Original Article

Comparing patient outcomes following minimally invasive coronary artery bypass grafting surgery *vs.* coronary artery bypass grafting: a single-center retrospective cohort study

Lin Liang[#], Xiaolong Ma[#], Qingyu Kong, Wei Xiao, Jiaji Liu, Liqun Chi, Junming Zhu

Department of Cardiac Surgery, Beijing Anzhen Hospital, Capital Medical University, Beijing, China

Contributions: (I) Conception and design: L Chi, L Liang, X Ma; (II) Administrative support: L Liang, J Zhu; (III) Provision of study materials or patients: Q Kong, W Xiao, X Ma; (IV) Collection and assembly of data: X Ma, L Liang, J Liu; (V) Data analysis and interpretation: X Ma; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

[#]These authors contributed equally to this work and should be considered as co-first authors.

Correspondence to: Liqun Chi, MD, PhD; Junming Zhu, MD, PhD. Department of Cardiac Surgery, Beijing Anzhen Hospital, Capital Medical University, No. 2 Anzhen Road, Chaoyang District, Beijing 100029, China. Email: chiliqun2002@qq.com; anzhenzjm@163.com.

Background: This present research was designed for comparing coronary artery disease (CAD) patient outcomes following minimally invasive coronary artery bypass grafting surgery (MICS) or coronary artery bypass grafting (CABG).

Methods: From 2014–2017, 679 CAD patients underwent MICS (n=281) or CABG (n=398) and were evaluated for the present study. Patient data were analyzed using 1:1 propensity score-matched assessment and a multivariate Cox proportional hazards regression model, and primary study achievements comprised major adverse cardiac and cerebrovascular events (MACCEs), myocardial infarction (MI), cardiac death, heart failure (HF), revascularization, and stroke. The median follow-up period was 2.68 years.

Results: CABG patients exhibited a trend towards higher cumulative overall rates of MACCEs at 2 years (CABG: 6.2% *vs.* MICS: 3.8%) and 4 years (CABG: 9.3% *vs.* MICS: 7.6%) [adjusted hazard ratio (HR): 1.33; 95% confidence interval (CI): 0.33–5.39 for CABG *vs.* MICS; P=0.687], although this difference was not significant. No significant differences in 2- or 4-year cardiac death rates were observed between groups (CABG: 3.5%, 5.6% *vs.* MICS 2.8%, 2.8%; adjusted HR: 0.23; 95% CI: 0.03–1.81 for CABG *vs.* MICS; P=0.160). Further, there existed no discrepancies in rates of MI (P=1.000), HF (adjusted HR: 4.76; 95% CI: 0.01–6.40 for CABG *vs.* MICS; P=0.996), stroke (adjusted HR: 9.58; 95% CI: 0.11–25.24 for CABG *vs.* MICS; P=0.320), or repeated revascularization (adjusted HR: 1.71; 95% CI: 0.01–7.21 for CABG *vs.* MICS; P=0.631) when comparing these patient groups. In a multivariable Cox proportional hazards regression analysis, patients that were male (adjusted HR: 5.28; 95% CI: 1.48–18.83; P=0.010) and cases with a history of previous MI epsiodes (adjusted HR: 3.20; 95% CI: 1.09–9.37; P=0.034) were found to be at a higher risk of MACCEs.

Conclusions: Follow-up data indicated that the MICS and CABG treatments could achieve similar outcomes.

Keywords: Minimally invasive coronary artery bypass grafting surgery (MICS); coronary artery bypass grafting (CABG); outcomes

Submitted Jan 05, 2022. Accepted for publication May 25, 2022.
doi: 10.21037/cdt-22-10
View this article at: https://dx.doi.org/10.21037/cdt-22-10

Introduction

Cardiovascular disease remains the fundamental driver of global mortality, and acute myocardial infarction (MI) is the most pervasive reason for sudden death, accounting for over 60% of sudden death being linked to acute MI and coronary heart disease (CHD) (1). Preventing and treating CHD thus remains one of the most urgent worldwide health care initiatives at present. The results of large-scale studies including the FREEDOM and SYNTAX trials have codified coronary artery bypass grafting (CABG) as the benchmark treatment for MI cases, reducing revascularization and enhancing survival in individuals with severe and complex coronary artery lesions (2-4).

While effective, conventional CABG is a highly traumatic operation that necessitates sternal dissection in order to access the heart, resulting in prolonged postoperative recovery and significant scarring (5). Recent advances in minimally invasive surgical techniques and technologies have led to the increasing utilization of minimally invasive CABG surgery (MICS) for the treatment of CHD (6,7). The revascularization of all major coronary arteries using a single small incision in the left fifth intercostal space has been a primary topic of interest among cardiac surgeons (6,8). However, the relative effects of MICS and CABG procedures on patient outcomes are still relatively poorly understood and present, and more research is needed to fully compare these surgical strategies.

Therefore, we conducted a retrospective analysis of clinical and demographic data from coronary artery disease (CAD) patients that had undergone conventional CABG or MICS with the goals of exploring the characteristics of patients selected to undergo MICS and comparing the long-term follow-up outcomes associated with these two treating strategies. We present the following article in accordance with the STROBE reporting checklist (available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-10/rc).

Methods

Study design

The current research was a retrospective observational cohort exploration executed in Beijing Anzhen Hospital, Capital Medical University, Beijing Institute of Heart Lung and Blood Vessel Diseases, Beijing, China. Overall, 679 CAD cases that had undergone either CABG or MICS between 2014 and 2017 in the Department of Cardiac Surgery of Anzhen Hospital were included. These cases who fulfilled the considered criteria were allowed to participate in the research, inclusion criteria: (I) received CABG in our center due to coronary atherosclerotic heart disease, (II) received isolated CABG, and (III) the clinical data were complete, finally were stratified into the CABG and MICS groups based upon the surgical approach which they underwent (*Figure 1*), patients with missing data were excluded. One cardiologist and one cardiac surgeon reviewed all patient data, while follow-up data were collected from patients by two cardiologists via telephone, mail, or in-person visits. The Ethics Committee Institute of Beijing Anzhen Hospital approved the present study (No. 2020092X). The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Because of the retrospective nature of the study, the requirement for informed consent was waived.

