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Effectiveness of Saphenous Vein Y-Grafts in Patients Undergoing Off-Pump Complete Myocardial Revascularization

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Background: To evaluate perioperative and mid-term outcomes of saphenous vein Y-grafts in patients with multi-vessel coronary artery disease.





Material/Methods: Sixty patients who underwent off-pump coronary surgery with Y-graft between 2005 and 2016 were enrolled, including 38 patients with natural Y-graft. Sixty patients with multi-vessel lesions in the same period were randomly selected as a control group.

Results: A total of 484 conduits were employed. The intraoperative variables were insignificantly different between groups, but Y-graft group compared with control group had more grafts (4.2 ± 0.84 vs. 3.87 ± 0.85) and anastomoses (6.30 ± 1.39 vs. 5.62 ± 1.15). No patient died during coronary artery bypass grafting and no episode of perioperative myocardial infarction was found. Follow-up duration lasted from 1 to 137 (40.0 ± 27.7) months. No significant difference between Y-graft group and control group was found in Kaplan-Meier 3-year survival rate (93.4% vs. 88.0%) or 5-year survival rate (81.4% vs. 88.0%).

Conclusions: Saphenous vein Y-graft is a feasible and safe revascularization strategy for multi-vessel coronary artery disease patients and brings about satisfactory outcomes.

MeSH Keywords: **Coronary Artery Bypass • Coronary Artery Bypass, Off-Pump • Saphenous Vein**

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Background

Coronary artery disease (CAD) is one of the leading causes of death worldwide and subjects millions of patients to coronary artery bypass grafting (CABG) every year [1–3]. Since the patency of grafts is linked with a higher long-term survival rate, the selection of graft conduits essentially decides the success or failure of CABG. The left internal thoracic artery (LITA) used to bypass the left anterior descending artery (LAD) has been well studied and can reduce mortality and morbidity compared to other conduits [4,5]. Other types of grafts together with LITA are used to graft the remaining coronary in multi-vessel CAD patients. The saphenous vein is still the second candidate of bypass grafting only after LITA and is indispensable in clinical practice [5,6]. Many configurations and surgical techniques in anastomosis have been proposed to improve surgical treatment, including complete arterial revascularization, complete myocardial revascularization, bilateral internal thoracic artery graft, composite with various veins or/and arteries graft, single end-to-side anastomosis, and sequential side-to-side anastomosis. This study evaluated the perioperative and mid-term outcomes of multi-vessel CAD patients who underwent off-pump CABG with saphenous vein Y-graft at our department.

Material and Methods

Patients

From October 2005 to October 2016, 1537 consecutive serious CAD patients were treated with first-time isolated off-pump CABG at our department, including 60 multi-vessel CAD patients (rate of triple vessel disease=90%) undergoing saphenous vein Y-graft configuration. Twenty-two and 38 patients received saphenous vein Y-graft and natural Y-graft, respectively. In the same period, 60 patients with multi-vessel lesions (rate of triple vessel disease=92%) were randomly selected as a control group. The preoperative data of patents are shown in Table 1. All protocols adopted in this retrospective study were approved by local ethics committees (ID: 2017-45) and the clinical trial registry number was chiCTR1800014505. Written informed consent was received from all participants.

Surgical technique

After general anesthesia, the patients underwent median sternotomy without extracorporeal circulation and received LITA or saphenous vein conduits. LITA bypassed the left anterior descending coronary artery, while the saphenous vein bypassed the left or/and right coronary territory. The principles of off-pump grafting and graft harvesting were reported before [7–10]. LITA was bluntly dissected from the chest wall, and all the branches were clipped proximally and distally. Saphenous

vein branches meeting the following criteria were retained as Y-graft (Figure 1): 1. Bifurcations were in the same direction as the blood flow; 2. Branches reached more than 80% of main trunk; 3. Branches were longer than 3 cm; 4. Number of second-grade branches was less than 3.

