Original Article

Outcomes of Coronary Artery Bypass Graft Surgery Versus Percutaneous Coronary Intervention in Patients Aged 18–45 Years with Diabetes Mellitus

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Abstract

Background: Debate on treatment for young patients with coronary artery disease still exists. This study aimed to investigate the intermediate- and long-term outcomes between coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI) in patients aged 18–45 years with diabetes mellitus (DM).

Methods: Between January 2006 and March 2016, a total of 2018 DM patients aged 18–45 years including 517 cases of CABG and 1501 cases of PCI were enrolled in the study. Using propensity score matching (PSM), 406 patients were matched from each group. The intermediate- and long-term data were collected. The primary end point of this study was long-term death. The secondary end points included long-term major adverse cardiovascular and cerebrovascular events (MACCEs), stroke, angina, myocardial infarction (MI), and repeat revascularization.

Results: Before PSM, the in-hospital mortality was 1.2% in the CABG group and 0.1% in the PCI group, with statistically significant difference ($P < 0.0001$). The 10-year follow-up outcomes including long-term survival rate and freedom from MACCEs were better in the CABG group than those in the PCI group (97.3% vs. 94.5%, $P = 0.0072$; 93.2% vs. 86.3%, $P < 0.0001$), but CABG group was associated with lower freedom from stoke compared to PCI group (94.2% vs. 97.5%, $P = 0.0059$). After propensity score-matched analysis, these findings at 10-year follow-up were also confirmed. Freedom from MACCEs was higher in CABG group compared to PCI group, but no significant difference was observed (93.1% vs. 89.2%, $P = 0.0720$). The freedom from recurrent MI was significantly higher in CABG patients compared with PCI patients (95.6% vs. 92.5%, $P = 0.0260$). Furthermore, CABG was associated with a higher rate of long-term survival rate than PCI (97.5% vs. 94.6%, $P = 0.0403$). There was no significant difference in the freedom from stroke between CABG and PCI groups (95.3% vs. 97.3%, $P = 0.9385$). The hospital cost was greater for CABG (13,936 ± 4480 US dollars vs. 10,926 ± 7376 US dollars, $P < 0.0001$).

Conclusions: In DM patients aged 18–45 years, the cumulative survival rate, and freedom from MI and repeat revascularization for CABG were superior to those of PCI. However, a better trend to avoid stroke was observed with PCI.

Key words: Coronary Artery Bypass Grafting; Coronary Artery Disease; Diabetes Mellitus; Percutaneous Coronary Intervention

Introduction

Coronary artery disease (CAD) is a major cause of death in developed countries,[1] and this disease is diagnosed in an increasing number of adults nowadays,[2] particularly among patients with diabetes mellitus (DM). DM is a common but serious chronic disease, which can accelerate atherosclerosis and is responsible for the process of coronary artery stenosis.[3] The number of CAD patients combined with DM was estimated to be about 382 million in 2013 worldwide, adults accounted for 8.30% of all cases, and this number is expected to double over the next decade.[4] DM may lead to an increased risk of adverse clinical outcomes for CAD patients, such as mortality, myocardial infarction (MI), and stoke.[5] The effective approaches to resolve the ischemia in

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patients with multivessel disease (MVD) include coronary artery bypass grafting (CABG) and percutaneous coronary intervention (PCI). Several large studies, such as the Coronary Artery Revascularization in Diabetes (CARDia) trial,[6] Fibromyalgia Relapse Evaluation and Efficacy for Durability of Meaningful Relief (FREEDOM) trial,[7] and SYNergy between Percutaneous Coronary Intervention with TAXus and Cardiac Surgery (SYNTAX) trial,[8] have reported that the rates of major adverse cardiovascular and cerebrovascular events (MACCEs) were significantly higher in DM patients with PCI than those in patients with CABG. However, all of these investigations were mostly focused on the white race in European and American countries, and limited data are available in Asian country, especially for young patients. More than 5000 CABG and 10,000 PCI were performed in Beijing Anzhen Hospital per year, and these surgeries have been expertly carried out since the 1990s. This study aimed to compare the in-hospital and long-term outcomes between CABG and PCI in DM patients aged 18–45 years in China.

Methods

Ethical approval

The study was conducted in accordance with the *Declaration of Helsinki* and was approved by the Institutional Review Board and Ethics committee of Beijing Anzhen Hospital. Informed written consent was obtained from all patients prior to their enrollment in this study.

