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Original Article

Percutaneous coronary intervention and coronary artery bypass grafting

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Abstract: Objective: To compare the clinical efficacy of percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) in the treatment of patients with coronary heart disease (CHD) and type 2 diabetes mellitus. Methods: Patients with CHD and type 2 diabetes mellitus undergoing PCI (n=130) and patients with the two diseases undergoing CABG (n=95) were analyzed retrospectively and were compared in terms of their repeat revascularization rate, all-causes of mortality, etc. Results: At 1 year and 5 years after their surgeries, the PCI group showed a significantly higher repeat revascularization rate than the CABG group (both P<0.05). At 5 years after their surgeries, the CABG group showed a significantly lower all-cause mortality rate than the PCI group (P<0.05). The recurrent stroke rate was not significantly different between the PCI and CABG groups (both P>0.05) at 1 year and 5 years after the surgeries. At 5 years after the surgeries, the PCI group showed a significantly higher recurrent myocardial infarction rate than the CABG group (P<0.05). The CABG group experienced significantly improved cardiac function compared to the PCI group at 5 years after the surgeries (P<0.05). Conclusion: Patients with CHD and type 2 diabetes mellitus undergoing CABG showed a significantly lower incidence of adverse events (excluding stroke) than those undergoing PCI.

Keywords: Coronary heart disease, type 2 diabetes mellitus, percutaneous coronary intervention

Introduction

Coronary heart disease (CHD) is caused by coronary artery atherosclerosis and other coronary artery diseases which cause functional changes, such as the narrowing or obstruction of the coronary artery blood vessel lumina and coronary artery spasms, due to inflammation, embolization, malformation, and trauma. It's also called ischemic heart disease because of the myocardial ischemia, hypoxia, or necrosis [1-3]. The World Health Organization (WHO) classifies CHD into five types clinically: the asymptomatic type, the angina type, the myocardial infarction type, the ischemic cardiomyopathy type, and the sudden death type [4].

Recent years have witnessed an annually-increasing incidence of and mortality due to CHD in China. As the fifth national health interview survey reported in 2013, the incidence of ischemic heart disease among urban people above 15 years old and those above 60 years old were 12.3% and 27.8%, respectively, and the incidence among rural people was 8.1%. Then in 2015, the CHD mortality among urban people and rural people in China was 110.67/100,000 and 110.91/100,000, respectively [5]. It's been proved in previous studies that the main risk factors of CHD include personal and external factors such as gender, age, diet, smoking, metabolic disorder, and psychology, and they also include potential genetic factors [6-8].

With the rapid development of interventional techniques in recent years, in addition to drug therapy and coronary artery bypass grafting (CABG), percutaneous coronary intervention (PCI) also emerges as an important therapeutic means of treating CHD [9, 10]. Thanks to the steadily increasing application of PCI, CHD mortality can be controlled at a relatively low level. For example, the 6-month mortality rate of patients with acute ST-elevation myocardial infarction dropped from 17.2% in

Table 1. NYHA classification

Class	Clinical manifestation
Class I	Patients with cardiac disease but resulting in no limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitations, dyspnea, or anginal pain.
Class II	Patients with cardiac disease resulting in a slight limitation of physical activity. They are comfortable at rest. Ordinary physical activity results in undue fatigue, palpitations, dyspnea, or anginal pain.
Class III	Patients with cardiac disease resulting in a marked limitation of physical activity. They are comfortable at rest. Greater than ordinary activity causes undue fatigue, palpitations, dyspnea, or anginal pain.
Class IV	Patients with cardiac disease resulting in an inability to carry out any physical activity. Symptoms of heart failure may be present even at rest, which get worse after any physical activity.

Note: NYHA: New York Heart Association.