The order of revascularization was anterior wall, lateral wall, and posterior wall. Routine configuration of LITA was anastomosed to the left anterior descending artery in the end-to-side manner after heparin was given. If the length of the vessel allowed, first proximal anastomosis and then distal anastomosis were considered, which were beneficial to shortening the heart ischemic time during the operation. The saphenous vein Y-grafts were performed by side-to-end anastomosis with 7/0 Prolene, and the Y limbs formed angles of 45–60°. The Y-grafts were constructed at the same time of LITA harvesting, which shortened the time of myocardial ischemia. The natural Y-graft configuration was illustrated in Figure 2. Distal anastomosis was constructed with 7/0 polypropylene running suture.

Follow-up

All patients were followed up directly by outpatient examination or telephone consultation at 1, 3, and 6 months after discharge and then every 6 months. Survival rates and survival without cardiac events (e.g., myocardial infarction, need for reoperation, need for percutaneous transluminal coronary angioplasty) were considered as clinical outcomes. Questionnaires were used to compare current functions with preoperative functions and to clarify whether activity succeeded or failed [11].

Statistical analysis

Continuous variables are expressed as mean \pm standard deviation, while categorical variables are expressed as number and percentage. Statistical analysis was performed via the *t* test or Mann-Whitney U test, with significance level set at $P < 0.05$. The survival time was statistically described with the Kaplan-Meier curves. All calculations were conducted on SPSS 22.0 (IBM, Chicago, USA).

Results

Demographic data were not significantly different between groups, except for the incidence of cerebrovascular disease (Table 1). The Y-graft group consisted of 51 men and 9 women, and involved 38 natural Y-grafts and 22 saphenous vein Y-grafts. The control group consisted of 52 men and 8 women. The age distribution was 41 to 81 years old (65.37 ± 7.82) in the Y-graft group and 40 to 79 years old (65.68 ± 7.61) in the control group, showing no significant differences. Both groups involved about 30% of patients aged above 70 years old.

Table 1. Clinical characteristic of patients.

Characteristics of patients	Y-graft group (n=60)	Control group (n=60)	P value
Female (n, %)	9 (15.00%)	8 (13.33%)	0.794
Age (years)	65.68±7.61	65.37±7.82	0.822
<70 (n, %)	42 (70.00%)	43 (71.67%)	0.500
≥70 (n, %)	18 (30.00%)	17 (28.33%)	
Weight (kg)	69.33±8.51	71.68±10.24	0.175
Height (cm)	167.45±6.46	167.48±6.78	0.978
BMI (kg/m ²)	24.73±2.78	25.50±2.87	0.141
NYHA class (n)			0.197
I	4	4	
II	44	37	
III	12	18	
IV	0	1	
LVEF (%)	61.05±6.90	63.17±5.33	0.063
CAD classification			0.844
Stable angina (n, %)	9 (15.00%)	12 (20.00%)	
Unstable angina (n, %)	45 (75.00%)	40 (66.67%)	
Myocardial infarction (n, %)	6 (10.00%)	8 (13.33%)	
Hypertension (n, %)	39 (65.00%)	40 (66.67%)	0.848
Hyperlipemia (n, %)	4 (6.67%)	2 (3.33%)	0.404
Diabetes mellitus (n, %)	22 (36.67%)	23 (38.33%)	0.851
Smoking (n, %)	21 (35.00%)	30 (50.00%)	0.098
Cerebrovascular disease (n, %)	8 (13.33%)	17 (28.33%)	0.044
EuroSCORE	1.05±0.84	0.94±0.69	0.378
SinoSCORE	1.83±0.99	1.68±0.97	0.429

NYHA – New York Heart Association; LVEF – left ventricular ejection factor; CAD – coronary artery disease; EGJ – esophageal gastric junction; EuroSCORE – European system for cardiac operative risk evaluation; SinoSCOR – Sino system for coronary operative risk evaluation.

