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Predictors of early graft patency following coronary artery bypass surgery

Hossein Ali Bassiri[1], Farzad Salari[1], Fereidoun Noohi[1], Marzieh Motevali[2], Seifollah Abdi[1], Nader Givtaj[3], Kamal Raissi[3], Majid Haghjoo[4]

[1]Department of Interventional Cardiology, Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, Iran
[2]Department of Radiology, Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, Iran
[3]Department of Cardiovascular Surgery, Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, Iran
[4]Department of Pacemaker and Electrophysiology, Rajaie Cardiovascular Medical and Research Center, Iran University of Medical Sciences, Tehran, Iran

Abstract

Background: *The long-term success of coronary artery bypass graft surgery (CABG) is dependent on graft patency after the operation. Early occlusion (within the first week) affects the long-term results. Therefore, we sought to determine pre-operative, intraoperative, and perioperative factors associated with early coronary graft patency.*

Methods: *Between March 2007 and March 2008, 107 consecutive patients (81 men, 26 women, mean age 60 ± 9 years) who underwent CABG were included in this study. The enrolled patients underwent 16-slice computed tomography angiography one week after CABG.*

Results: *Based on the multislice computed tomography, acute graft occlusion was detected in 32 (8.7% of all) grafts, including 26 of 250 (10%) in venous grafts and 6 of 116 (5%) in arterial grafts. In univariate analysis, patients with patent coronary grafts had a lower serum glucose level (119 ± 30* vs. *141 ± 65 mg/dL, p = 0.02) and longer partial thromboplastin time (34 ± 11* vs. *30 ± 2 s, p = = 0.04). In addition, pump time was significantly longer in patients with occluded grafts than in those with patent grafts (119 ± 43* vs. *102 ± 32 min, p = 0.04). Those with longer pump time required more coronary grafts (pump time ≥ 120 min for 3.5 grafts* vs. *pump time < 120 min for 2.9 grafts, p = 0.02). Of the multiple pre-operative, intraoperative, and perioperative characteristics of the patients who underwent successful CABG, serum glucose level (OR: 2.014, 95% CI: 1.002–3.026, p = 0.002) and pump time < two hours (OR: 1.502, 95% CI: 1.001–2.030, p = 0.003) were the only predictors of coronary graft patency seven days after surgery in multivariate analysis.*

Conclusions: *Our study demonstrated that the patients with successful CABG and patent coronary grafts within the first week after surgery had optimal blood glucose control and pump time < two hours.* (Cardiol J 2010; 17, 4: 344–348)

Key words: coronary artery bypass grafting, early patency, predictor

Address for correspondence: Majid Haghjoo, MD, FESC, Department of Pacemaker and Electrophysiology, Rajaie Cardiovascular Medical and Research Center, Mellat Park, PO Bax: 15745-1341, Vali-e-Asr Street, Tehran, Iran, tel: 0098 21 2392 2163, fax: 0098 21 2204 8174, e-mail: majid.haghjoo@gmail.com

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Introduction

Coronary artery bypass graft (CABG) surgery is the standard of care in the treatment of advanced coronary artery disease. CABG provides excellent short- and intermediate-term results in the management of stable coronary artery disease; its long-term results are affected by failure of venous graft [1]. Early occlusion (before hospital discharge) affects the long-term results. Early occlusion has been found to occur in 7 to 10% of coronary grafts [1]. Previous studies have mainly evaluated the predictors of late graft patency [2, 3].

The aim of this study was to evaluate pre-operative, intraoperative, and perioperative factors associated with early graft patency in patients who underwent successful CABG.

Methods

Between March 2007 and March 2008, 107 consecutive patients (81 men, 26 women, mean age 60 ± 9 years) who underwent CABG were included in this study. The enrolled patients underwent 16-slice computed tomography (CT) angiography one week after CABG.

The study protocol was approved by the institution's ethics committee and written informed consent was obtained from all patients.

Exclusion criteria were: serum creatinine >1.5 mg/dL, allergy to contrast material, hyperthyroidism, and inability to give informed consent. A total of 366 grafts (250 venous grafts and 116 arterial grafts) were evaluated, all of which could be assessed for patency and occlusion using 16-slice CT. Six patients (5.6%) had two grafts, 54 (50.5%) had three grafts, 43 (40.2%) had four grafts, and four (3.7%) had five grafts. Based on the multislice copmputed tomography (MSCT), acute graft occlusion was detected in 32 (8.7% of all) grafts, including 26 of 250 (10%) in venous grafts and six of 116 (5%) in arterial grafts. All patients received aspirin, 325 mg daily, immediately after CABG.