Participants

Between January 2006 and March 2016, 517 consecutive DM patients undergoing CABG at Beijing Anzhen Hospital who were aged 18–45 years were enrolled in the study. During the same period, 1501 consecutive patients with DM undergoing PCI at Beijing Anzhen Hospital who were aged 18–45 years were also recruited. Using propensity score matching (PSM), 406 patients were matched from each group. Patients aged 18–45 years who were diagnosed with stable angina, unstable angina, silent ischemia, ST-elevation MI (STEMI) or non-STEMI, and underwent PCI or CABG were eligible for participation in the study. Medical records of patients were reviewed, and data on the preoperative and procedural variables as well as the immediate outcomes were collected. Then the patients, their relatives, and/or their physicians were contacted to obtain data on the late events, and patients' records were checked for any event of interest. Patients were excluded from the study if they had another coexisting condition, which was a contraindication to CABG or PCI. PCI procedures were performed according to the standard techniques. Considering the patient recruitment time frames, both sirolimus-eluting stents (SES) and paclitaxel-eluting stents were used predominantly. Patients received on- or off-pump CABG surgery using standard techniques.

Study end points

The primary end point of this study was long-term death. The secondary end points included long-term MACCEs, stroke, angina, MI, repeat revascularization and in-hospital death, cost and major complication such as stroke, multiorgan failure, reintubation, and renal failure. Follow-up information was obtained from visits or telephone/mail contacts with patients or family members, or from their local health-care providers. The medical records in outpatient clinics of those who reported any adverse events after discharge were reviewed for further confirmation. When any major adverse event was reported by another hospital, patients were requested to mail a copy of all relevant medical information.

Statistical analysis

For propensity-matched analysis, the matching criteria included demographics such as gender, age, and weight, and comorbidities known to be risk factors for surgical procedures such as left ventricular ejection fraction (LVEF), blood creatinine, hypertension, smoking status, and a history of congestive heart failure (CHF). Age, weight, LVEF, and blood creatinine were variables included as continuous variables. Sex, hypertension, smoking status, and history of CHF were variables included as categorical variables. First, logistic regression was used to develop a propensity score that reflects the probability of receiving the CABG procedure, conditional on the same covariates. Then, each patient in the PCI group was matched to that in the CABG group with an estimated logit within 0.2 standard deviations (SDs) of the selected patient undergoing PCI (one-to-one nearest neighbor matching).

Quantitative variables were expressed as mean ± SD and categorical variables as frequencies and percentages. Continuous variables with normal distribution were compared between the two groups by the paired *t*-test and continuous variables without normal distribution by the Wilcoxon rank-sum test. Categorical variables were compared between groups using the McNemar's test. All data were prospectively analyzed using the SPSS Statistics for Windows, version 19.0 (IBM, Chicago, Illinois, USA). A $P < 0.05$ was considered statistically significant.

Results

The preoperative baseline characteristics, perioperative lesion variables, and postoperative complications between CABG and PCI groups before propensity score matching are summarized in Tables 1–3, respectively. Compared with PCI group, CABG group was associated with significantly higher incidences of hypertension, previous MI, prior transient ischemic attack or stroke, heart failure, and carotid artery stenosis (all $P < 0.01$). Higher prevalences of smoking, previous PCI, and STEMI were noticed in patients who underwent PCI (all $P < 0.01$). The levels of blood glucose, creatine kinase-MB (CK-MB), and LVEF were also higher in PCI patients (all $P < 0.01$). The degree of coronary artery lesion including narrowed coronary artery number and left main stenosis was more serious in CABG patients (all

Table 1: Comparison of preoperative baseline characteristics between CABG and PCI groups before propensity score matching

Clinical variables	CABG group (n = 517)	PCI group (n = 1501)	Statistical values	P
Age (years)	42.1 ± 3.1	41.4 ± 3.7	4.4230*	<0.0001
Male	461 (89.2)	1415 (94.3)	14.0505	0.0002
Hypertension	340 (65.8)	858 (57.2)	11.9555	0.0005
Family history	33 (6.4)	235 (15.7)	32.7441	<0.0001
BMI (kg/m^2)	26.5 ± 3.3	27.7 ± 3.3	−6.7101*	<0.0001
Smoking	321 (62.1)	1092 (72.8)	20.2639	<0.0001
Previous MI	196 (37.9)	302 (20.1)	61.8153	<0.0001
Previous TIA or stroke	29 (5.6)	32 (2.1)	14.0114	0.0002
COPD	6 (1.2)	9 (0.6)		0.2336
Previous PCI	57 (11.0)	234 (15.6)	6.8161	0.0090
Heart failure	20 (3.9)	12 (0.8)	19.5742	<0.0001
Blood glucose (mmol/L)	8.6 ± 3.2	9.0 ± 3.5	−2.3677*	0.0181
Diabetes treatment				
Oral drugs	374 (72.3)	1266 (84.4)	34.5402	<0.0001
Insulin therapy	139 (26.9)	544 (32.5)	5.6620	<0.0001
ALT (U/L)	43.91 ± 35.70	44.45 ± 32.05	−0.3043*	0.7610
Triglyceride (mmol/L)	2.73 ± 2.43	2.90 ± 2.52	−1.3754*	0.1691
Cholesterol (mmol/L)	4.52 ± 1.75	4.46 ± 1.33	0.7419*	0.4584
Creatinine (µmol/L)	73.77 ± 17.08	78.33 ± 48.57	−3.1188*	0.0018
CK-MB (ng/ml)	17.50 ± 1.26	28.55 ± 1.72	−2.8068*	0.0051
Carotid artery stenosis	42 (8.1)	59 (3.9)	12.8942	0.0003
≤50%	39 (7.5)	53 (3.5)	13.7794	0.0032
>50%	3 (0.6)	6 (0.4)		
Emergency surgery	10 (1.9)	201 (13.4)	71.2406	<0.0001
LVEF (%)	57.75 ± 10.2	59.9 ± 9.2	−4.3398*	<0.0001
<35	8 (1.5)	15 (1.0)	11.6893	0.0029
35–50	107 (20.7)	218 (14.5)		
>50	402 (77.8)	1268 (84.5)		
LVEDD (mm)	51.81 ± 6.40	50.44 ± 5.88	4.2873*	<0.0001
Ventricular aneurysm	26 (5.0)	37 (2.5)	7.5728	0.0059
MI degree			1.0902	0.7794
0	389 (75.2)	1143 (76.1)		
1	118 (22.8)	330 (22.0)		
2	8 (1.6)	21 (1.4)		
3–4	2 (0.4)	7 (0.5)		
NYHA classification			8.0781	0.0176
I–II	384 (74.3)	1200 (79.9)		
III–IV	133 (25.7)	301 (20.1)		
NSTEMI	71 (13.7)	142 (9.5)	7.0714	0.0078
STEMI	37 (7.2)	207 (13.8)	17.5462	<0.0001
Unstable angina pectoris	317 (61.3)	707 (47.1)	35.9139	<0.0001

