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Original Article

Effects of off-pump coronary artery bypass grafting on clinical efficacy, cardiac function and the incidence of major adverse cardiovascular events in patients with coronary heart disease

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Abstract: Objective: To explore the effects of off-pump coronary artery bypass grafting (OPC) on clinical efficacy, cardiac function and the occurrence of major adverse cardiovascular events (MACE) in patients with coronary heart disease. Methods: According to different surgical methods, 93 patients with coronary heart disease who were hospitalized and treated in our hospital were collapsed into the off-pump coronary artery bypass grafting group (OPC group) and the extracorporeal circulation coronary artery bypass grafting group (PC group). The perioperative indexes, cardiac function indexes, postoperative recovery, quality of life, the incidence of MACE and adverse reactions and the survival rate of patients in PC group and OPC group were analyzed and compared. Results: Compared with the PC group, the operation time and blood transfusion volume of OPC group were both largely decreased ($P<0.05$), but the number of bypass grafts was similar ($P>0.05$). The cardiac function index of OPC group was much higher than that of PC group ($P<0.05$). The postoperative recovery after operation of OPC group was better than that of PC group ($P<0.05$). The scores of quality of life scale in OPC group were markedly higher than those in PC group ($P<0.05$). The incidence of MACE in OPC group was obviously lower than that in PC group ($P<0.05$). Patients in in the OPC group had slightly lower incidence of adverse reactions, and slightly higher survival rate than the PC group, but there was no statistical difference ($P>0.05$). Conclusion: Compared with PC, OPC has a significantly better therapeutic effect on patients with coronary heart disease, which can significantly improve the perioperative indices and cardiac function, and enhance the quality of life of patients.

Keywords: Off-pump coronary artery bypass grafting, coronary heart disease, major adverse cardiovascular events, cardiac function, clinical efficacy

Introduction

Coronary heart disease (CHD) is an ischemic heart disease and the incidence of CHD has been increasing in clinic [1]. The elderly are the main population group affected by CHD, which may be due to a number of underlying diseases [2]. In clinical practice, main prevention measures include changing living habits, drug intervention, surgery and other methods, and regular detection of relevant indicators [3, 4]. Studies have shown that extracorporeal circulation coronary artery bypass grafting (PC) has a certain therapeutic effect on CHD, which can significantly improve the clinical symptoms of patients. However, it is needs to fully expose the blood vessels during PC, which may cause other injuries to the patients [5]. Nowadays, the clinical application of off-pump coronary artery bypass grafting (OPC) is gradually increasing. With the same treatment efficacy, the influence of OPC on the health of patients and the incidence of postoperative complications were both largely reduced. Previous studies usually focused on the comparative study of PC surgery and other surgical methods, or the comparison of clinical effects after PC and OPC treatment, but less focused on the study of postoperative general indicators, major adverse cardiovascular events (MACE) and the risk of adverse reactions [6]. Therefore, our present study selected two different surgical methods

Table 1. General material (n/$\bar{x}$ ± sd)

Factors	Group PC (n=45)	Group OPC (n=48)	χ^2/t	P
Gender			0.088	0.765
Male	26	25		
Female	19	23		
Smoking			0.159	0.690
Yes	30	28		
No	15	20		
Number of vascular lesions			0.102	0.748
Single	13	12		
Two	15	16		
Three	17	20		
Clinical feature			0.002	0.957
Atrial fibrillation	23	25		
Atrial flutter	24	18		
Frequent ventricular premature beats	19	23		
Co-morbidity			0.083	0.772
Hypertension	15	18		
Diabetes	16	13		
Hyperlipidemia	23	19		
Obstructive pulmonary emphysema	14	21		
Others	6	8		
BMI (kg/cm^2)	22.15±3.16	23.24±3.19	0.895	0.372
Age (years)	45.2±6.2	46.2±5.3	0.863	0.390

Note: PC: extracorporeal circulation coronary artery bypass grafting; OPC: off-pump coronary artery bypass grafting; BMI: body mass index.

for the treatment of patients with coronary heart disease and compared the differences between them through analyzing perioperative indicators, cardiac function indicators, postoperative general situation, quality of life, MACE incidence and adverse reactions.