Study definitions

Herein, CABG refered to CABG through median thoracotomy, including off-pump or on-pump CABG. MICS refered to CABG through left fourth or fifth intercostal incision, including off-pump or on-pump CABG. Proximal aortic anastomat was a device for perforating the proximal part of the ascending aorta. Major adverse cardiac and cerebrovascular events (MACCEs) included MI, cardiac death, heart failure (HF), revascularization, or stroke, as defined through an independent event committee (1). Cardiac death was described as mortality occurring in stable patients that was associated with MI, HF, sudden death, or fatal arrhythmia (9). MI was described as (I) increases in myocardial enzymes including cTnT and CK-MB to over two times the upper limit of the normal reference range and (II) ST-T changes evident upon electrocardiography (10). HF was described as hospitalization associated with gradual HF with consistent radiographic imaging and clinical results. Revascularization was described as any consequent revascularization procedures conducted via PCI or repeated CABG following initial CABG or MICS in the Department of Cardiac Surgery of Anzhen Hospital.

Surgical techniques

MICS: the patient was in supine position with 30° left chest cushion, general anesthesia and double lumen endotracheal intubation. About 6 cm incision was made between the 4th or 5th rib of the left anterior chest, and the right one lung ventilation was performed after entering the chest.

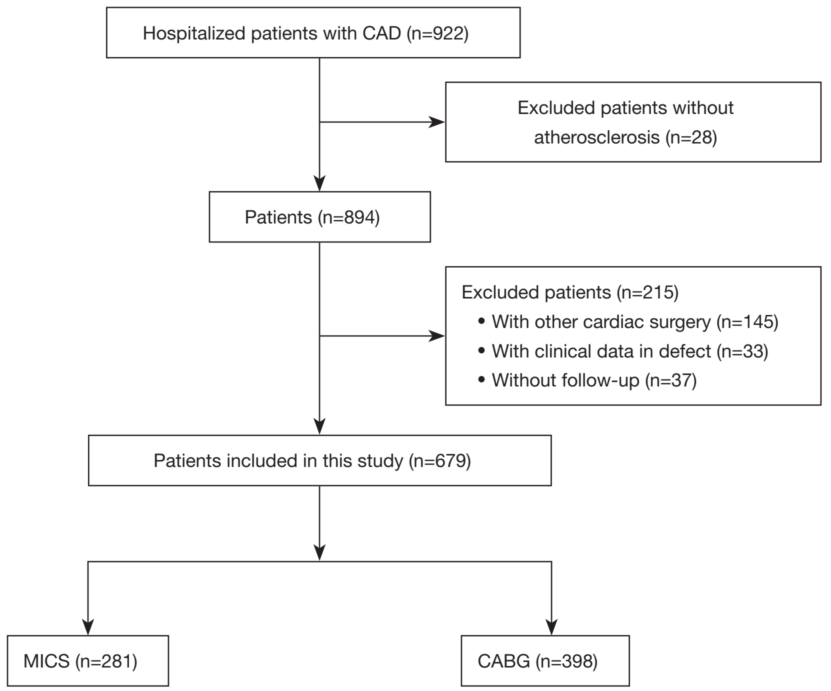

Figure 1 Outline of patients included and classified in this study. CAD, coronary artery disease; MICS, minimally invasive coronary artery bypass grafting surgery; CABG, coronary artery bypass grafting.

Through the suspension left internal mammary artery (LIMA) traction system, ribs were pulled out, chest wall was raised, and the operation field was well exposed. Under direct vision, LIMA was obtained as one graft, saphenous vein graft (SVG) was also taken in necessary. Pericardium was cut to determine the anastomosis position of the target vessel. Then we would use the cardiac stabilizer to fix locally, cut the coronary artery, install the intracoronary shunt, anastomose LIMA with the left anterior descending (LAD) with a suture. The proximal end of the ascending aorta was sutured and connected with other stenotic coronary arteries through SVG to complete MICS. MICS usually requires two cardiac surgeons while conventional CABG requires three.

Statistical analysis

IBM SPSS Statistics® for Windows, v22.0 was employed for analyzing all study outcomes. Continuous outcomes are given as means ± standard deviations (SDs), while categorical outcomes are presented as numbers (percentages). Data between groups were scrutinized employing Fisher's exact test and Mann-Whitney-Wilcox nonparametric tests as appropriate. To diminish the influence of potential confounding on MACCEs on the achievements of the observational research, 1:1 propensity score matching was executed to select cases with corresponding baseline information. Following the assessment of covariates correlated clinically or/and statistically with the treatment group and elimination of repeatedly described or collinear variables, comprising baseline properties, medical background, risk factors, clinical circumstances at admission and processing during hospitalization, variables are given in *Table 1* were considered in the propensity score matching model employing greedy closest adjoining matching without substitution and a caliper of 0.01. Moreover, following matching, the assessment of Cox proportional hazards regression was exerted for the assessment of the relationship between follow-up and variables findings. The models of univariable Cox proportional hazards regression were primarily executed, succeeded by the models of multivariable Cox proportional hazards regression. The selected variables were potential confounding variables that were also mainly regarded in the propensity score matching model. Following the forward stepwise selecting with inclusion criteria both set at P=0.2, the variables were ultimately considered in the models of multivariable Cox proportional hazards regression of cardiac death and