The data are shown as mean ± SD or n (%). *Compared by paired t-test; otherwise by McNemar's test or Fisher's exact test. CABG: Coronary artery bypass grafting; PCI: Percutaneous coronary intervention; BMI: Body mass index; MI: Myocardial infarction; TIA: Transient ischemic attack; COPD: Chronic obstructive pulmonary disease; ALT: Alanine aminotransferase; CK-MB: Creatine kinase-MB isoenzyme; LVEF: Left ventricular ejection fraction; LVEDD: Left ventricular end-diastolic dimension; NYHA: New York Heart Association; STEMI: ST-elevation myocardial infarction; NSTEMI: Non-STEMI; SD: Standard deviation.

$P < 0.01$). The percentage of CABG patients undergoing left internal mammary artery harvesting, total artery graft, and off-pump CABG was 93.6%, 5.4%, and 96.7%, respectively, and drug-eluting stent (DES) was used in 94.8% patients with PCI.

The unadjusted overall in-hospital mortality rate was found to be 1.2% in CABG patients and 0.1% in PCI patients, which was significantly different ($P < 0.0001$). CABG patients suffered more complications such as dialysis and atrial fibrillation, and their costs for recovery were much higher.

The mean follow-up time of the present study was 5.0 ± 3.0 years [Table 4]. In the CABG group, the survival rates at 1 year, 5 years, and 10 years were 99.8%, 98.6%, and 97.3%, which were better than those of PCI group (98.7%, 96.1%, and 94.5%, all $P < 0.01$); freedom from MACCEs were 99.0%, 95.6%, and 93.2%, which were higher than

Table 2: Comparison of perioperative lesion data between CABG and PCI groups before propensity score matching

Procedural variables	CABG group (n = 517)	PCI group (n = 1501)	Statistical values	P
Left main stenosis	89 (17.2)	80 (5.3)	62.0164	<0.0001
Number of narrowed coronary arteries	3.2 ± 0.8	2.2 ± 1.1	22.4167*	<0.0001
1	9 (1.7)	458 (30.5)		
2	71 (13.7)	452 (30.1)		
3	261 (50.5)	411 (27.4)		
≥4	176 (34.1)	180 (12.0)		
Artery intervention				
LAD	508 (98.3)	1140 (75.9)	176.0434	<0.0001
Diagonal	262 (50.7)	267 (17.8)	199.7940	<0.0001
LCX	418 (80.9)	793 (52.8)		<0.0001
PDA	333 (64.4)	101 (6.7)	687.7465	<0.0001
PLA	134 (25.9)	66 (4.4)	170.9934	<0.0001
RCA	298 (57.6)	839 (55.9)	0.4763	0.4901
Number of grafts	2.0 ± 0.8	–		
Number of stents	–	1.4 ± 0.4		
Left internal thoracic artery usage	484 (93.6)	–		
Total artery graft	28 (5.4)	–		
Off-pump CABG	500 (96.7)	–		
Drug-eluting stent usage	–	1423 (94.8)		

The data are shown as mean ± SD or n (%).*Compared by paired t-test; otherwise by McNemar's test or Fisher's exact test. CABG: Coronary artery bypass grafting; PCI: Percutaneous coronary intervention; –: Not applicable; LAD: Left anterior descending artery; LCX: Left circumflex; PDA: Posterior descending artery; PLA: Posterior left ventricle artery; RCA: Right coronary artery; SD: Standard deviation.