Materials and methods

General material

According to different surgical methods, 93 patients with CHD who were hospitalized and treated in The First Department of Cardiac Surgery, Tangshan Gongren Hospital during February 2018 to December 2019 were collapsed into two groups: PC group PC (45 cases) and OPC group (48 cases) for the prospective study. No difference existed in general information between the two groups. The results are shown in **Table 1**. This study was approved by Ethics Committee of Tangshan Gongren Hospital, and the patients signed the informed consent form.

Inclusion and exclusion criteria

Inclusion criteria: (1) All patients met the diagnostic criteria of coronary heart disease [7]; (2) All the patients received surgical treatment for the first time; (3) The patients with complete data can cooperate with surgery and related examination. Exclusion criteria: (1) Patients who cannot express their feelings clearly; (2) Patients with incomplete data collection; (3) Patients with other heart diseases.

Treatment methods

Patients in PC group were treated with coronary artery bypass grafting under cardiopulmonary bypass. The patient was kept in the supine position. During the operation, 100 U/kg of heparin (Guangzhou Ruite Biotechnology Co., Ltd., China) was given systematically to achieve half dose heparinization, and cardiopulmonary bypass was established through right atrium and aorta cannulation. The patients were treated with local cooling in pericardial cavity. After

Table 2. Comparison of perioperative indexes between PC group and OPC group ($\bar{x} \pm sd$)

Groups	Operation time (h)	Number of SVBG (branch)	Blood transfusion volume (L)
PC group (n=45)	6.07±0.79	2.64±0.59	2.09±0.58
OPC group (n=48)	3.96±0.65	2.65±0.23	1.23±0.36
t	3.409	0.109	5.553
p	<0.001	0.913	<0.001

Note: PC: extracorporeal circulation coronary artery bypass grafting; OPC: off-pump coronary artery bypass grafting; SVBG: saphenous vein bypass graft.

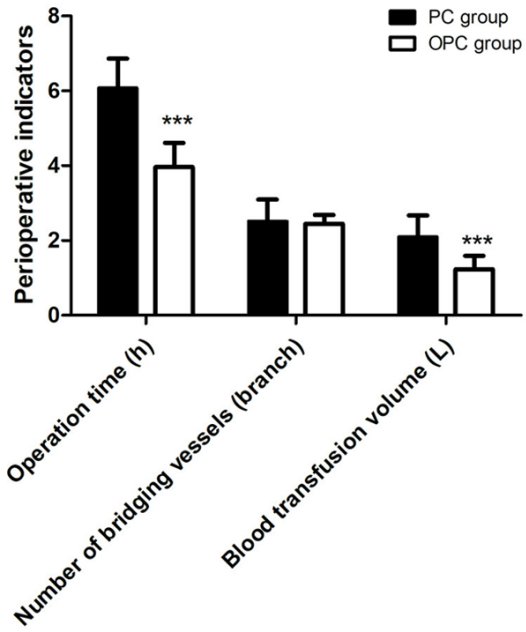

Figure 1. Perioperative indicators. ***P<0.001 vs. PC group. PC: extracorporeal circulation coronary artery bypass grafting; OPC: off-pump coronary artery bypass grafting.

cardiac arrest, the end of coronary artery was anastomosed with the proximal great saphenous vein bridge and the distal radial artery. After distal anastomosis, the aorta was opened and the proximal bypass was anastomosed with ascending aorta on the lateral wall of aortic clip after heart beating.