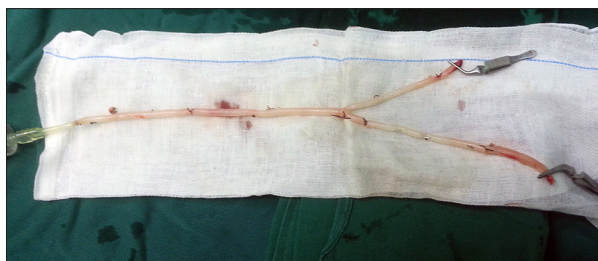


Figure 1. A saphenous vein was harvested with a branch used as natural saphenous vein Y-graft. Branches of saphenous vein were retained as Y-grafts.

No remarkable differences in co-morbidities were found between groups, including hypertension, hyperlipidemia, diabetes mellitus, and smoking as the main risk factors for heart diseases. The stages of cardiac impairment according to New York Heart Association (NYHA) classification were variable among patients from both groups.

The control patients were successfully paired to the Y-graft patients, with a similar revascularization strategy (Table 2). A total of 484 conduits were employed, with 252 from the Y-graft group (including 84 arterial conduits) and 232 from the control group (including 90 arterial conduits). No significant differences in intraoperative blood loss, blood transfusion, grafts to



Figure 2. Off-pump CABG with natural saphenous vein Y-graft to posterior descending and posterolateral arteries. The natural Y-graft configuration.

different coronary region, or proximal anastomoses were found between groups. The Y-graft group compared with the control group had significantly more grafts (4.2 ± 0.84 vs. 3.87 ± 0.85 , $P=0.033$) and anastomoses (6.30 ± 1.39 vs. 5.62 ± 1.15 , $P=0.004$). The Y-graft group received significantly more grafts to the LAD region than the control group. There was no death or myocardial ischemia event in either group. Analysis of postoperative outcomes suggested the operation time durations were not significantly different between groups (Table 3). No significant difference between groups was found in the mechanical ventilation time, length of stay in intensive care unit, drainage at

24 or 48 h, total drainage after operation, blood transfusion, or postoperative length of stay in hospital ($P>0.05$).

Follow-up

No patient was lost to follow-up. In the Y-graft group, the patients were followed up for 1.2 to 136.8 months. One patient died of esophageal carcinoma, 6 died of cardiovascular events, and the remaining 53 patients survived for 2.9 to 136.8 months (mean 41.5 months).

The patients in the control group were followed up for 1.1 to 96.6 months. Seven patients died of major cardiovascular events, and the remaining 53 patients survived for 13.1 to 96.6 months (mean=28.9 months).

Seven patients (3 from Y-graft group) underwent postoperative angiogram or coronary computed tomography angiography at 6 to 36 months (mean=19 months) because of their symptoms. No patient was identified as having Y-graft dysfunction. One patient from the control group underwent revascularization by percutaneous coronary intervention (PCI) due to progression of native coronary artery stenosis.

The functional statuses (NYHA classification) of all patients were generally satisfactory (Table 3). About 50%, 30%, and 10% of the patients were classified as 'unrestricted', 'mild limitation' and 'moderate limitation', respectively, but no 'severely disabled' was found in either group ($P>0.05$).

No significant difference between the Y-graft group and control group was found in the Kaplan-Meier curves 3-year survival

Table 2. Intraoperative outcomes.

Variables	Y-graft group (n=60)	Control group (n=60)	P value
Operation time (min)	271.85±60.43	267.75±84.32	0.760
Blood loss (ml)	547.00±280.34	518.50±279.88	0.578
Plasma transfusion (ml)	191.50±343.73	201.00±281.89	0.869
RBC transfusion (unit)	1.35±1.79	1.51±1.92	0.630
Number of grafts (n)	4.20±0.84	3.87±0.85	0.033
Anastomosis (n)	6.30±1.39	5.62±1.50	0.004
Grafts to LAD region (n)	1.83±0.56	1.58±0.59	0.019
Grafts to LCX region (n)	1.07±0.48	1.08±0.50	0.852
Grafts to Intermediate region (n)	0.12±0.32	0.05±0.22	0.190
Grafts to RCA region (n)	1.15±0.58	1.15±0.55	1.000
Number of proximal anastomoses (n)	1.73±0.52	1.77±0.46	0.711

RBC – red blood cell; LAD – left anterior descending; LCX – left circumflex; RCA – right coronary artery.