Table 3: Comparison of postoperative data between CABG and PCI groups before propensity score matching

Postoperative variables	CABG group (n = 517)	PCI group (n = 1501)	Statistical values	P
LVEF (%)	57.9 ± 9.9	57.8 ± 9.8	0.2541*	0.7995
LVEDD (mm)	49.46 ± 5.82	50.36 ± 6.18	−2.8997*	0.0038
IABP	53 (10.3)	14 (0.9)	87.4176	<0.0001
Blood glucose (mmol/L)	12.45 ± 3.22	8.66 ± 2.99	23.5406*	<0.0001
ALT (U/L)	41.93 ± 4.20	29.84 ± 3.96	4.7509*	<0.0001
In-hospital mortality	6 (1.2)	2 (0.1)		<0.0001
Dialysis	6 (1.2)	3 (0.2)		0.0112
Stoke	4 (0.8)	4 (0.3)		0.1223
MI	75 (14.5)	402 (26.8)	34.6001	<0.0001
AF	62 (12.0)	15 (1.0)	106.6154	<0.0001
Cost (US dollar)	13,861 ± 4276	9477 ± 1959	18.0348*	<0.0001
Medication at discharge				
Aspirin	503 (97.9)	1264 (84.3)	87.0389	<0.0001
Beta-blockers	484 (94.2)	1095 (73.0)	123.7368	<0.0001
Statin	436 (84.8)	1134 (75.5)	20.3191	<0.0001
Nitrates	454 (88.3)	737 (49.1)	275.3714	<0.0001
Clopidogrel	307 (59.7)	1220 (81.3)	90.5537	<0.0001
Calcium channel blockers	261 (50.8)	403 (26.8)	95.5515	<0.0001

The data are shown as mean ± SD or n (%). *Compared by paired t-test; otherwise by McNemar's test or Fisher's exact test. CABG: Coronary artery bypass grafting; PCI: Percutaneous coronary intervention; LVEF: Left ventricular ejection fraction; LVEDD: Left ventricular end-diastolic dimension; IABP: Intra-aortic balloon pump; ALT: Alanine aminotransferase; MI: Myocardial infarction; AF: Atrial fibrillation; SD: Standard deviation.

those of PCI group (96.9%, 89.6%, and 86.3%; all $P < 0.01$); freedom from repeat revascularization were 100.0%, 98.6%, and 98.1%, which were also higher than those of PCI group (98.9%, 96.5%, and 95.8%, all $P < 0.05$). However, CABG group was associated with lower freedom from stoke at 10 years compared to PCI group (94.2% vs. 97.5%, $P = 0.0059$).

After adjusting confounders by one-to-one PSM, 406 patients were matched from each group. The preoperative baseline characteristics, perioperative lesion variables, and postoperative complications after matching are summarized in Tables 5–7, respectively. All preoperative variables were well matched between the two groups without statistical significance, except for the percentage of oral diabetic drugs, emergency surgery, history of heart failure, and the degree of carotid artery stenosis. The proportion of each narrowed coronary artery was distinct, thus leading to different interventions. The postoperative levels of blood

Table 4: Comparison of follow-up data between CABG and PCI groups before propensity score matching, *n* (%)

End points	CABG group (*n* = 517)	PCI group (*n* = 1501)	Statistical values*	*P*
Survival rate				
1 year	516 (99.8)	1482 (98.7)	4.7509	0.0062
5 years	510 (98.6)	1443 (96.1)	1.9867	0.0024
10 years	503 (97.3)	1419 (94.5)	9.6574	0.0072
Freedom from stroke				
1 year	515 (99.6)	1486 (99.0)	8.9765	0.0164
5 years	507 (98.1)	1475 (98.3)	7.5430	0.0666
10 years	487 (94.2)	1463 (97.5)	0.8765	0.0059
Freedom from repeat revascularization				
1 year	517 (100.0)	1484 (98.9)	3.2231	0.0100
5 years	510 (98.6)	1449 (96.5)	2.9875	0.0079
10 years	507 (98.1)	1438 (95.8)	0.0976	0.0113
Freedom from myocardial infarction				
1 year	516 (99.8)	1467 (97.7)	10.9876	<0.0001
5 years	507 (98.1)	1404 (93.5)	2.7865	<0.0001
10 years	497 (96.1)	1378 (91.8)	23.0987	0.0005
Freedom from MACCEs				
1 year	512 (99.0)	1454 (96.9)	2.8902	<0.0001
5 years	494 (95.6)	1345 (89.6)	4.9076	<0.0001
10 years	482 (93.2)	1295 (86.3)	2.7654	<0.0001

*McNemar's test. CABG: Coronary artery bypass grafting; PCI: Percutaneous coronary intervention; MACCEs: Main adverse cardiovascular and cerebrovascular events.

glucose and ALT were higher in patients undergoing CABG than those in patients undergoing PCI (12.57 ± 3.34 mmol/L vs. 8.70 ± 3.21 mmol/L, $P < 0.0001$; 42.06 ± 4.40 mmol/L vs. 21.61 ± 3.49 mmol/L, $P < 0.0001$, respectively). The in-hospital mortality ($P = 0.1306$) and rates of complications such as stoke ($P = 0.6831$) and dialysis ($P = 0.2888$) between CABG and PCI groups were not significantly different. However, the incidences of postoperative MI in PCI patients were significantly higher compared to CABG patients (21.7% vs. 14.8%, $P = 0.0112$). PCI had an economical advantage over CABG during the hospital care (10,926 ± 7376 US dollars vs. 13,936 ± 4480 US dollars, $P < 0.0001$).