OPC group received off-pump coronary artery bypass grafting. The patient was placed in supine position. After anesthesia, the patient was treated with heparin (100 U/kg) for whole-body half heparinization treatment and normal body temperature, heart rate and blood pressure were maintained. The great saphenous vein was dissociated in the middle of sternum. Pericardium was opened to fully expose the heart and the stenosis of coronary artery branches was explored. Blood vessels to receive bypass grafting were confirmed. According to the location of the vascular lesion, the appropriate bridging vessels were selected. Finally, the ascending aorta was anastomosed with the great saphenous vein, and the pericardium was sutured after the anastomosis. After hemostasis, the drainage tube was placed routinely, and then the thoracic cavity was closed.

Outcome measures

Main outcome measures include perioperative indicators, cardiac function indicators, quality of life and prognosis; Secondary outcome measures include postoperative general conditions, incidence of MACE, and adverse reactions.

Perioperative indicators: In the process of treatment, the perioperative indicators of the two groups were observed and recorded, including operation time, blood transfusion volume, number of bridging vessels, number of Saphenous vein bypass graft (SVBG), etc.

Cardiac function index: Four weeks after the operation, the patients' cardiac function was monitored by color Doppler ultrasound (Model number: DC-N2S; Manufacturer: Shanghai Sanwei medical equipment company, China), and left ventricular ejection fraction (LVEF) was recorded.

Recovery after operation: After treatment, the general conditions of the two groups were recorded and analyzed, such as postoperative hospitalization time and the time in ICU, etc.

Quality of life: Four weeks after the operation, the quality of life scale (SF-36) was used to evaluate the two groups of patients. There are eight items in the scale, each with 100 points. The higher the score is, the better the quality of life is.

Incidence of MACE: One week after treatment, the incidence of cardiovascular adverse events in the two groups was observed, including massive and small amount of bleeding, intractable ischemic state and recent myocardial infarction.

Table 3. Comparison of cardiac function indexes between PC group and OPC group

Time	Groups	n	CO (L/h)	LVEF (%)
Before Operation	PC group	45	3.89±0.32	43.65±3.45
	OPC group	48	3.91±0.29	44.01±3.56
	t		0.316	0.494
	P		0.752	0.622
After Operation	PC group	45	4.21±0.47^{aaa}	49.37±3.95^{aaa}
	OPC group	48	4.87±0.56^{aaa}	53.24±4.74^{aaa}
	t		6.135	4.262
	P		<0.001	<0.001

Note: PC: extracorporeal circulation coronary artery bypass grafting; OPC: off-pump coronary artery bypass grafting; CO: cardiac output; LVEF: left ventricular ejection fraction. Compared with that before treatment in the same group, ^{aaa}P<0.001.

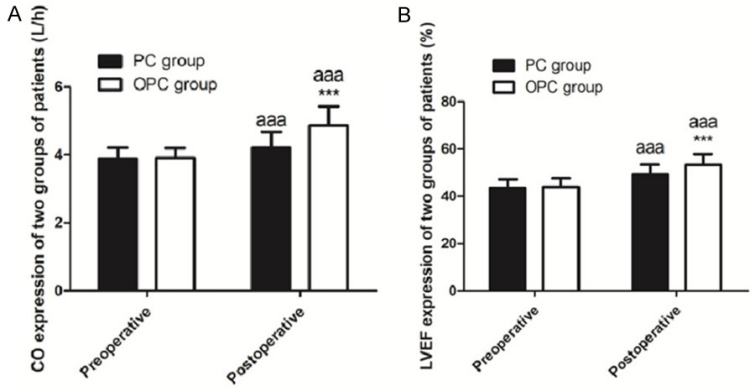

Figure 2. Cardiac function indexes. A: The comparison of CO index between the two groups; B: The comparison of LVEF index between the two groups. Compared with that before treatment in the same group, ^{aaa}P<0.001 means; compared with PC group, ***P<0.001. PC: extracorporeal circulation coronary artery bypass grafting; OPC: off-pump coronary artery bypass grafting; CO: Cardiac output; LVEF: means left ventricular ejection fraction.