Table 2. Comparison of the baseline data ($\bar{x}$ ± sd, n (%))

Factors	PCI group (n=130)	CABG group (n=95)	t/χ^2	P
Gender			-0.278	0.781
Male	95 (73.1)	71 (74.7)		
Female	35 (26.9)	24 (25.3)		
Age (year)			0.388	0.825
Range	50-70	52-70		
Average	59.9±6.1	59.9±5.8		
BMI (kg/m^2)	26.13±2.04	25.96±1.49	0.702	0.484
Smoking			-0.086	0.932
Yes	80 (61.5)	59 (62.1)		
No	50 (38.5)	36 (37.9)		
Alcohol consumption			-1.891	0.060
Yes	56 (43.1)	53 (55.8)		
No	74 (56.9)	42 (44.2)		
History of Myocardial infarction			-1.617	0.107
Yes	25 (19.2)	27 (28.4)		
No	105 (80.8)	68 (71.6)		
Cerebrovascular history			-1.496	0.136
Yes	12 (9.2)	10 (10.5)		
No	118 (90.8)	85 (89.5)		
Hypertension history				
Yes	82 (63.1)	63 (66.3)	0.313	0.618
No	48 (36.9)	32 (33.7)		
History of hyperlipidemia			-1.377	0.170
Yes	73 (56.2)	62 (65.3)		
No	57 (43.8)	33 (34.7)		

Note: BMI: body mass index; PCI: percutaneous coronary intervention; CABG: coronary artery bypass grafting.

1995 to 6.9% in 2010, and then to 5.3% in 2015, and the rate of patients with non-ST-segment elevation myocardial infarction dropped from 17.2% in 1995 to 6.9% in 2010 and then to 6.3% in 2015 [11].

Previous studies have shown that CABG and PCI have their own advantages and disadvantages in the treatment of patients with CHD and type 2 diabetes mellitus in terms of revascularization, restenosis prevention, and other aspects [12, 13]. The latest evidence indicates there is a similar clinical efficacy between PCI and CABG in the treatment of CHD, but after CABG, patients suffer a higher incidence of stroke, and after PCI, patients are exposed to a higher repeat revascularization rate [13]. To further explore this, we collected the clinical data of patients with CHD and type 2 diabetes mellitus undergoing PCI or CABG from January 2012 to January 2013. The study aimed to compare and analyze repeat revascularization, all-cause mortality, non-lethal recurrent myocardial infarction, and recurrent stroke incidence, together with postoperative heart function, so as to provide a clinical basis for the treatment of CHD.

Materials and methods

General data

Among the patients with CHD and type 2 diabetes mellitus treated in Nanfang Hospital, Southern Medical University from January 2012 to January 2013, a total of 130 patients undergoing PCI were enrolled as the PCI group, while the 95 patients undergoing CABG were enrolled as the CABG group. All the subjects signed an informed consent form, and the

Table 3. Comparison of the repeat revascularization rates (n, %)

Follow-up time	PCI group (n=130)	CABG group (n=95)	χ^2	P
At 1 year after surgery	17 (13.1)	2 (2.1)	8.546	0.003
At 5 years after surgery	36 (27.7)	6 (6.3)	16.520	0.000

Note: PCI: percutaneous coronary intervention; CABG: coronary artery bypass grafting.

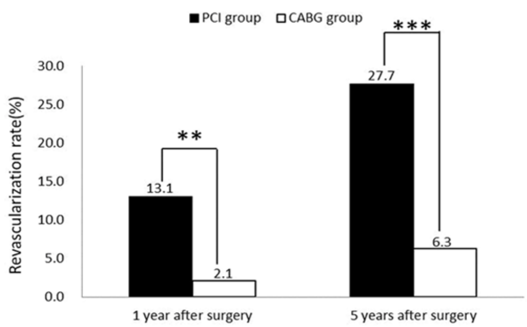

Figure 1. Comparison of the repeat revascularization rate (%). Compared with the CABG group at the same time after the surgeries, **P<0.01, ***P<0.001. PCI: percutaneous coronary intervention; CABG: coronary artery bypass grafting.

study was examined and approved by the Ethics Committee of Nanfang Hospital, Southern Medical University.

Inclusion criteria: Patients who were (1) diagnosed with CHD based on their clinical efficacy and examination indexes such as electrocardiogram, echocardiography, coronary angiography, and myocardial enzyme levels, according to the diagnostic criteria of ischemic heart disease established by the American College of Cardiology and WHO in 2014 [14]; (2) patients diagnosed with type 2 diabetes mellitus based on their relevant symptoms of the disease: fasting blood glucose ≥7 mmol/L, either blood glucose concentration >11.1 mmol/L at any time or 2 h postprandial blood glucose ≥11.1 mmol/L using an oral glucose tolerance test [15]; (3) patients who also have left main coronary artery disease or multivessel disease.