Outcome variables at follow-up between CABG and PCI groups after PSM are shown in Table 8. Freedom from MACCEs at 10-year follow-up was higher in CABG patients compared with PCI patients, but no significant difference was observed (93.1% vs. 89.2%, $P = 0.0720$). Freedom from recurrent MI was significantly higher in CABG patients than those in PCI patients (95.6% vs. 92.5%, $P = 0.0260$). Moreover, CABG was associated with a higher rate of long-term survival (10-year) than PCI (97.5% vs. 94.6%, $P = 0.0403$). There was no significant difference in the freedom from stroke at 10-year follow-up between CABG and PCI groups (95.3% vs. 97.3%, $P = 0.9385$).

The CABG and PCI patients were divided into four subgroups: insulin therapy, STEMI, LVEF ≤50% before surgery, and MVD subgroups. After PSM, no significant difference was observed during the follow-up among paired subgroups (all $P > 0.05$).

Discussion

CAD and DM are two common chronic diseases with high rates of mortality and morbidity, and DM is often accompanied with CAD.[9] DM is a risk factor for CAD individuals that may lead to poor recovery following revascularization in contrast to nondiabetic patients.[10,11] Currently, the incidence of CAD among young patients has increased significantly,[2] and it also has been proved that young age was another adverse determiner.[12-14]

In the present study, many meaningful results have been obtained. Before propensity score adjustment, differences in baseline characteristics could reflect the serious preoperative status in CABG group, and the higher rate of left main stenosis or MVD was in accordance with the principle that CABG was more beneficial for complicated lesions.[15] The disparate baseline characteristics in our study were similar to the findings about the risk factors for these two therapy strategies: in CABG patients, recent MI, ventricular arrhythmias, dialysis, creatinine levels higher than 200 mmol/L, and chronic obstructive pulmonary disease were independent predictors of MACCE, and LVEF ≤50%, previous CABG, dialysis, and ventricular arrhythmias were associated with higher risk of late mortality.[16] Smoking and high BMI were the risk factors in young patients who underwent PCI.[17]

Other significant findings were found after propensity score adjustment. The hospital mortality for CABG in this study was 1.5%, similar to the result reported by other studies,[18,19] and nonsignificant result between the two groups was observed, which could be acceptable. More CABG patients required intra-aortic balloon pump (IABP) support for

Table 5: Comparison of preoperative baseline characteristics between CABG and PCI groups after propensity score matching

Clinical variables	CABG group (n = 406)	PCI group (n = 406)	Statistical values	P
Age (years)	42.0 ± 3.2	41.9 ± 3.3	0.2497*	0.8030
Male	369 (90.9)	366 (90.1)	0.1304	0.7180
Hypertension	258 (63.5)	247 (60.8)	0.6612	0.4163
Family history	32 (7.9)	34 (8.4)	0.0690	0.7928
BMI (kg/m²)	26.8 ± 3.3	26.8 ± 3.0	−0.1178*	0.9063
Smoking	265 (65.3)	268 (66.0)	0.0526	0.8185
Previous MI	131 (32.3)	109 (26.8)	3.1026	0.0782
Previous TIA or stroke	24 (5.9)	9 (2.2)	0.0000	1.0000
COPD	1 (0.2)	2 (0.5)	0.0000	1.0000
Previous PCI	52 (12.8)	53 (13.1)	0.0101	0.9199
Heart failure	12 (3.0)	4 (1.0)	377.1628	<0.0001
Blood glucose (mmol/L)	8.66 ± 3.31	8.58 ± 3.29	0.3819*	0.7028
Diabetes treatment				
Oral drugs	297 (73.2)	350 (86.2)	20.5036	<0.0001
Insulin therapy	105 (25.9)	132 (32.6)	0.0000	1.0000
ALT (U/L)	43.92 ± 37.11	40.12 ± 26.12	1.6888*	0.0920
Triglyceride (mmol/L)	2.67 ± 2.29	2.80 ± 2.89	−0.6942*	0.4879
Cholesterol (mmol/L)	4.43 ± 1.63	4.34 ± 1.32	0.8485*	0.3967
Creatinine (μmol/L)	74.55 ± 16.90	76.65 ± 41.74	−0.9451*	0.3452
CK-MB	17.97 ± 2.39	18.98 ± 6.86	−0.1652*	0.8689
Carotid artery stenosis	32 (7.9)	16 (3.9)	5.8182	0.0159
≤50%	394 (96.0)	399 (98.3)		0.0001
>50%	12 (4.0)	7 (1.7)		
Emergency surgery	9 (2.2)	43 (10.6)	24.0833	<0.0001
LVEF (%)	58.3 ± 9.8	58.7 ± 10.2	−0.5395*	0.5898
<35	4 (1.0)	5 (1.2)	1.0323	0.7934
35–50	78 (19.2)	79 (19.5)		
>50	324 (79.8)	322 (79.3)		
LVEDD (mm)	51.69 ± 6.27	50.61 ± 6.23	2.4118*	0.6163
Ventricular aneurysm	15 (3.7)	8 (2.0)	1.7143	0.1904
MI degree			1.9612	0.9232
0	312 (77.0)	300 (73.9)		
1	86 (21.2)	95 (23.4)		
2	6 (1.5)	10 (2.5)		
3–4	1 (0.2)	1 (0.2)		
NYHA classification			1.4766	0.6877
I–II	309 (76.1)	316 (77.8)		
III–IV	97 (23.9)	90 (22.2)		
NSTEMI	51 (12.6)	36 (8.9)	2.8481	0.0915
STEMI	34 (8.4)	29 (7.1)	0.4098	0.5211
Unstable angina pectoris	240 (59.1)	231 (56.9)	1.4879	0.6851