Table 1 Comparison of the baseline characteristics of patients that underwent MICS and CABG (n=679)

Variables	Unmatched			Matched		
	MICS (n=281)	CABG (n=398)	P value	MICS (n=174)	CABG (n=174)	P value
Age (years)	60.51±9.47	61.63±8.87	0.117	60.81±9.10	60.51±8.69	0.748
≥65 years	103 (36.7)	160 (40.2)	0.379	63 (36.6)	62 (36.0)	0.911
Sex (male)	236 (84.0)	296 (74.4)	0.003	142 (82.6)	150 (87.2)	0.229
Comorbidities						
Diabetes	108 (38.4)	162 (40.7)	0.578	113 (65.7)	114 (66.3)	0.909
Hypertension	177 (63.0)	271 (68.1)	0.188	71 (41.3)	72 (41.9)	0.913
Dyslipidemia	76 (27.05)	111 (27.9)	0.985	54 (31.4)	52 (30.2)	0.815
Chronic lung disease	21 (7.5)	64 (16.1)	0.001	17 (9.9)	18 (10.5)	0.858
Chronic renal disease	7 (2.5)	22 (5.5)	0.056	7 (4.1)	7 (4.1)	1.000
Prior PVD	12 (4.3)	8 (2.0)	0.107	7 (4.1)	5 (2.9)	0.557
Prior CVA	78 (27.8)	168 (42.2)	0.0001	62 (36.0)	61 (35.5)	0.910
Prior MI	87 (31.0)	155 (38.9)	0.035	56 (32.6)	64 (37.2)	0.365
Prior PCI	62 (22.1)	70 (17.6)	0.168	36 (20.9)	34 (19.8)	0.789
UA	134 (47.7)	217 (54.5)	0.086	92 (53.5)	95 (55.2)	0.745
Smoking	149 (53.0)	200 (50.3)	0.484	88 (51.2)	100 (58.1)	0.194
BMI	25.40±3.55	25.71±3.38	0.252	25.52±2.89	25.64±3.29	0.733
UCG						
LVEF%	61.61±6.49	57.90±9.98	0.0001	60.86±6.70	60.37±8.61	0.567
CAG characteristics						
Three vessel disease	117 (41.6)	285 (71.6)	0.0001	97 (56.4)	102 (59.3)	0.585
Diffuse lesions	64 (22.8)	151 (37.9)	0.0001	53 (30.8)	53 (30.8)	1.000
CTO	49 (36.3)	72 (50.7)	0.021	29 (16.8)	32 (18.6)	0.705
Opening involved	36 (26.7)	61 (43.0)	0.006	22 (12.7)	27 (15.1)	0.604
Left main artery disease	35 (25.9)	61 (43.0)	0.004	23 (13.3)	30 (17.4)	0.553
SYNTAX score I	38.07±20.68	51.50±19.71	0.0001	46.88±20.91	45.90±18.81	0.773
Medication						
Aspirin	268 (95.4)	380 (95.5)	1.000	165 (95.9)	165 (95.9)	1.000
Clopidogrel	271 (96.4)	375 (94.2)	0.208	162 (94.2)	161 (93.6)	0.935
Beta blockers	275 (97.9)	391 (98.2)	0.780	168 (97.7)	166 (96.5)	0.748
Isosorbide mononitrate	275 (97.9)	393 (98.7)	0.376	168 (97.7)	168 (97.7)	1.000
Statin	230 (81.9)	325 (81.7)	1.000	129 (75.0)	133 (77.3)	0.613

Data are present as mean ± SD or n (%). MICS, minimally invasive coronary artery bypass grafting surgery; CABG, coronary artery bypass grafting; PVD, peripheral vascular disease; CVA, cerebrovascular accident; MI, myocardial infarction; PCI, percutaneous coronary intervention; UA, unstable angina; BMI, body mass index; UCG, ultrasonic cardiogram; LVEF, left ventricular ejection fraction; CAG, coronary angiography; CTO, chronic total occlusion; SD, standard deviation.

Table 2 Procedure-related baseline characteristics of patients that underwent MICS and CABG (n=679)

Variables	Unmatched			Matched		
	MICS (n=281)	CABG (n=398)	P value	MICS (n=172)	CABG (n=172)	P value
Average operation time (min)	272.29±76.13	221.01±55.72	0.0001	286.81±78.11	228.28±62.42	0.0001
Off-pump	278 (98.9)	373 (93.7)	0.001	170 (98.8)	161 (93.6)	0.011
Turn to median thoracotomy	2 (0.7)	–	–	1 (99.4)	–	–
Sequential anastomosis	125 (44.5)	311 (78.1)	0.0001	100 (58.1)	130 (75.6)	0.001
Proximal aortic anastomat	–	41 (10.3)	–	–	11 (6.4)	–
Endarterectomy	8 (2.8)	9 (2.3)	0.628	5 (2.9)	4 (2.3)	0.736
Use of LIMA	259 (92.2)	276 (69.3)	0.0001	163 (94.8)	123 (71.5)	0.0001
Total SVG	22 (7.8)	122 (30.7)	0.0001	9 (5.2)	49 (28.5)	0.0001
Average number of distal anastomoses	2.28±1.10	3.08±0.82	0.0001	2.63±1.11	2.98±0.79	0.001

Data are present as mean ± SD or n (%). MICS, minimally invasive coronary artery bypass grafting surgery; CABG, coronary artery bypass grafting; LIMA, left internal mammary artery; SVG, saphenous vein graft; SD, standard deviation.

MACCEs, accordingly. By employing a log-rank assessment, the comparison of the achievements was accomplished and given as the curves of Kaplan-Meier. P values were two-sided for the reported assessments. Statistical discrepancies were regarded meaningful for the values of P<0.05.