Exclusion criteria: (1) Patients without type 2 diabetes mellitus; (2) patients who previously underwent PCI or CABG operations; (3) patients with anemia, infections, tumors, hepatic and kidney function obstacles, systemic immune disease, or other cardiac diseases such as rheumatic valvular disease, congenital heart disease, or dilated cardiomyopathy.

Methods

The hospitalization data of all subjects were acquired, including their general conditions, past medical histories, examination results at admission, and treatment methods. The patients were followed up through telephone and reexamination in terms of any major adverse cardiovascular events (MACE) including all-causes of death, repeat revascularization (confirmed based on coronary angiography), non-lethal recurrent myocardial infarction, and recurrent stroke [16]. The patients in the two groups were compared in terms of MACE and cardiac function at 1 year and 5 years after their surgeries. The cardiac function impairment was classified into 4 classes according to the New York Heart Association (NYHA) classification proposed in 1928 [17]. See **Table 1**.

Statistical analysis

SPSS 22.0 was used to process the data. Checked using Kolmogorov-Smirnov test tests, the measurement data in a normal distribution were expressed as the mean ± standard deviation ($\bar{x}$ ± sd), and the comparison between groups were subject to independent t tests. The enumeration data were expressed as the number of cases/percentage (n/%) and were compared between groups using χ^2 tests. The cardiac function classification was compared using rank sum tests using the Kruskal Wallis method. P<0.05 indicated a significant difference.

Results

General condition

There was no significant difference between the PCI group and CABG group in terms of the general data such as gender composition, age, body mass index, smoking history, drinking history, history of myocardial infarction, cerebrovascular disease, hypertension, or hyperlipidemia (all P>0.05). See **Table 2**.

Repeat revascularization rate

At 1 year and 5 years after the surgeries, the PCI group showed a significantly higher repeat

Table 4. Comparison of the postoperative mortality (n, %)

Follow-up time	PCI group (n=130)	CABG group (n=95)	X^2	P
At 1 year after surgery	3 (2.3)	1 (1.1)	0.495	0.482
At 5 years after surgery	21 (16.2)	5 (5.3)	6.370	0.012

Note: PCI: percutaneous coronary intervention; CABG: coronary artery bypass grafting.

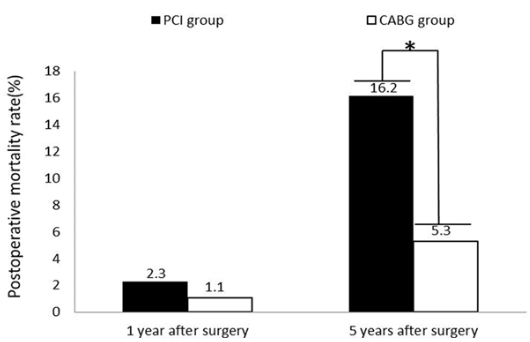

Figure 2. Comparison of the postoperative mortality (%). The postoperative mortality of the CABG group at 5 years after surgery was significantly lower than it was in the PCI group (*P<0.05). PCI: percutaneous coronary intervention; CABG: coronary artery bypass grafting.

revascularization rate than the CABG group (13.1% and 27.7% vs. 2.1% and 6.3%, both P<0.05). See **Table 3** and **Figure 1**.

Postoperative mortality

At 1 year after the surgeries, the PCI group and the CABG group showed no significant differences in mortality (2.3% vs. 1.1%, P>0.05), but at 5 years after the surgeries, the CABG group showed significantly lower all-cause mortality than the PCI group (5.3% vs. 16.2%, P<0.05). The CABG group's survival time was significantly better than the PCI group's survival time. See **Table 4**; **Figures 2** and **3**.

Recurrent stroke rate

At 1 year and 5 years after the surgeries, there was no significant difference between the PCI group and the CABG group (2.3% and 9.2% vs. 0.0% and 4.2%, both P>0.05). See **Table 5**.

Recurrent myocardial infarction

At 1 year after the surgeries, there was no significant difference between the PCI group and CABG group in their recurrent myocardial infarction rates (5.4% vs. 2.3%, P>0.05), but at 5 years after the surgeries, the PCI group showed a significantly higher recurrent myocardial infarction rate than the CABG group (15.4% vs. 6.3%, *P*<0.05). See **Table 6**.