The data are shown as mean ± SD or n (%).*Compared by paired t-test; otherwise by McNemar's test or Fisher's exact test. CABG: Coronary artery bypass grafting; PCI: Percutaneous coronary intervention; LVEF: Left ventricular ejection fraction; LVEDD: Left ventricular end-diastolic dimension; ALT: Alanine aminotransferase; MI: Myocardial infarction; SD: Standard deviation; STEMI: ST-elevation myocardial infarction; NSTEMI: Non-STEMI; NYHA: New York Heart Association; CK-MB: Creatine kinase-MB isoenzyme; TIA: Transient ischemic attack; BMI: Body mass index; COPD: Chronic obstructive pulmonary disease.

recovery because of complicated artery lesion, anesthesia, and surgical strike. IABP is a protective device, which could effectively reduce the incidence of perioperative MI and arrhythmia, especially for patients with left main stenosis and low LVEF.[20] In our study, the percentage of IABP usage in CABG patients was about 10.3%, and almost one-third were used before surgery. It was noted that preventive application should be advocated. For the PCI procedure, the initial cost-effectiveness was obtained due to the smaller number of narrowed arteries, but the follow-up advantage was doubtful as the FREEDOM trial reported.[21] CABG surgery provided better intermediate-term health status and quality of life than PCI using DES.[22] Another amazing finding was the less aggressive dual anti-platelet treatment in CABG patients on account of only 59.7% taking clopidogrel, which was in conflict to the recommendations by American College of Cardiology.[23] DM patients can gain huge benefits for patency using bilateral internal mammary artery grafts,

Table 6: Comparison of perioperative lesion data between CABG and PCI groups after propensity score matching

Procedural variables	CABG group (n = 406)	PCI group (n = 406)	Statistical values	P
Left main stenosis	50 (12.3)	51 (12.6)	0.0130	0.9093
Number of narrowed coronary arteries	3.0 ± 0.7	3.0 ± 1.1	0.1780*	0.8588
1	9 (2.2)	43 (10.6)		<0.0001
2	71 (17.5)	71 (17.5)		
3	225 (55.4)	152 (37.4)		
≥4	11 (24.9)	140 (34.5)		
Artery intervention				
LAD	397 (97.8)	349 (86.0)	36.0000	<0.0001
Diagonal	185 (45.6)	123 (30.3)	22.3488	<0.0001
LCX	319 (78.6)	295 (72.7)	4.6301	0.0314
PDA	246 (60.6)	49 (12.1)	159.7078	<0.0001
PLA	96 (23.6)	39 (9.6)	26.4146	<0.0001
RCA	225 (55.4)	294 (72.4)	24.4154	<0.0001

The data are shown as mean ± SD or n (%). *Compared by paired t-test; otherwise by McNemar's test or Fisher's exact test. CABG: Coronary artery bypass grafting; PCI: Percutaneous coronary intervention; LAD: Left anterior descending artery; LCX: Left circumflex; PDA: Posterior descending artery; PLA: Posterior left ventricle artery; RCA: Right coronary artery; SD: Standard deviation.