Results

Baseline characteristics

A total of 922 CAD patients were hospitalized and underwent CABG over the study period, of whom 679 met with study inclusion criteria (*Figure 1*), including 281 individuals in the MICS group.

Table 1 demonstrates the patients' baseline properties. Before matching, relative to cases in the CABG group, those in the MICS group were more likely to be male, were less possible to have comorbid chronic lung disease, less possible to have a background of cerebrovascular accident (CVA) or prior MI, and were likely to have a higher LVEF. Coronary angiography (CAG) results indicated that there were fewer patients in the MICS group with three-vessel lesions, diffuse lesions, chronic total occlusion (CTO) lesions, ostial lesions, and left main artery lesions relative to the CABG group, with the SYNTAX scores of MICS patients being lower than those of patients in the CABG group. Following matching, there existed 174 cases in each group, the statistical differences above were none significant.

Surgery-related baseline characteristics

Relative to patients in the CABG group (*Table 2*), After matching, those in the MICS group still exhibited a longer operative duration (min) (MICS: 286.81±78.11 *vs.* CABG: 228.28±62.42; P=0.0001), a higher rate of off-pump technique (MICS: 98.8% *vs.* CABG: 93.6%; P=0.011), a lower rate of sequential anastomosis (MICS: 58.1% *vs.* CABG: 75.6%; P=0.001), higher rates of internal mammary artery utilization (MICS: 94.8% *vs.* CABG: 71.5%; P=0.0001), a lower proportion of total veins (MICS: 5.2% *vs.* CABG: 28.5%; P=0.0001).

Postoperative characteristics

After matching, compared to cases in the group of CABG, those in the MICS group exhibited a trend towards shorter postoperative hospitalization (days) (MICS: 5.98±1.59 *vs.* CABG: 6.07±2.59; P=0.689), although the difference was not significant (*Table 3*). Postoperative drainage volume (mL) (MICS: 391.29±272.72 *vs.* CABG: 459.17±271.37; P=0.022)and drug use rates were substantially lesser in the MICS group relative to the CABG group. Specifically, rates of dopamine, vasoconstrictor, and positive inotropic drug use in these patients were lower, while postoperative hemoglobin (HB) (g/L) was significantly higher in these same MICS patients relative to CABG patients (MICS: 118.12±16.45 *vs.* CABG: 114.67±17.97; P=0.015). There existed no remarkable discrepancies in IABP use, MI, or

Table 3 Perioperative complications and postoperative data for patients that underwent MICS and CABG treatment (n=679)

Variables	Unmatched			Matched		
	MICS (n=281)	CABG (n=398)	P value	MICS (n=172)	CABG (n=172)	P value
ICU stay (h)	22.21±19.74	21.71±17.37	0.732	22.59±23.06	22.45±18.76	0.950
Ventilation time (h)	17.90±17.46	18.46±31.14	0.783	18.58±16.42	18.29±15.48	0.883
Drainage tube time (days)	2.28±1.03	2.79±0.87	0.552	2.94±0.91	2.80±0.86	0.150
Postoperative hospital stay (days)	6.02±1.71	6.19±3.41	0.456	5.98±1.59	6.07±2.59	0.689
Total duration of hospitalization (days)	12.52±4.16	14.13±4.76	0.0001	12.85±4.26	14.27±4.65	0.003
Drainage amount in 24 hours (mL)	388.01±308.90	436.01±257.19	0.029	391.29±272.72	459.17±271.37	0.022
Use of RBC	8 (2.8)	22 (5.5)	0.128	5 (2.9)	5 (2.9)	1.000
HB before surgery (g/L)	139.65±14.32	139.61±16.06	0.976	140.51±14.84	140.69±16.13	0.933
HB after surgery (g/L)	116.27±17.31	112.21±17.69	0.013	118.12±16.45	114.67±17.97	0.015
Medication						
Dopamine use	258 (91.8)	383 (96.2)	0.017	161 (93.6)	170 (98.8)	0.011
Adrenaline use	13 (4.6)	110 (27.6)	0.0001	10 (5.8)	51 (29.7)	0.001
Norepinephrine use	18 (6.4)	59 (14.8)	0.001	12 (7.0)	25 (14.5)	0.024
Postoperative UCG						
LVEF%	60.33±6.70	56.03±9.22	0.0001	60.03±6.91	57.68±8.51	0.007
Perioperative complications						
Death	1 (0.4)	0 (0.0)	0.414	0 (0.0)	0 (0.0)	–
Rethoracotomy	3 (1.1)	9 (2.3)	0.377	1 (0.6)	3 (1.7)	0.314
Arrhythmia	58 (20.6)	87 (21.9)	0.776	38 (22.1)	32 (18.6)	0.422
MI	2 (0.7)	5 (1.3)	0.706	2 (1.2)	2 (1.2)	1.000
Pulmonary infection	0 (0.0)	5 (1.3)	0.080	0 (0.0)	0 (0.0)	–
Renal insufficiency	1 (0.4)	1 (0.3)	1.000	1 (0.6)	1 (0.6)	1.000
Stroke	1 (0.4)	1 (0.3)	0.620	0 (0.0)	0 (0.0)	–
IABP	7 (2.5)	11 (2.8)	1.000	6 (3.5)	6 (3.5)	1.000
ECMO	0 (0.0)	5 (1.3)	0.080	0 (0.0)	3 (1.7)	0.082

Data are present as mean ± SD or n (%). MICS, minimally invasive coronary artery bypass grafting surgery; CABG, coronary artery bypass grafting; ICU, intensive care unit; RBC, red blood cell; HB, hemoglobin; UCG, ultrasonic cardiogram; LVEF, left ventricular ejection fraction; MI, myocardial infarction; IABP, intra-aortic balloon pump; ECMO, extracorporeal membrane oxygenation; SD, standard deviation.

pulmonary infection rates between groups.