Cardiac function

At 1 year after the surgeries, the two groups showed no significant difference in their cardiac function (P>0.05), but at 5 years after the surgery, compared with the PCI group, the CABG group experienced significantly improved cardiac function (P<0.05). See **Table 7**.

Discussion

Type 2 diabetes mellitus, a systemic metabolic disorder, is an independent risk factor for cardiovascular diseases. Patients with type 2 diabetes mellitus are at a significantly increased risk of cardiovascular death. The incidence of coronary artery disease in patients with type 2 diabetes mellitus is 2.57 times higher than it is in those without type 2 diabetes mellitus (95% CI 2.49-2.66) [18]. Patients with CHD and type 2 diabetes mellitus are also more likely to suffer from complications such as hypertension, cerebrovascular diseases, and kidney diseases so they would be more seriously ill with worse basic conditions [19].

CABG has long been recognized as the first choice for the treatment of multivessel disease [20]. However, with the rapid development of interventional techniques and the invention and improvement of drug eluting stents, the clinical efficacy of PCI has improved greatly, an improvement which significantly reduces the restenosis rate after stent implantation [21]. However, the choice of revascularization strategy depends not only on the complexity of the coronary artery lesions, but also on the patient's clinical background and complications. There have been many studies on the clinical efficacy of PCI combined with CABG in the treatment of patients with CHD and type 2 diabetes mellitus. Most scholars consider that CABG is superior to PCI for treating patients with CHD and type 2 diabetes mellitus, because it can lower both the mortality rate and the repeat revascularization rate [22-24].

The results of this study showed that the repeat revascularization rate of patients with CHD and type 2 diabetes mellitus at 1 year and 5 years after CABG was lower than the

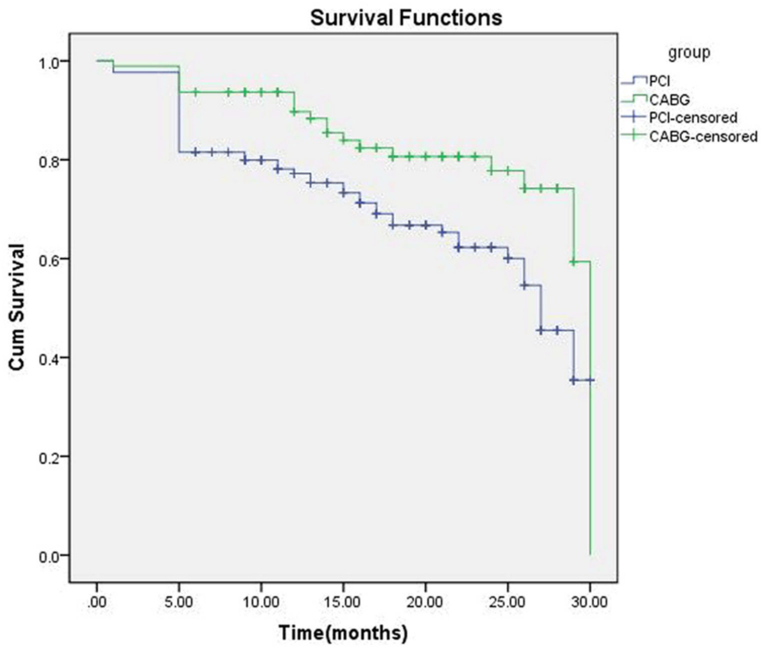

Figure 3. The survival curves of the PCI and CABG groups. χ^2=7.154, P=0.007. PCI: percutaneous coronary intervention; CABG: coronary artery bypass grafting.

Table 5. Comparison of the recurrent stroke rate (n, %)

Follow-up time	PCI group (n=130)	CABG group (n=95)	χ^2	P
At 1 year after surgery	3 (2.3)	0 (0.0)	2.222	0.138
At 5 years after surgery	12 (9.2)	4 (4.2)	2.094	0.148

Note: PCI: percutaneous coronary intervention; CABG: coronary artery bypass grafting.