Table 7: Comparison of postoperative data between CABG and PCI groups after propensity score matching

Postoperative variables	CABG group (n = 406)	PCI group (n = 406)	Statistical values	P
LVEF (%)	58.2 ± 10.0	57.8 ± 10.0	0.4966*	0.6198
LVEDD (mm)	49.46 ± 5.73	50.57 ± 6.06	−2.7000*	0.6172
IABP	43 (10.6)	3 (0.7)	34.7826	<0.0001
Blood glucose (mmol/L)	12.57 ± 3.34	8.70 ± 3.21	16.9151*	<0.0001
ALT (U/L)	42.06 ± 4.40	21.61 ± 3.49	5.1903*	<0.0001
In-hospital mortality	6 (1.5)	1 (0.2)	2.2857	0.1306
Dialysis	6 (1.5)	2 (0.5)	1.1250	0.2888
Stoke	4 (1.0)	2 (0.5)	0.1667	0.6831
MI	60 (14.8)	88 (21.7)	6.4262	0.0112
AF	44 (10.8)	5 (1.2)	31.0408	<0.0001
Cost (US dollars)	13,936 ± 4480	10,926 ± 7376	6.8135*	<0.0001
Medication at discharge				
Aspirin	394 (97.8)	347 (85.5)	0.0000	1.0000
Beta-blockers	380 (94.3)	301 (74.1)	1.7778	0.1824
Statin	343 (85.1)	315 (77.6)	9.3889	0.0022
Nitrates	351 (87.1)	212 (52.2)	22.3214	<0.0001
Clopidogrel	234 (58.1)	339 (83.5)	23.3103	<0.0001
Calcium channel blockers	205 (50.9)	113 (27.8)	148.0000	<0.0001

The data are shown as mean ± SD or n (%). *Compared by paired t-test; otherwise by McNemar's test or Fisher's exact test. CABG: Coronary artery bypass grafting; PCI: Percutaneous coronary intervention; LVEF: Left ventricular ejection fraction; LVEDD: Left ventricular end-diastolic dimension; IABP: Intra-aortic balloon pump; ALT: Alanine aminotransferase; MI: Myocardial infarction; AF: Atrial fibrillation; SD: Standard deviation.

which was recommended in 2014 European Association for Cardio-Thoracic Surgery guideline. However, the proportion in the present study was lower than previously reported,[19,24] and this need to be improved, especially for young adults in our department. DES was widely used recently and its proportion was more than 90% in this study, providing favorable outcomes compared with traditional bare metal stent.[25,26]

The long-term outcome could reflect the advantage of the suitable solution selected, and several studies have already shown similar results. The most well-known study was the SYNTAX trial comparing 5-year outcomes between two surgeries in patients with DM, and the results showed that the incidence of MACCEs was higher after PCI than those after CABG at 1 year, 3 years, and 5 years because of the higher revascularization, stroke was higher in patients treated with CABG, and mortality was higher among insulin-treated DM patients undergoing DES than patients with noninsulin-treated DM receiving DES.[19,24,27] At 5 years, there was no difference in the composite of all-cause death/stroke/MI (PCI 23.9% vs. CABG 19.1%; P = 0.26) or individual components of all-cause death (PCI 19.5% vs. CABG 12.9%; P = 0.065), stroke (PCI 3.0% vs. CABG 4.7%; P = 0.34), or MI (PCI 9.0% vs. CABG 5.4%; P = 0.20).[27] The Bypass Angioplasty Revascularization Investigation (BARI) study was the first trial summarized in a meta-analysis of 7794 patients, indicating the different mortality rates between CABG

Table 8: Comparison of follow-up data between CABG and PCI groups after propensity score matching, *n* (%)

Outcome variables	CABG group (*n* = 406)	PCI group (*n* = 406)	*P*	*HR* (95% *CI*)
Survival rate				
1 year	405 (99.8)	403 (99.3)	0.4378	0.126 (0.017–0.913)
5 years	401 (98.8)	392 (96.6)	0.0665	
10 years	396 (97.5)	384 (94.6)	0.0403	
Freedom from stroke				
1 year	404 (99.5)	403 (99.3)	0.4378	0.947 (0.238–3.763)
5 years	398 (98.0)	393 (96.8)	0.3827	
10 years	368 (95.3)	356 (97.3)	0.9385	
Freedom from repeat revascularization				
1 year	406 (100.0)	402 (99.0)	0.3572	0.359 (0.099–1.300)
5 years	400 (98.5)	395 (97.3)	0.3320	
10 years	357 (97.5)	369 (95.6)	0.1187	
Freedom from myocardial infarction				
1 year	406 (99.8)	400 (98.5)	0.0472	0.340 (0.132–0.879)
5 years	399 (98.3)	386 (95.1)	0.0164	
10 years	350 (95.6)	357 (92.5)	0.0260	
Freedom from MACCEs				
1 year	402 (99.0)	397 (97.8)	0.0342	0.515 (0.250–1.061)
5 years	389 (95.8)	376 (92.6)	0.0526	
10 years	378 (93.1)	362 (89.2)	0.0720	

HR: Hazard ratio; *CI*: Confidence interval; CABG: Coronary artery bypass grafting; PCI: Percutaneous coronary intervention; MACCEs: Main adverse cardiovascular and cerebrovascular events.