Multidetector computed tomography angiography protocol

Patients were scanned using a 16-section multidetector CT scanner (SOMATOM Sensation 16, Siemens, Forchheim, Germany). Patients were positioned in the gantry supine and feet first, with electrocardiographic leads placed on the anterior thorax to enable a retrospectively gated scan. Scan parameters were 140 kV, 0.4-second rotation speed, 400 mA, and 10 × 0.75 detectors. Pitch, which was dependent on the heart rate, averaged 0.3. The CT system automatically recommended a pitch value to optimize the temporal resolution by the number of sectors reconstructed from each scan. Scans were performed in the caudal to cephalic direction, with a scan range from the thoracic inlet through the lung bases. The proximal subclavian arteries were also included. To familiarize the patient with the protocol, the exam, including breath-holding, was practiced in advance. Beta-blockers (propranolol or esmolol) were injected intravenously for heart rates exceeding 70 beats per minute, unless underlying contraindications such as asthma were present. A nonionic, iodinated, low-osmolar contrast medium was injected intravenously in doses ranging from 120 to 150 mL, without direct variation with respect to patient weight. In addition, 20 mL saline flush (saline chaser) was used to optimize the graft visualization.

Data analysis

Variables are expressed as mean ± standard deviation for the continuous variables and as absolute or relative frequencies for categorical variables. Chi-square test was used for categorical data and Fisher exact test for cell count less than five. Patient characteristics were compared by means of Student's *t*-test in case of continuous variables. Otherwise, a non-parametric test of Mann-Whitney U test was used. A stepwise logistic regression analysis was used to determine the independent predictive factors for early graft patency. The variables exhibiting differences between groups with a p value < 0.10 in the univariate analysis were included in the multivariate analysis. A two-tailed $p < 0.05$ was considered statistically significant. The software SPSS version 15.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis.

Results

The study population consisted of 107 consecutive patients with CABG who completed the MSCT protocol. Among the arterial grafts, 107 (96.4%) of 111 grafts to the left anterior descending artery (LAD) were classified as patent, whereas one (33%) of the three grafts in the left circumflex (LCX) region and one (50%) of the two grafts in the right coronary artery (RCA) territory were found to be occluded. In the venous category, eight (13.8%) of the 58 grafts to LAD were found to be occluded. In the LCX region, nine (8.5%) of the 106 grafts were classified as occluded, while the remaining 97 (91.5%) grafts were patent. The venous

Table 1. Comparison of baseline demographic and clinical characteristics in patients with patent and occluded coronary grafts.

Variable	Graft patent (n = 80)	Graft occluded (n = 27)	P
Age (years)	59 ± 9.6	60 ± 8.3	0.63
Male	61 (76)	20 (74)	0.80
Number of native vessels involved	2.8 ± 0.37	2.9 ± 0.19	0.20
Total graft number	3.4 ± 0.65	3.4 ± 0.69	0.83
Diabetes	25 (31)	11 (41)	0.37
Insulin treatment in diabetes patients	8/25 (32)	0/11 (0)	0.03
Dyslipidemia	30 (37.5)	12 (44.4)	0.52
Smoking	25 (31)	5 (18.5)	0.20
Hypertension	33 (41)	10 (37)	0.70
Pre-operative LVEF	44 ± 8.5	46 ± 6.3	0.17
Nitrate	77 (96)	27 (100)	0.57
Calcium blocker	3 (3.8)	0 (0)	0.57
Beta-blocker	80 (100)	27 (100)	1.0

Values are n (%) or mean ± standard deviation; LVEF — left ventricular ejection fraction

Table 2. Comparison of baseline laboratory data in patients with patent and occluded coronary grafts.

Variable	Graft patent (n = 80)	Graft occluded (n = 27)	P
Fasting blood sugar [mg/dL]	119 ± 30	141 ± 65	0.02
Serum blood urea nitrogen [mg/dL]	20.7 ± 6.3	20.7 ± 4.8	0.99
Serum triglyceride [mg/dL]	165 ± 80	169 ± 81	0.79
Serum cholesterol [mg/dL]	184 ± 53	178 ± 43	0.60
Serum LDL-C [mg/dL]	110 ± 44	116 ± 40	0.52
Serum HDL-C [mg/dL]	33 ± 8	33 ± 7	0.95
Hemoglobin [g/dL]	11.4 ± 1.6	11.6 ± 1.5	0.07
White blood cell count ($\times 10^3/\mu L$)	9.125 ± 3.804	8.529 ± 4.020	0.82
Platelet count ($\times 10^3/\mu L$)	182.112 ± 38.452	179.444 ± 28.479	0.74
Partial thromboplastin time [s]	34 ± 11	30 ± 2	0.04
Prothrombin time [s]	12.8 ± 1.5	12.7 ± 1.0	0.64

LDL-C — low-density lipoprotein cholesterol; HDL-C — high-density lipoprotein cholesterol

grafts to RCA were occluded in nine (10.5%) of the 86 grafts.

Pre-operative predictors of early graft patency

The baseline clinical and demographic characteristics were similar between the patients with patent and occluded coronary grafts (Table 1). In addition, early patency of coronary grafts was comparable irrespective of anti-ischemic therapy, pre-operative left ventricular function, and coronary artery anatomy (number of native vessels involved). Two groups also showed no significant differences in the biochemical and hematological profiles (Table 2). The only differences observed were related to the baseline fasting blood sugar (FBS) and partial thromboplastin time (PTT). The patients with patent coronary grafts had lower serum FBS level (119 ± 30 *vs*. 141 ± 65 mg/dL, p = 0.02) and longer PTT (34 ± 11 *vs*. 30 ± 2 s, p = 0.04).

