetic patients [42]. They found 5- and 10-year survivals of 76% and 38%, respectively, among diabetic surgically revascularized patients, results comparable with those of percutaneous coronary intervention patients ($p = 0.47$). However, the authors raised a concern about angioplasty for insulin-requiring diabetic patients with multivessel disease because their outcome was definitely better with surgery. The investigators of the Bypass Angioplasty Revascularization Investigation randomized trial have reported a 10-year survival for nondiabetic and diabetic patients of 77% versus 57%, respectively—numbers that are very similar to our study [43]. Diabetic patient outcome was negatively affected when first-intention percutaneous angioplasty was used. The authors attributed this survival difference to reduced cardiac mortality among the surgical cohort. The rate of post-CABG subsequent revascularization procedures at 5 years was 14% in diabetic patients (43) and 8% in nondiabetic patients (44), differences that were more noticeable than what was observed in our population (6% versus 4%). The reason for this remains unclear, but the two studies were not contemporary.

The current study failed to find DM as an independant predictor of decreased long-term survival and MACE-free survival. Diabetic patients tended to be older and had more comorbidities, as suggested by a higher preoperative Parsonnet score, than nondiabetic patients. A lesser use of multiple ITA grafts was found to be a significant perioperative factor of decreased survival and increased prevalence of recurrent MACE. Owing to a higher anticipation of wound infection, surgeons are generally more reluctant to use multiple ITA grafts in diabetic patients. Because of the small number of events, a Cox regression model could not be built specifically for these events. However, that should motivate surgeons to be more aggressive in arterial grafting for the diabetic population. Among several explanations in favor of ITA grafting is the presence of more complex diffuse coronary artery disease and more rapid progressive disease in diabetic patients.

Limitations

Although the data were collected prospectively, the main limitation is the retrospective analysis and the nonspecific design of the data for the analysis of the diabetic population.

In conclusion, in our OPCABG series, diabetic patients had an operative mortality comparable with that of nondiabetic patients but had an increased incidence of postoperative sepsis, deep sternal infection, and acute renal failure. Long-term overall survival and MACE-free survival were decreased in the diabetic population mainly because of more associated comorbidities and lesser use of multiple ITA grafts. However, DM was found to be a cause of recurrent myocardial infarction and to a lesser degree, congestive heart failure.

We thank Mariève Cossette for her expert statistical advice and help.