Unmatched follow-up outcomes

The comprehensive follow-up information was acquired for all patients in the research population, with an average follow-up period of 2.68 years (*Table 4*, *Figure 2*).

Before matching, the curves of Kaplan-Meier (*Figure 2A*) revealed that the overall rate of cumulative MACCEs was greater in the CABG group at 2 years (CABG: 6.2% *vs.* MICS: 3.8%) and 4 years (CABG: 9.3% *vs.* MICS: 7.6%) [adjusted hazard ratio (HR): 1.33; 95% confidence interval (CI): 0.33–5.39 for CABG *vs.* MICS; P=0.687], but these differences were not significant.

There existed no substantial discrepancies in rates of 2- or 4-year cardiac death when comparing these patient

Table 4 Unmatched follow-up outcomes of patients that underwent MICS or CABG (n=679)

Variables	MICS (n=281), n (%)	CABG (n=398), n (%)	P value	Adjusted HR (95% CI), P value
MACCE	10 (3.6)	27 (6.8)	0.081	1.33 (0.33–5.39), 0.687
Death	7 (2.5)	16 (4.0)	0.397	0.23 (0.03–1.81), 0.160
HF	0 (0.0)	3 (0.8)	0.162	4.76 (0.01–6.40), 0.996
MI	1 (0.4)	0 (0.0)	1.000	–
Revascularization	1 (0.4)	3 (0.8)	0.590	1.71 (0.01–7.21), 0.631
Stroke	3 (1.1)	7 (1.8)	0.510	9.58 (0.11–25.24), 0.320

MICS, minimally invasive coronary artery bypass grafting surgery; CABG, coronary artery bypass grafting; MACCE, major adverse cardiac and cerebrovascular events; HF, heart failure; MI, myocardial infarction.

Table 5 Matched follow-up outcomes of patients that underwent MICS or CABG (n=344)

Variables	MICS (n=172), n (%)	CABG (n=172), n (%)	P value
MACCE	6 (3.5)	10 (5.8)	0.303
Death	5 (2.9)	5 (2.9)	0.855
HF	0 (0.0)	1 (0.6)	0.377
MI	1 (0.6)	0 (0.0)	–
Revascularization	0 (0.0)	2 (1.2)	0.211
Stroke	2 (1.2)	2 (1.2)	0.944

MICS, minimally invasive coronary artery bypass grafting surgery; CABG, coronary artery bypass grafting; MACCE, major adverse cardiac and cerebrovascular events; HF, heart failure; MI, myocardial infarction.

groups (*Figure 2B*) (CABG: 3.5%, 5.6% *vs.* MICS: 2.8%, 2.8%; adjusted HR: 0.23; 95% CI: 0.03–1.81 for CABG *vs.* MICS; P=0.160).

There were also no significant differences in rates of MI (P=1.000), HF (adjusted HR: 4.76; 95% CI: 0.01–6.40 for CABG *vs.* MICS; P=0.996), stroke (adjusted HR: 9.58; 95% CI: 0.11–25.24 for CABG *vs.* MICS; P=0.320), or repeated revascularization (adjusted HR: 1.71; 95% CI: 0.01–7.21 for CABG *vs.* MICS; P=0.631) between these groups (*Figure 2C-2F*).

A multivariable Cox proportional hazards regression analysis indicated that cases who were male (adjusted HR: 5.28; 95% CI: 1.48–18.83; P=0.010) and patients with a history of prior MI (adjusted HR: 3.20; 95% CI: 1.09–9.37; P=0.034) were more possible to experience a MACCE.

Matched follow-up outcomes

Following matching (*Table 5*), the curves of Kaplan-Meier (*Figure 3A*) revealed that the overall rate of cumulative MACCEs was greater in the CABG group at 2 years (CABG: 4.6% *vs.* MICS: 3.1%) and 4 years (CABG: 9.9% *vs.* MICS: 8.8%), but these differences were not significant. There was no significant difference in cardiac death (P=0.855) between two groups (*Figure 3B*). After matching, the incidence of MI events in the CABG group was 0, the P value could not be calculated between MICS group and CABG group. In order to provide the result of matched MI events, we also provided the cumulative incidence curve of MI after matching (*Figure 3C*). Besides, there were also no remarkable discrepancies in HF (P=0.377), stroke (P=0.944) or repeated revascularization (P=0.211) between these groups (*Figure 3D-3F*).

Discussion

In the present large-scale single-center observational studies, outcomes were compared between CAD patients that underwent CABG or MICS, revealing no remarkable discrepancies between these treatment groups in relation to the incidence rates of MACCEs including cardiac death, MI, HF, stroke, or repeated PCI revascularization.