Intraoperative and perioperative predictors of early graft patency

There were no differences in patency rate of coronary grafts in terms of surgical technique (on-pump *vs*. off-pump), saphenous vein graft (SVG) location (bypass to LAD, RCA, or LCX), urgency of surgery, need for packed cell transfusion, post-

Table 3. Comparison of intraoperative and perioperative characteristics of patients with patent and occluded grafts.

Variable	Graft patent (n = 80)	Graft occluded (n = 27)	P
On-pump *vs*. off-pump CABG	76 (95)/4 (5)	24 (89)/3 (11)	0.27
Graft location			
SVG to LAD	45 (56)	13 (48)	0.51
SVG to LCX	80 (100)	26 (96)	0.86
SVG to RCA	62 (77.5)	24 (88.9)	0.20
Pump time [min]	102 ± 32	119 ± 43	0.04
Post-operative LVEF	43 ± 8	41 ± 9	0.27
Packed cell transfusion	56 (70)	19 (69.4)	0.98
Postoperative cardiac arrest	2 (2.5)	1 (3.7)	0.74

Values are n (%) or mean ± standard deviation; LVEF — left ventricular ejection fraction; CABG — coronary artery bypass graft; SVG — saphenous vein graft; LAD — left anterior descending artery; LCX — left circumflex artery; RCA — right coronary artery

-operative bleeding, and post-operative cardiac arrest (Table 3). However, pump time was significantly longer in patients with occluded grafts than those with patent grafts (119 ± 43 *vs*. 102 ± 32 min, p = 0.04). The patients with longer pump time required more coronary grafts (pump time ≥ 120 min for 3.5 grafts *vs*. pump time < 120 min for 2.9 grafts, p = 0.02).

Multivariate analysis

Of the multiple pre-operative, intraoperative, and perioperative characteristics of the patients who underwent successful CABG, serum FBS level (OR: 2.014, 95% CI: 1.002–3.026, p = 0.002) and pump time two hours (OR: 1.502, 95% CI: 1.001––2.030, p = 0.003) were the only predictors of early graft patency after CABG.

Discussion

This study shows that pre-operative serum FBS and pump time are the two independent predictors of early coronary graft patency after CABG. This study also confirmed an early patency rate of more than 90% after CABG [4].

Diabetes has been reported to have an adverse effect on surgical outcomes [5–9]. Interestingly, the presence of diabetes mellitus itself did not predict early graft patency in our study. However, pre-operative serum FBS level was an important predictor of early graft patency. Similarly, Godman et al. [2] failed to find a relation between diabetes and graft patency. This issue is also addressed in another study on 517 patients with multi-vessel disease who underwent total arterial off-pump CABG [10]. In the latter study, early post-operative and one-year angiographies demonstrated similar patency rates in the diabetic and non-diabetic patients. The association of hyperglycemia with early graft occlusion may be related to a hypercoagulable state in poorly controlled patients with diabetes mellitus. Boden et al. [11] demonstrated that acute normalization of hyperglycemia with insulin resulted in significant reduction of the tissue factor procoagulant activity. Therefore, optimal FBS control, preferably with insulin, may significantly reduce the incidence of coronary graft occlusion within the first week of CABG.

Early occlusions of coronary bypass grafts usually occur in the first hours and days after surgery and are thrombotic in origin. Therefore, it is expected to see a beneficial effect by antiplatelet and anticoagulant agents on early graft patency. The beneficial effect of aspirin on SVG patency has been demonstrated in several studies [12–14]. In the present study, aspirin was administered to all patients, precluding any comparison between treated and untreated patients. Data on the use of oral anticoagulants in the prevention of SVG occlusion is less clear than the data regarding aspirin [15––17]. In our study, prolonged PTT was protective against the acute graft occlusion in univariate analysis. However, this difference disappeared in multivariate analysis, again demonstrating the controversial effect of anticoagulant agents on early graft patency.

The serum cholesterol and triglyceride levels were not predictors of early graft patency in our study population. Considering the pathophysiological mechanism of early graft occlusion, we would not expect to see a positive effect from an aggressive lipid lowering strategy in reducing the incidence of early graft occlusion. However, an aggressive lipid lowering therapy has been associated with improved late graft patency [2].

Our data also demonstrated that operative factors, such as pump time, affect early graft patency. This may be explained by the severity of coronary artery disease, number of grafted vessels, and graft location. The number of the involved vessels and the SVG location were similar in patients with patent grafts and those with occluded grafts. The small number of arterial grafts in the LCX and the RCA territories does not permit such a comparison. Despite the similar mean graft number, patients with pump time ≥ two hours required more coronary grafts than those who had shorter pump time. A similar association has been demonstrated between pump time and late graft patency [3]. However, other operative factors, such as on-pump *vs* off-pump surgery, elective *vs*. emergent surgery, the need for packed cell transfusion, post-operative bleeding, and post-operative cardiac arrest had no effect on early graft patency.

Conclusions

The present study demonstrated that patients with successful CABG and patent coronary grafts within the first week after surgery are those who had optimal FBS level and a pump time of less than two hours.

Acknowledgements

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