Table 3. Postoperative outcomes.

Variables	Y-graft group (n=60)	Control group (n=60)	P value
Intubation time (h)	21.40±25.07	20.85±34.43	0.920
24-h drainage after operation (ml)	429.50±235.04	442.58±215.24	0.751
48-h drainage after operation (ml)	341.83±149.95	339.87±157.07	0.944
Postoperative total drainage (ml)	1231.50±578.00	1374.03±845.39	0.283
24-h red blood cell transfusion after operation (unit)	0.87±1.21	0.74±1.11	0.544
24h plasma transfusion after operation (ml)	457.50±278.86	457.67±411.35	0.998
ICU LOS (h)	49.23±73.81	38.99±40.65	0.349
Postoperative hospital LOS (day)	12.80±4.37	14.65±8.30	0.129
Follow-up period	42.94±30.54	37.00±24.44	0.241
Daily activity			0.612
Unlimited (n,%)	31 (58.49%)	26 (49.06%)	
Mild limitation (n,%)	16 (30.19%)	19 (35.85%)	
Moderately disabled (n,%)	6 (11.32%)	8 (15.09%)	

ICU – intensive care unit; LOS – length of stay.

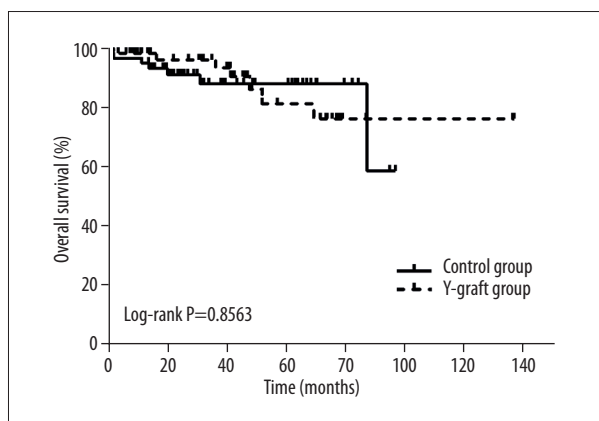


Figure 3. Kaplan-Meier survival curves of patients under off-pump CABG in 2 groups. Dotted line: Y-graft group; solid line: control group.

rate (93.4% vs. 88.0%, $P>0.05$) or 5-year survival rate (81.4% vs. 88.0%, $P>0.05$) (Figure 3).

Discussion

Few studies on the use of SV Y-graft in CABG operation have been published. In this study, we operated on patients with multiple CAD using LITA combined with SV Y-graft. Compared to the control group, the Y-graft group had more grafts and may have had more anterior wall blood supply improvement. No significant difference in short- or mid-term outcomes was found between groups.

Coronary artery narrowing or occlusion can result in tissue hypoxia by impairing the antegrade blood flow to the myocardium. The myocardium impairment can be salvaged by restoring the coronary artery blood flow. CABG has been recommended as more therapeutically effective than PCI and fibrinolysis for CAD patients with left main coronary artery stenosis and/or multi-vessel disease [12]. CABG is a clinically and economically attractive revascularization strategy for most multi-vessel disease patients [13]. Different graft conduits have been used in myocardium revascularization, particularly the long saphenous vein and LITA [14]. LITA has been defined as the optimal vessel graft in revascularization of the left anterior descending artery, and can improve the results of CABG in multi-vessel CAD patients [15]. The saphenous vein graft might be a better choice than radial artery [6], especially for elderly patients undergoing CABG. In this study, each patient had more than 3 grafts on average in both groups, which means that more grafts other than LITA were needed. All patients underwent complete revascularization by the same surgical team at the same period. Complete revascularization compared with incomplete or repeated revascularization can reduce the risk of death for multi-vessel CAD patients [16]. Complete revascularization via surgery is recommended for patients with reasonable life expectancy, whereas the incomplete one via PCI may cause higher mortality and potential harm to patients with complex multi-vessel CAD [17]. Undoubtedly, multi-vessel disease patients need more conduits during revascularization. Due to the lack of arterial grafts, right internal thoracic artery (RITA) has been applied to CABG patients since around 2000. Reportedly, RITA also has good effect on patients with