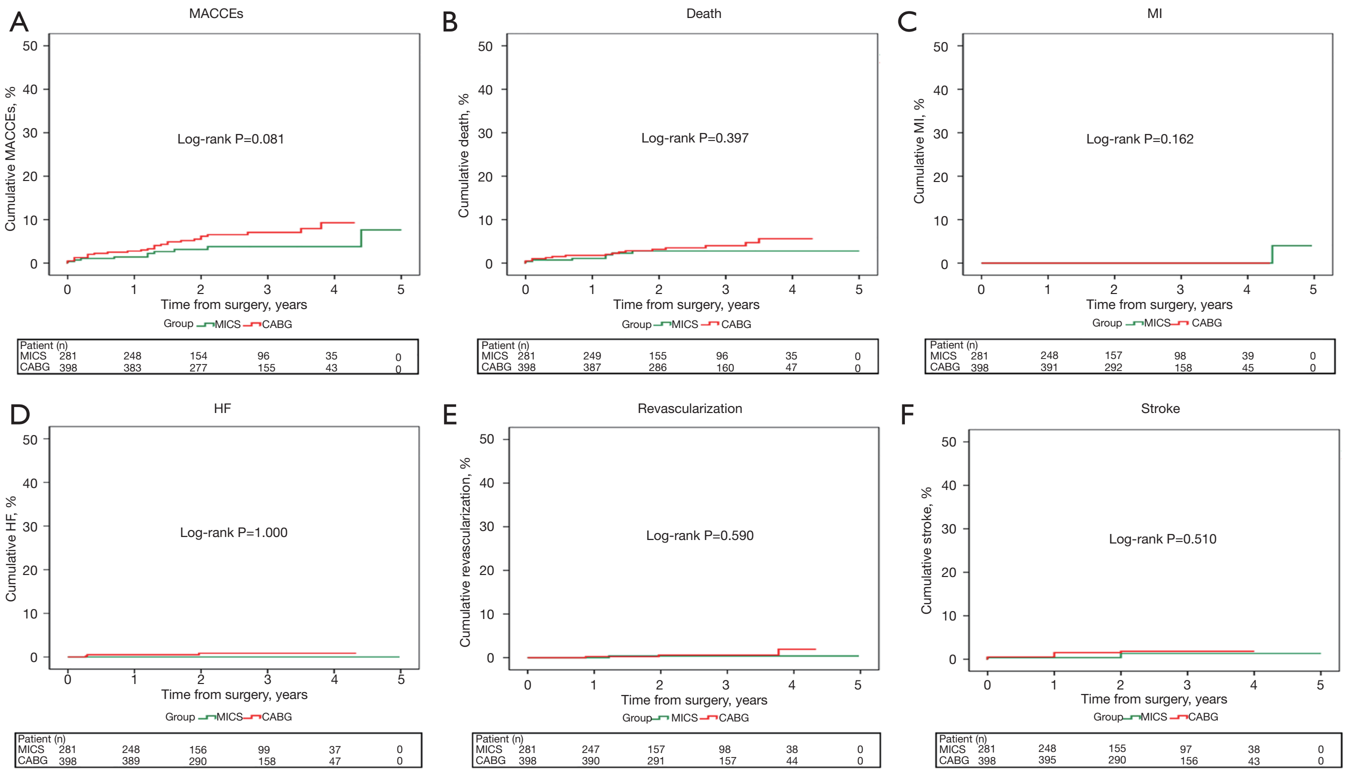

Figure 2 Before matching, rates of cumulative rate of MACCEs (A), including: cardiac death (B), MI (C), HF (D) or revascularization (E) and stroke (F) in the MICS group (green line) compared with the CABG group (red line) using the Kaplan-Meier method. P value was calculated by multivariable Cox proportional hazards regression. MACCE, major adverse cardiac and cerebrovascular events; MICS, minimally invasive coronary artery bypass grafting surgery; CABG, coronary artery bypass grafting; MI, myocardial infarction; HF, heart failure.

Multivariate Cox proportional hazards regression analyses further indicated that male patients and individuals with a prior history of MI were more likely to suffer a MACCE following MICS or CABG.

To maximize perioperative safety, MICS patients must undergo preoperative evaluation to exclude individuals with (I) valvular disease, ventricular aneurysm, or a requirement for extracorporeal circulation surgery, (II) patients with a left ventricular ejection fraction (LVEF) ≤50%, (III) patients with a closed chest due to thoracic deformities or severe pleural adhesions, and (IV) patients with severe lung disease and difficulties tolerating single-lung ventilation (11-14), (V) patient had severe calcification of the ascending aorta, (VI) patient's requirements. Patients in the present study in the MICS group were more likely to be male, and were less likely to have comorbid pulmonary disease, prior CVA, prior MI, and mild CAD. Regarding the patients in the CABG group, those in the MICS group illustrated a longer operative duration and a lower average number of anastomoses.

The MICS approach employed for patients in the present study employed a left fourth or fifth intercostal incision (8,15). Relative to CABG, MICS procedures necessitate significantly smaller surgical incisions and avoid the need for sternotomy, thereby preserving thoracic and sternum integrity while reducing patient pain, allowing patients to cough and move more freely (7,14,16,17). MICS is also associated with decreased postoperative drainage, a reduced postoperative need for active cardiovascular drug use, and higher HB levels, all of which are beneficial to patient recovery and reduce the duration of postoperative hospitalization.

The internal mammary artery was routinely utilized to decrease the number of proximal anastomoses, and sequential anastomosis technologies were employed were appropriate (18), in this study, bilateral internal