References

1. Narayan KMV, Gregg EW, Fagot-Campagna A, Engelgau MM, Vinicor F. Diabetes: a common, growing, serious, costly, and potentially preventable public health problem. Diabetes Res Clin Pract 2000;50(Suppl):77–84.
2. Berry C, Tardif JC, Bourassa MG. Coronary heart disease in patients with diabetes. Part I: recent advances in prevention and noninvasive management. J Am Coll Cardiol 2007;49:631–42.
3. Kannel W. Lipids, diabetes, and coronary heart disease: insights from the Framingham Study. Am Heart J 1985;110:1100–7.
4. Berry C, Tardif JC, Bourassa MG. Coronary heart disease in patients with diabetes. Part II: recent advances in coronary revascularization. J Am Coll Cardiol 2007;49:643–56.
5. Detre KM, Guo P, Holubkov R, et al. Coronary revascularization in diabetic patients. A comparison of the randomized and observational components of the Bypass Angioplasty Revascularization Investigation (BARI). Circulation 1999;99:633–40.
6. Magee MJ, Coombs LP, Peterson ED, Mack MJ. Patient selection and current practice strategy for off-pump coronary artery bypass surgery. Circulation 2003;108(Suppl 2):9–14.
7. Stamou SC, Jablonski KA, Hill PC. Coronary revascularization without cardiopulmonary bypass versus the conventional approach in high-risk patients. Ann Thorac Surg 2005;79:552–7.
8. Muneretto C, Bisleri G, Negri A, et al. Off-pump coronary artery bypass surgery technique for total arterial myocardial revascularization: a prospective randomized study. Ann Thorac Surg 2003;76:778–82.
9. Silva JA, Escobar A, Collins TJ, Ramee SR, White CJ. Unstable angina: a comparison of angioscopic findings between diabetic and nondiabetic patients. Circulation 1995;92:1731–6.
10. Demaria RG, Fortier S, Carrier M, Perreault LP. Early stenosis after coronary artery snaring during off-pump coronary artery bypass in a patient with diabetes. J Thorac Cardiovasc Surg 2001;122:1044–5.
11. El-Hamamsy I, Cartier R, Demers P, Bouchard D, Pellerin M. Long-term results after systematic off-pump coronary artery bypass graft surgery in 1000 consecutive patients. Circulation 2006;114(Suppl 1):486–49.
12. Gardner TJ, Greene PS, Rykiel MF, et al. Routine use of the left internal mammary artery graft in the elderly. Ann Thorac Surg 1990;49:188–94.
13. Hirotani T, Kameda T, Kumamoto T, et al. Effects of coronary artery bypass grafting using internal thoracic arteries for diabetic patients. J Am Coll Cardiol 1999;34:532–8.
14. Herlitz J, Wognsen BG, Emanuelsson H, et al. Mortality and morbidity in diabetic and nondiabetic patients during a 2-year period after coronary artery bypass grafting. Diabetes Care 1996;19:698–703.
15. Horvath KA, DiSesa VJ, Peigh PS, et al. Favorable results of coronary artery bypass grafting in patients older than 75 years. J Thorac Cardiovasc Surg 1990;99:92–6.
16. Morris JJ, Smith LR, Jones RH, et al. Influence of diabetes and mammary artery grafting on survival after coronary bypass. Circulation 1991;84(Suppl 3):275–84.
17. Pick AW, Orszulak TA, Anderson BJ, et al. Single versus bilateral internal mammary artery graft: 10-year outcome analysis. Ann Thorac Surg 1997;64:599–605.
18. Cohen Y, Raz I, Gideon M, Mozes B. Comparison of factors associated with 30-day mortality after coronary artery bypass grafting in patients with versus without diabetes mellitus. Am J Cardiol 1998;81:7–11.
19. Furnary AP, Gao G, Grunkemeier GL, et al. Continuous insulin infusion reduces mortality in patients with diabetes undergoing coronary artery bypass grafting. J Thorac Cardiovasc Surg 2003;125:1007–21.
20. Zerr KJ, Furnary AP, Grunkemeier GL, Bookin S, Kanhere V, Starr A. Glucose control lowers the risk of wound infection in diabetics after open heart operations. Ann Thorac Surg 1997;63:356–61.
21. Lytle BW, Blackstone EH, Loop FD, et al. Two internal thoracic artery grafts are better than one. J Thorac Cardiovasc Surg 1999;117:855–72.
22. Srinivasan AK, Grayson AD, Fabri BM. On-pump versus off-pump coronary artery bypass grafting in diabetic patients: a propensity score analysis. Ann Thorac Surg 2004;78:1604–9.
23. Magee MJ, Dewey TM, Acuff T, et al. Influence of diabetes on mortality and morbidity: off-pump coronary artery bypass grafting versus coronary artery bypass grafting with cardiopulmonary bypass. Ann Thorac Surg 2001;72:776–81.
24. Calafiore AM, Di Mauro M, Di Giammarco G, et al. Effects of diabetes on early and late survival after isolated first coronary bypass surgery in multivessel disease. J Thorac Cardiovasc Surg 2003;125:144–54.
25. Szabó Z, Håkanson E, Svedjeholm R. Early postoperative outcome and medium-term survival in 540 diabetic and 2,239 nondiabetic patients undergoing coronary artery bypass grafting. Ann Thorac Surg 2002;74:712–9.
26. The BARI Investigators. Influence of diabetes on five-year mortality and morbidity in a randomized trial comparing PTCA and CABG in patients with multivessel disease. The Bypass Angioplasty Revascularization Investigation (BARI). Circulation 1997;96:1761–9.
27. Luciani N, Nasso G, Gaudino M, et al. Coronary artery bypass grafting in type II diabetic patients: a comparison between insulin-dependent and non-insulin-dependent patients at short- and mid-term follow-up. Ann Thorac Surg 2003;76:1149–54.
28. Nashef SA, Roques F, Michel P, et al. Coronary surgery in Europe: comparison of the national subsets of the European system for cardiac operative risk evaluation database. Eur J Cardiothorac Surg 2000;17:396–9.
29. Choi JS, Cho KR, Kim KB. Does diabetes affect the postoperative outcomes after total arterial off-pump coronary bypass surgery in multivessel disease? Ann Thorac Surg 2005;80:1353–61.
30. Rajakaruna C, Rogers CA, Suranimala C, Angelini GD, Ascione R. The effect of diabetes mellitus on patients undergoing coronary surgery: a risk-adjusted analysis. J Thorac Cardiovasc Surg 2006;132:802–10.
31. Kubal C, Srinivisan AK, Grayson AD, Fabri BM, Chalmers JAC. Effect of risk-adjusted diabetes on mortality and morbidity after coronary artery bypass surgery. Ann Thorac Surg 2005;79:1570–6.
32. Thourani VH, Weintraub WS, Stein B, et al. Influence of diabetes mellitus on early and late outcome after coronary artery bypass grafting. Ann Thorac Surg 1999;67:1045–52.
33. Adler DS, Goldman L, O'Neil A, et al. Long-term survival of more than 2,000 patients after coronary artery bypass grafting. Am J Cardiol 1986;58:195–202.
34. Morris JJ, Smith LR, Jones RH, et al. Influence of diabetes and mammary artery grafting on survival after coronary bypass. Circulation 1991;84(Suppl 3):275–84.