Adverse reactions: After treatment, the incidence and number of adverse reactions in the two groups were observed and analyzed, including: acute myocardial infarction, pulmonary infection, acute renal failure, gastrointestinal bleeding. Incidence (%) = number of adverse reactions/total number * 100%.

Prognosis: After treatment, the patients were followed up for 4 months, and the survival rate and mortality rate were calculated. The survival rate (%) = survival number/total number * 100%. Mortality rate (%) = (total number-survivors)/total number of people * 100%.

Statistical analysis

The data were analyzed by SPSS 23.00 software. Firstly, distribution normality was examined, and the data conforming to normal distribution were expressed as mean ± standard deviation ($\bar{x}$ ± sd). The comparison between the two groups was performed by independent samples t-test; Chi square test was used for enumeration data comparison and log-rank test was used for survival comparison. P<0.05 was considered as statistically significant.

Results

Comparison of perioperative indexes between PC group and OPC group

The results showed that the operation time and blood transfusion volume of OPC group were significantly decreased compared with the PC group (P<0.001), and the number of bridging vessels was similar (P>0.05). See **Table 2** and **Figure 1**.

Comparison of cardiac function indexes between PC group and OPC group

Before operation, the CO and LVEF of the two groups were similar (P>0.05). After operation, the cardiac function indexes of OPC group were much higher than that of PC group (P<0.001). See **Table 3** and **Figure 2**.

Comparison of postoperative recovery between PC group and OPC group

The results showed that the postoperative hospitalization time, duration of ventilator assistance and time in ICU (d) of OPC group was better than that of PC group (P<0.001). See **Table 4** and **Figure 3**.

Comparison of postoperative quality of life between PC group and OPC group

According to our study, the scores of physiological function, daily activities and energy in OPC group were all higher than those in PC group after operation (P<0.05). See **Table 5**.

Table 4. Comparison of postoperative general condition between PC group and OPC group

Groups	Postoperative hospitalization time (d)	Duration of ventilator assistance (h)	Time in ICU (d)
PC group (n=45)	18.56±5.14	20.37±4.81	3.47±0.36
OPC group (n=48)	13.02±4.09	13.26±3.52	2.15±0.21
t	5.759	8.171	21.760
P	<0.001	<0.001	<0.001

Note: PC: extracorporeal circulation coronary artery bypass grafting; OPC: off-pump coronary artery bypass grafting.

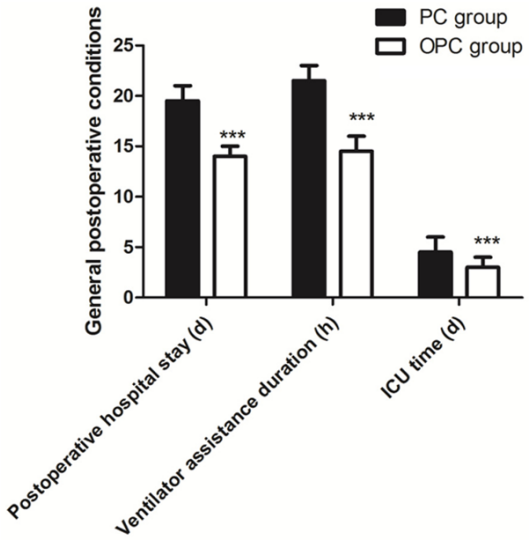

Figure 3. Postoperative general condition. Compared with PC group, ***P<0.001. PC: extracorporeal circulation coronary artery bypass grafting; OPC: off-pump coronary artery bypass grafting.

Comparison of major adverse cardiovascular events (MACE) between PC group and OPC group

There were 11 cases of MACE in PC group and 4 cases in OPC group. The incidence of MACE in OPC group was lower than that in OPC group (P<0.05). See **Table 6**.