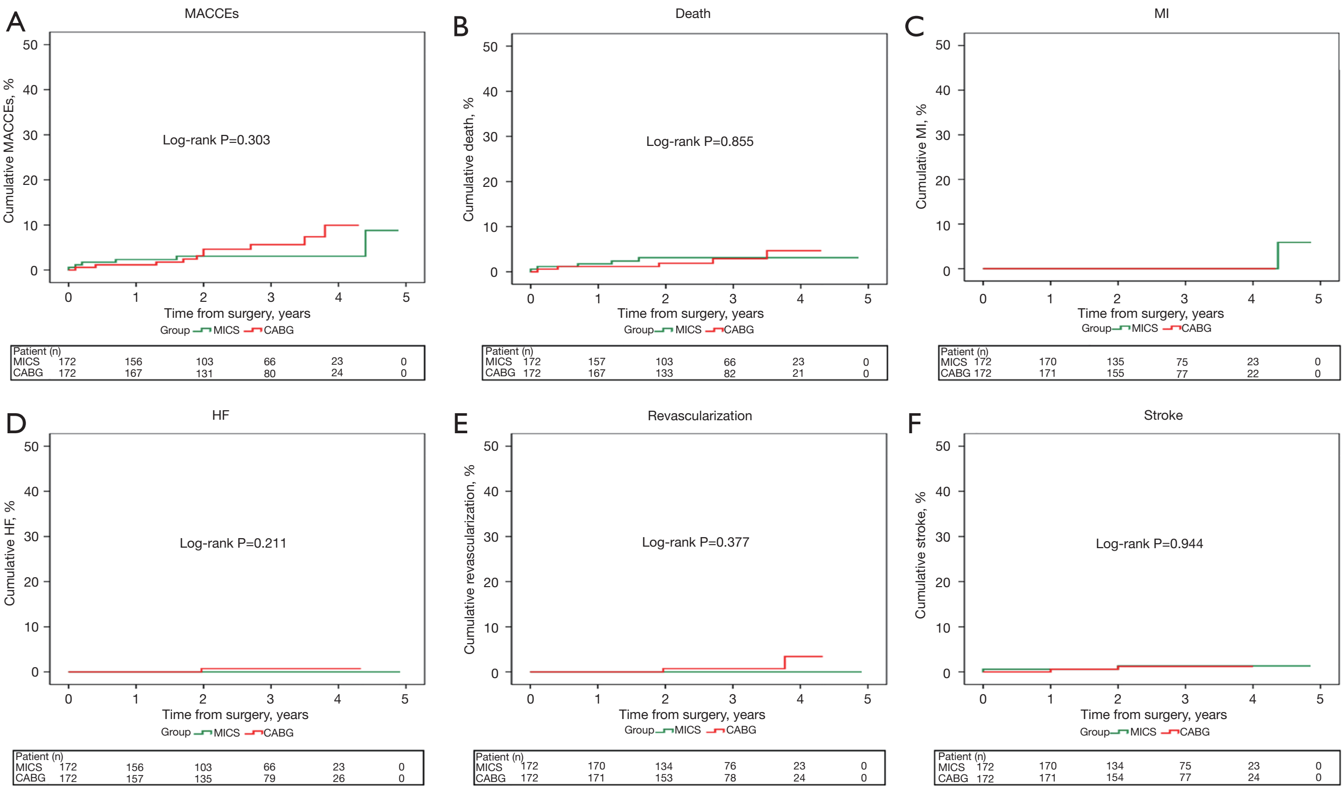

Figure 3 After matching, rates of cumulative rate of MACCEs (A), including: cardiac death (B), MI (C), HF (D) or revascularization (E) and stroke (F) in the MICS group (green line) in comparison to the CABG group (red line) by employing the Kaplan-Meier approach. P value was evaluated through multivariable Cox proportional hazards regression. MACCE, major adverse cardiac and cerebrovascular events; MICS, minimally invasive coronary artery bypass grafting surgery; CABG, coronary artery bypass grafting; MI, myocardial infarction; HF, heart failure.

mammary arteries were not used, there were concerns about the increased risk of sternal nonunion during median thoracotomy and the increased difficulty and risk during MICS. Intraoperatively, multiple measures (19) including suspending the pericardium, applying gauze to the right side of the aorta, freeing the aorta and the pulmonary artery septum, using special sidewall forceps to clamp the anterior wall of the ascending aorta, and completing the end-to-side anastomosis of the SVG to the ascending aorta was completed using minimally invasive instruments. Through the left fifth intercostal incision, it was convenient to treat the lesion of right coronary artery area with the apical and pericardial fixator.

Relative to the CABG group, there were fewer perioperative complications observed in the MICS group such as death, MI, pulmonary infection, secondary thoracotomy, cerebrovascular events, IABP, and ECMO use, but these differences were not significant. It is important to note that there is a degree of bias in the selection of patients for inclusion in the MICS group, as relative to the CABG group, cases in the MICS group were possible to exhibit better surgical tolerance, decreased perioperative risk, and less extensive lesions. Even so, we believe that the perioperative risk of MICS is still low. Prior reports have found that MICS can decrease the risk of wound infection and sternal dehiscence, although no such data were collected for the present study (6,7).

Analyses of patient follow-up outcomes indicated that while the absolute incidence of MACCEs, death, HF, revascularization, and cerebrovascular events were lesser in the MICS group relative to the CABG group, these differences were not significant. During follow-up, we found that some patients had two or three follow-up events, including MI and stroke, or death after stroke, or death after MI. The models of Multivariate Cox proportional hazards regression and 1:1 propensity score matching were employed to reduce bias by controlling for variables that differed significantly at baseline between these two patient groups. Even after such correction, however, MACCE incidence rates were comparable between the MICS and CABG patient groups. While there have been prior controversies regarding the ability of MICS to achieve total revascularization (20), in our center MICS was able to achieve this operative outcome when performed through a small left fourth and fifth intercostal incision. We believe that the follow-up outcomes for these patients are reasonable and that the associated data are robust, indicating that MICS can achieve satisfactory mid-term outcomes comparable to those associated with conventional CABG procedures.

Limitations

There are multiple restrictions to this research. First, this was a retrospective observational study and it is thus limited by the constraints associated with this study design. Second, the selection of patients for MICS treatment may have been subject to some level of bias, and so multivariate Cox proportional hazard regression analyses and 1:1 propensity score matching were employed in an effort to reduce selection bias between these two groups. Third, the study follow-up duration was relatively short.

Conclusions

There were no substantial discrepancies in rates of MACCEs including cardiac death, MI, HF, stroke, or repeated revascularization when comparing CAD patients treated via MICS or CABG, suggesting that these approaches are associated with similar outcomes. Male patients and patients with a history of prior MI are more likely to suffer from a MACCE following CABG or MICS.