and PCI,[28] and demonstrated that CABG was superior over PCI in diabetic patients.[29] Recently, the randomized FREEDOM trial also showed the same findings with BARI trial that CABG was superior to DES for the composite primary end point of death, stroke, and MI at 2 years.[7] The incidence of death (16.3% in the PCI vs. 10.9% in the CABG group, 95% confidence interval [*CI*]: 1.5–9.2; $P = 0.049$) and MI (13.9% in the PCI vs. 6.0% in the CABG group, $P < 0.001$) was increased in the PCI group, while the incidence of stroke was lower in this team (2.4% vs. 5.2%; $P = 0.03$) at 5 years.[7] The Arterial Revascularization Therapy Study II trial has demonstrated that CABG therapy reduced the incidence of repeat revascularization and overall MACCE, but it did not influence the hard end points, such as death and MI, compared to treatment with SES.[30] The CARDia trial enrolled 510 DM patients with MVD and found that there was no difference in the primary end point between PCI and CABG (26.6% vs. 20.5%; hazard ratio [*HR*]: 1.34, 95% *CI*: 0.94–1.93, $P = 0.11$, respectively) at the 5-year follow-up. However, the rates of repeat revascularization and MI were higher in PCI compared to CABG (21.9% vs. 8.3%; *HR* = 2.87, 95% *CI*: 1.74–4.74, $P < 0.001$; 14% vs. 6.3%, *HR* = 2.26, 95% *CI*: 1.25–4.08, $P = 0.007$, respectively). The stroke rate was numerically higher in the CABG group but with no significant difference (4.3% vs. 3.1%, *HR* = 0.72, 95% *CI*: 0.29–1.79, $P = 0.48$, respectively).[6] This finding was repeated in the recently published ACCF-STS Database Collaboration on the Comparative Effectiveness of Revascularization Strategies (ASCERT) study, in which CABG showed its survival superiority over PCI in all subgroups, particularly beyond 1 year.[31]

In the present study, almost all of the clinical results were similar to the trials reported above, except for freedom from MACCEs which was not statistically significant due to the higher prevalence of stroke in CABG group compared with PCI group. This distinction might be attributed to the severe degree of carotid artery stenosis before surgery, and even after PSM, this discrepancy still exists. Furthermore, different from SYNTAX trial, the inferior long-term survival associated with PCI procedure was noted (94.6% vs. 97.5%, $P = 0.0403$, respectively). Another different finding was about the impact of insulin between CABG and PCI. Several studies have found that insulin therapy could be a risk factor even in patients with type 2 DM,[32] and patients with insulin-treated diabetes could represent a particular high-risk group of patients.[33] However, in this study, no significant difference of immediate- and long-term survival was observed, thus suggesting that insulin was not a crucial factor for surgery selection.

Rare previous studies have evaluated the outcome of CABG or whether CABG was superior to PCI for young adults with DM with regard to racial disparities. Growing evidences suggested that disadvantaged populations like nonwhite patients had higher mortality rates after a wide range of surgical procedures including CABG,[34,35] which might be the result of low income or limited access to high-quality hospital. Rangrass *et al*.[36] found that hospital quality significantly contributed to racial disparities in outcomes following CABG surgery. With respect to yellow race, Marui *et al*.[37] reported that among DM patients with 3-vessel and/or left main disease, CABG was associated with significantly better 5-year outcomes of cardiac death, MI, and any coronary revascularization than PCI, and the cumulative

5-year survival rate in Japan and Western countries was identical. In our observation, this disparity also did not exist in China. The in-hospital mortality or morbidity rates and follow-up outcomes were similar to the white race in adult patients with DM. Both procedures were safety and reliable, thus the decision on choosing the suitable surgery should focus on individual characteristic rather than race imparity. In the recent years, the most remarkable change in China was the higher use of CABG without cardiopulmonary bypass and cardiac arrest (off-pump) and exciting clinical results were reported in more than 90% in our study. To master this technique, each cardiac surgeon needs rigorous training and long learning curve, but this could not take the place of traditional methods, especially for serious or combined disease.

There were several important limitations to the study. First, all data were collected from a single center with a highly sophisticated surgical technique and experienced staff. Nevertheless, data obtained from other cardiac surgical centers were also crucial. Second, due to the retrospective observational study, the possibility of selection bias existed, and the propensity score analysis may not complete the adjustment for these biases. Third, although more than 5-year follow-up results were investigated in our study, partial patients were lost to follow-up, and long-term data need to be evaluated continuously. Finally, the high prevalence of off-pump CABG procedure and DES application may be additional sources of bias in this study.

In conclusion, the in-hospital and long-term follow-up results were both satisfactory for two procedures. In DM patients aged 18–45 years, the cumulative survival rate, and freedom from MI and repeat revascularization for CABG were superior to PCI. However, a better trend to avoid stroke was observed with PCI.

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Conflicts of interest

There are no conflicts of interest.

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