multiple coronary artery diseases [18–20], but RITA is not commonly used in our heart center due to traditional and technical reasons. We will gradually apply RITA to CABG patients in suitable occasions. The saphenous vein complements the insufficiency of arteries, especially in the elderly. In clinical practice, the patency rates of the saphenous vein were often underestimated to be 80% to 90% [21,22]. In this study, the mean age of each group was over 65 years and about 30% of patients were aged above 70 years, indicating the life expectancy and benefits from the durability of arterial conduits were reduced. Conversely, total arterial revascularization may significantly ameliorate the outcomes by increasing surgical trauma [23]. Recent studies suggested the radial artery graft did not improve, and sometimes even reduced, graft patency or outcomes compared with the saphenous vein graft [24,25]. We combined LIMA and saphenous vein grafts into complete revascularization in multi-vessel CAD patients during primary CABG. To reduce the inflammatory response during CABG [26], we used the off-pump technique, which is commonly used in China and may reduce postoperative complications such as stroke, wound infection, and pneumonia [27,28].

Long-term graft failure is greatly influenced by increased intimal hyperplasia and atherosclerotic lesion development [29]. Intimal hyperplasia development is the main factor influencing graft patency at the anastomosis between the coronary artery and the graft, and may lead to restenosis and graft failure [30]. The hypothesized mechanisms of intimal hyperplasia development mainly include the presence of hemodynamic disturbances and local stress concentrations in the anastomosis of graft wall [31,32].

Multi-vessel disease patients need more grafts and even raise the technical requirements for surgeons. Drug therapy after CABG improves the graft patency by inhibiting vascular remodeling [33]. Moreover, the end-to-side anastomosis is simpler than the side-to-side anastomosis for the lateral and posterior branches of the left ventricle. Stabilizers are often used to expose target arteries, but beating hearts are associated with cardiac arrhythmias and hemodynamic instability. The Y-graft is anastomosed to lateral branches of the circumflex artery and branches of the right coronary artery. All Y-grafts are single anastomosis per limb. The end-to-side anastomosis with

less turbulence of blood flow can improve the patency rate of the graft and shorten the operation time [34–36]. Thus, due to its convenience of use, the Y-graft is preferred by surgeons.

The composite saphenous vein Y-graft, which outperforms the solitary one, can be safely used for multi-vessel CAD patients, and the safety may be attributed to the distribution of inflow from the aorta into more than 1 outflow [37]. The natural Y-graft may be superior to the composite Y-graft in several other areas. First, the natural Y-graft reduces the vessel length, surgical trauma, and operation time; second, the high hemodynamic performances of natural Y-shaped bifurcations decrease wall shear stress and shear oscillation; and third, anastomotic bleeding is avoided due to lack of anastomosis.

No significant difference in outcomes was found between groups, probably due to the small sample size, low event rates, and short-term follow-up. The natural Y-shaped bifurcation was not used if the patient had no suitable saphenous vein. The experience of the surgeon was also crucial in using the Y-graft, and our surgeons were still at the primary stage of the learning curve, compared to the control group, in which a proven technique was used.

Conclusions

Complete coronary revascularization with saphenous vein Y-graft is a feasible and safe strategy for multi-vessel CAD patients, and can achieve satisfactory outcomes. Valuable lessons have been learned in Y-graft CABG, which can help shorten the learning curve for other surgeons embarking on use of this technique.

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Conflict of interest

None.

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