Table 6. Comparison of the recurrent myocardial infarctions (n, %)

Follow-up time	PCI group (n=130)	CABG group (n=95)	χ^2	P
At 1 year after surgery	7 (5.4)	3 (2.3)	0.641	0.423
At 5 years after surgery	20 (15.4)	6 (6.3)	4.417	0.036

Note: PCI: percutaneous coronary intervention; CABG: coronary artery bypass grafting.

rates at 1 year and 5 years after PCI (2.1% and 6.3% vs. PCI 13.1% and 27.7%), and the all-cause mortality of those patients at 5 years after CABG was significantly lower than it was at 5 years after PCI (5.3% vs. 16.2%). What's more, patients undergoing CABG showed a significantly lower rate of recurrent myocardial infarction than those undergoing PCI (6.3% vs. 15.4%). At 1 year after the surgeries, the two groups showed no significant difference in cardiac function, but at 5 years after surgery, compared with the PCI group, the CABG group experienced significantly improved cardiac function. To figure out why type 2 diabetes mellitus is closely related to cardio-cerebrovascular diseases, first, in the early stage of type 2 diabetes mellitus, glyeolipid metabolism disorder causes a decrease of vascular elasticity, and endothelial cell dysfunction results in the generation of a large number of inflammatory mediators, causing vasospasms and promoting the progression of atherosclerosis. Secondly, insulin resistance weakens hemangiectasis, further accelerating the influence on blood vessels [25]. Last but not least, abnormal lipid metabolism leads to a decrease in high density lipoprotein and an increase in low density lipoprotein, thus promoting coronary artery disease, even complicated coronary artery disease, such as multiple coronary artery branches lesions and multiple lesions, which further cause complications such as heart failure and arrhythmia [26].

The results of this study are consistent with the repeat revascularization rate of the PCI group and the CABG group at 1 year after surgery (PCI 10.3%, CABG 3.1%) reported by Que et al. and are also consistent with the mortality at 1 year after surgery (PCI 5.83%; CABG 0.85%) reported by Su et al. [27, 28]. This study found that patients with type 2 diabetes mellitus are prone to aggravated atherosclerosis. CABG is usually performed on the internal mammary arteries, and it better contributes to the long-term patency rate. That is the main reason why the repeat revascularization rate in patients

Table 7. Comparison of the cardiac function (n, %)

Follow-up time	≤ Class II	≥ Class III
Before surgery		
PCI group (n=130)	57 (43.8)	73 (56.2)
CABG group (n=95)	33 (34.7)	62 (65.3)
χ^2	1.615	
P	0.204	
At 1 year after surgery		
PCI group (n=130)	64 (49.2)	66 (50.8)
CABG group (n=95)	55 (57.9)	40 (42.1)
χ^2	3.409	
P	0.065	
At 5 years after surgery		
PCI group (n=130)	72 (55.4)	58 (44.6)
CABG group (n=95)	66 (69.5)	29 (30.5)
χ^2	18.279	
P	0.000	

Note: PCI: percutaneous coronary intervention; CABG: coronary artery bypass grafting.

with CHD and type 2 diabetes mellitus after CABG is lower than it is in the patients after PCI [29, 30].

This study has the following deficiencies: First of all, this study belongs to a retrospective analysis, which may have some bias in the inclusion of study subjects and collection of clinical data, thus failing to reflect the real clinical efficacy. Secondly, the CABG and PCI were performed by different doctors, bringing in some artificial error. In addition, there is a lack of hierarchical research on the vascular subtypes and the severity of coronary artery lesions in this study, which will also be the focus of further study. In our ongoing clinical observations, we will also refer to the patients' coronary angiography results and their clinical characteristics, and then we will conduct a comprehensive analysis according to the differences in single-branch, double-branch, and localized coronary artery lesions considering patients at a high risk for surgery, with a long-term follow up, so as to provide more technical support for the diagnosis, treatment, and disease prevention of patients with complex coronary artery lesions.

To sum up, patients with CHD and type 2 diabetes mellitus often suffer complications such as coronary artery lesions with various clinical manifestations. Since PCI is not effective for them, we recommend CABG. Patients with CHD and type 2 diabetes mellitus undergoing CABG show a significantly lower incidence of adverse events than those undergoing PCI, and they show a significantly decreased repeat revascularization rate in the long term, which effectively improves their prognoses and quality of life. In sum, choosing a therapeutic regimen more suitable for patients according to their actual situations should be the main direction of future research.

Disclosure of conflict of interest

None.

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