Comparison of the occurrence of adverse reactions between PC group and OPC group

According to the study, there were 12 cases of adverse reactions in PC group and 5 cases in OPC group. The incidence of adverse reactions in OPC group was lower than that in PC group with no significant difference (P>0.05). See **Table 7**.

Prognosis

After 4 months of follow-up, 8 patients died and 37 survived (82.22%) in PC group; 2 patients died and 46 survived (95.83%) in OPC group. Log-rank test showed that there was no significant difference in survival rate between OPC group and PC group (χ^2=1.040, P=0.307). See **Figure 4**.

Discussion

Due to the influence of diet, life and other factors, the onset age of patients with heart disease is gradually declining, resulting in an increase in the number of young and middle-aged patients. The conventional treatment of coronary heart disease is surgical treatment, and the number of surgical methods is gradually increasing with the development of the medical industry. Thus, looking for the surgical scheme with the best treatment effect, least damage to patients and the lowest postoperative complications is one of the keys to the treatment of coronary heart disease [8]. The results showed that the indexes during perioperative period, cardiac function index, quality of life scale and other indicators after OPC treatment were all better than those of PC treatment, and the incidence of cardiovascular adverse events and adverse reactions were both lower.

Studies have shown that coronary artery bypass grafting, as a commonly used surgical method for the treatment of coronary heart disease, uses the internal arm, leg or chest blood vessels to reconstruct the coronary flow path. Although it helps to improve the cardiac blood flow and reduce the occurrence of adverse events such as myocardial infarction to a certain extent, it can easily induce immune system reaction and increase the pain of patients [9, 10]. With the continuous reform and development of medical technology, OPC surgery has been widely used in the clinical treatment of coronary heart disease, which can effectively overcome the shortcomings of coronary artery bypass grafting, maintain the balance of the body's coagulation system, reduce the incidence of cardiovascular and general adverse events, and avoid the operation risk [11].

Table 5. SF-36 score of patients in PC group and OPC group ($\bar{x} \pm sd$)

Groups	Group PC (n=45)	Group OPC (n=48)	t	P
Physiological function	75.12±5.85	88.39±6.89	8.041	<0.001
Physical pain	74.72±6.07	85.33±7.32	6.101	<0.001
Energy	73.29±7.13	82.07±8.13	4.447	0.004
Social function	70.25±5.44	79.47±7.62	5.367	0.002
Emotional title	77.29±6.52	82.34±6.03	3.091	0.031
Mental health	71.69±5.83	82.77±7.41	6.656	<0.001
General health	70.23±7.69	82.05±7.19	6.151	<0.001
Daily activities	74.92±5.69	85.23±6.59	6.486	<0.001

Note: PC: extracorporeal circulation coronary artery bypass grafting; OPC: off-pump coronary artery bypass grafting.

Table 6. Comparison of MACE incidence between PC group and OPC group (n (%))

Groups	Massive bleeding	Minor hemorrhage	Intractable ischemic state	Recent myocardial infarction	Incidence of MACE (%)
PC group (n=45)	2 (4.44)	4 (8.89)	3 (6.67)	2 (4.44)	11 (24.44)
OPC group (n=48)	0 (0.00)	2 (4.17)	1 (2.08)	1 (2.08)	4 (8.33)
χ^2	2.086	0.753	1.087	0.388	3.459
P	0.148	0.385	0.297	0.533	0.046

Note: MACE: major adverse cardiovascular events; PC: extracorporeal circulation coronary artery bypass grafting; OPC: off-pump coronary artery bypass grafting.

Table 7. Comparison of the occurrence about adverse reactions between PC group and OPC group (n (%))

Group	Acute myocardial infarction	Pulmonary infection	Acute renal failure	Gastrointestinal bleeding	Incidence of adverse reactions (%)
PC group (n=45)	4 (8.89)	3 (6.67)	2 (4.44)	3 (6.67)	12 (26.67)
OPC group (n=48)	2 (4.17)	1 (2.08)	1 (2.08)	1 (2.08)	5 (10.42)
χ^2	0.753	1.087	0.388	1.087	2.087
P	0.385	0.297	0.533	0.297	0.092

Note: PC: extracorporeal circulation coronary artery bypass grafting; OPC: off-pump coronary artery bypass grafting.