Acknowledgments

The most important acknowledgment is to the participants in the study at Anzhen Hospital. We would like to thank Meiji Compilation Company for its help in polishing our paper.
Funding: This study was supported by the Capital Health Research and Development of Special (No. 2018-2-1052), Beijing Gold-Bridge Project (No. ZZ19006) and Capital Clinical Diagnosis and Treatment Technology Research and Transformation Application Project (No. Z20111000550000).

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-10/rc

Data Sharing Statement: Available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-10/dss

Peer Review File: Available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-10/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-10/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The Ethics Committee Institute of Beijing Anzhen Hospital approved the present study (No. 2020092X). The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Because of the retrospective nature of the study, the requirement for informed consent was waived.

References

1. Sousa-Uva M, Neumann FJ, Ahlsson A, et al. 2018 ESC/EACTS Guidelines on myocardial revascularization. Eur J Cardiothorac Surg 2019;55:4-90.
2. Farkouh ME, Domanski M, Sleeper LA, et al. Strategies for multivessel revascularization in patients with diabetes. N Engl J Med 2012;367:2375-84.
3. Mohr FW, Morice MC, Kappetein AP, et al. Coronary

artery bypass graft surgery versus percutaneous coronary intervention in patients with three-vessel disease and left main coronary disease: 5-year follow-up of the randomised, clinical SYNTAX trial. Lancet 2013;381:629-38.
4. Ruel M, Shariff MA, Lapierre H, et al. Results of the Minimally Invasive Coronary Artery Bypass Grafting Angiographic Patency Study. J Thorac Cardiovasc Surg 2014;147:203-8.
5. Hannan EL, Wu Y, Cozzens K, et al. Hybrid Coronary Revascularization Versus Conventional Coronary Artery Bypass Surgery: Utilization and Comparative Outcomes. Circ Cardiovasc Interv 2020;13:e009386.
6. Kikuchi K, Mori M. Minimally invasive coronary artery bypass grafting: a systematic review. Asian Cardiovasc Thorac Ann 2017;25:364-70.
7. Florisson DS, DeBono JA, Davies RA, et al. Does minimally invasive coronary artery bypass improve outcomes compared to off-pump coronary bypass via sternotomy in patients undergoing coronary artery bypass grafting? Interact Cardiovasc Thorac Surg 2018;27:357-64.
8. Kikuchi K, Une D, Suzuki K, et al. Off-Pump Minimally Invasive Coronary Artery Bypass Grafting With a Heart Positioner: Direct Retraction for a Better Exposure. Innovations (Phila) 2015;10:183-7.
9. Nakamura Y, Asaumi Y, Miyagi T, et al. Comparison of long-term mortality in patients with previous coronary artery bypass grafting who underwent percutaneous coronary intervention with versus without optimal medical therapy. Am J Cardiol 2018;122:206-12.
10. Honda S, Asaumi Y, Yamane T, et al. Trends in the clinical and pathological characteristics of cardiac rupture in patients with acute myocardial infarction over 35 years. J Am Heart Assoc 2014;3:e000984.
11. Ma X, Dong R, Chen P, et al. Percutaneous coronary intervention in diabetic versus non-diabetic patients with prior coronary artery bypass grafting: a propensity score matching study. BMC Cardiovasc Disord 2020;20:159.
12. Sakaguchi T, Totsugawa T, Tamura K, et al. Minimally invasive coronary artery bypass grafting: useful routine option for coronary revascularization in selected cases. Gen Thorac Cardiovasc Surg 2020;68:1128-33.
13. Saha S, Varghese S, Herr M, et al. Minimally invasive versus conventional extracorporeal circulation circuits in patients undergoing coronary artery bypass surgery: a propensity-matched analysis. Perfusion 2019;34:590-7.
14. Guan Z, Zhang Z, Gu K, et al. Minimally Invasive CABG or Hybrid Coronary Revascularization for Multivessel Coronary Diseases: Which Is Best? A Systematic Review and Metaanalysis. Heart Surg Forum 2019;22:E493-502.
15. Kikuchi K, Une D, Kurata A, et al. Off-pump minimally invasive coronary artery bypass grafting using the bilateral internal thoracic arteries and the right gastroepiproic artery. Eur J Cardiothorac Surg 2016;49:1285-6.
16. Halkos ME, Vassiliades TA, Myung RJ, et al. Sternotomy versus nonsternotomy LIMA-LAD grafting for single-vessel disease. Ann Thorac Surg 2012;94:1469-77.
17. Sabashnikov A, Patil NP, Weymann A, et al. Outcomes after different non-sternotomy approaches to left single-vessel revascularization: a comparative study with up to 10-year follow-up. Eur J Cardiothorac Surg 2014;46:e48-55.
18. Une D, Sakaguchi T. Initiation and modification of minimally invasive coronary artery bypass grafting. Gen Thorac Cardiovasc Surg 2019;67:349-54.
19. Kikuchi K, Une D, Endo Y, et al. Minimally Invasive Coronary Artery Bypass Grating Using Bilateral In Situ Internal Thoracic Arteries. Ann Thorac Surg 2015;100:1082-4.
20. Rodriguez ML, Lapierre HR, Sohmer BF, et al. Repeat Revascularization After Minimally Invasive Coronary Artery Bypass Grafting: Is It a Problem? Innovations (Phila) 2017;12:269-74.

Cite this article as: Liang L, Ma X, Kong Q, Xiao W, Liu J, Chi L, Zhu J. Comparing patient outcomes following minimally invasive coronary artery bypass grafting surgery *vs.* coronary artery bypass grafting: a single-center retrospective cohort study. Cardiovasc Diagn Ther 2022;12(3):378-388. doi: 10.21037/cdt-22-10