35. Carson JL, Scholz PM, Chen AY, Peterson ED, Gold J, Schneider SH. Diabetes mellitus increases short-term mortality and morbidity in patients undergoing coronary artery bypass graft surgery. J Am Coll Cardiol 2002;40:418–23.
36. Furnary AP, Zerr KJ, Grunkemeier GL, Starr A. Continuous intravenous insulin infusion reduces the incidence of deep sternal wound infection in diabetic patients after cardiac surgical procedures. Ann Thorac Surg 1999;67:352–60.
37. Jacoby RM, Nesto RW. Acute myocardial infarction in the diabetic patient: pathophysiology, clinical course and prognosis. J Am Coll Cardiol 1992;20:726–44.
38. Matata BM, Galinanes M. Cardiopulmonary bypass exacerbates oxidative stress but does not increase proinflammatory cytokine release in patients with diabetes compared with patients without diabetes: regulatory effects of exogenous nitric oxide. J Thorac Cardiovasc Surg 2000;120:1–11.
39. FitzGibbon GM, Kafka HP, Leach AJ, et al. Coronary bypass graft fate and patient outcome: angiographic follow-up of 5,065 grafts related to survival and reoperation in 1,388 patients during 25 years. J Am Coll Cardiol 1996;28:616–26.
40. Ömeroglu SN, Kirali K, Güler M, et al. Midterm angiographic assessment of coronary artery bypass grafting without cardiopulmonary bypass. Ann Thorac Surg 2000;70:844–50.
41. van der Meer J, Hillege HL, van Gilst WH, et al. A comparison of internal mammary artery and saphenous vein grafts after coronary artery bypass surgery: no difference in 1-year occlusion rate and clinical outcome. Circulation 1994;90:2367–74.
42. Weintraub WS, Stein B, Kosinski A, et al. Outcome of coronary bypass surgery versus coronary angioplasty in diabetic patients with multivessel coronary artery disease. J Am Coll Cardiol 1998;31:10–9.
43. BARI Investigators. The final 10-year follow-up results from the BARI randomized trial. J Am Coll Cardiol 1007;49:1600–6.
44. BARI Investigators. Comparison of coronary bypass surgery with angioplasty in patients with multivessel disease. N Engl J Med 1996;335:217–25.