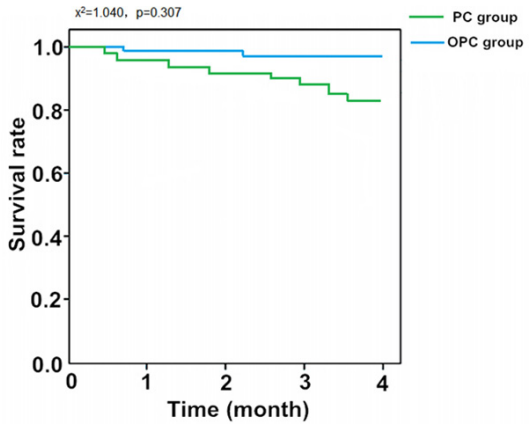

Figure 4. Prognosis analysis. PC: extracorporeal circulation coronary artery bypass grafting; OPC: off-pump coronary artery bypass grafting.

OPC can promote the recovery of myocardial blood supply, alleviate myocardial injury, improve the indexes of cardiac function, reduce the incidence of cardiac output syndrome and other adverse reactions, and enhance the safety of operation. In addition, anterograde sequential anastomosis technology can completely discharge the micro thrombus and its residue, prevent the intima damage of vein bridge caused by acupuncture exhaust, and further enhance the long-term patency rate of the bridge vessel [12, 13].

Studies have also shown that OPC can build a new circulatory system without destroying the balance of the body's coagulation system, so as to avoid systemic inflammatory reaction and

ischemia-reperfusion injury and effectively shorten the length of hospital stay, ventilator assisted time, and ICU time, etc. [14].

With the progress of medical technology', the traditional evaluation methods, such as mortality rate and complication rate, are not commonly accepted by clinic because of many defects in the evaluation of individual and group health status. Quality of life assessment, as a new generation of health evaluation indicators, is more and more widely used in clinical practice. PC can directly solve the problem of reperfusion of stenosed coronary artery, reduce the emotional depression and discomfort caused by the disease, and thus promote the rehabilitation of patients after surgery and improve the quality of life [15, 16]. OPC does not need cardiopulmonary bypass. Besides, OPC reduces the damage to myocardial tissue caused by cardiac arrest to a certain extent and improves the success rate. Therefore, OPC has been rapidly developed in recent years and is widely applied [17, 18].

Studies have shown that OPC can effectively shorten the duration of ICU stay and improve vascular patency rate compared with PC. Besides, OPC can reduce the incidence of complications such as acute renal failure and respiratory system disorder, reduce the mortality rate and improve the survival rate compared with PC [19, 20]. The results of our present study are also consistent with the above conclusions.

Wu et al. showed that left atrial function, left ventricular ejection fraction and left ventricular diastolic function in patients with coronary heart disease 1 month and 6 months were all significantly improved after OPC operation, and left atrial function can be used as an important index to evaluate the curative effect of OPC [21].

There are some deficiencies in the process of research. Due to physical reasons of some patients, not all of the test personnel received fully physical examination, so we cannot exclude the impact of other diseases on the patient's physical and mental function and adverse reactions. During our present experiment, there are few examinations about the related indexes (hemodynamics, central venous pressure, B-type natriuretic peptide, etc.) in patients, thus the influence of the operation method on other indicators was not explored, which has certain limitations. More experimental methods should be added in the future research to provide more favorable experimental basis for the treatment of coronary heart disease.

In conclusion, OPC has a significant better therapeutic effect on patients with coronary heart disease than PC. We found that OPC could significantly improve relevant indicators and the quality of life in patients with coronary heart disease and has low incidence of adverse reactions.

Disclosure of conflict of interest

None.

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