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In-Hospital Outcome of Patients Undergoing off-Pump Coronary Artery Bypass Graft With and Without Coronary Endarterectomy

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Abstract

Background: Coronary endarterectomy (CE) can be used in patients with diffused coronary artery disease (CAD) as an adjunct technique to coronary artery bypass grafting (CABG) for complete revascularization. Because the impact of CE has been debated, hospital outcomes are of concern.

Objectives: The aim of the current study is to compare hospital outcomes of patients undergoing off-pump CABG with and without CE.

Methods: We performed a retrospective analysis of data on patients undergoing CABG and CE between 2011 and 2012 by a single surgeon using off-pump technique. Patients were divided into CABG and CABG + CE groups. Preoperative, perioperative, and postoperative data were collected from the data bank.

Results: CABG was performed in 478 patients, of whom 69 had a CE. Hospital mortality was 0.7% in CABG and 0% in CABG + CE group ($P > 0.05$). The duration of stay in the intensive care unit (ICU) was 37.23 ± 0.88 hours in the CABG group and 51.31 ± 5.59 hours in the CABG + CE group ($P = 0.015$). Logistic regression confirms that CE is one of the factors affecting longer ICU stay. Blood transfusion was 324.71 ± 22 milliliters in the CABG group and 650.62 ± 110 milliliters in the CABG + CE group ($P = 0.001$). There were no significant differences between myocardial infarction (MI) rate, arrhythmia, intra-aortic balloon pump insertion, or low cardiac output between the two groups.

Conclusions: The current study demonstrates that the results of CE are acceptable with respect to hospital outcome. CE as an adjunct to CABG offers a valuable surgical option for patients in whom complete revascularization cannot be obtained. With careful selection of patients, a well-judged and well-executed surgical technique, and good postoperative care, excellent results can be obtained.

Keywords: In-Hospital Outcome, Coronary Endarterectomy, Off-Pump Coronary Artery Bypass Graft

1. Background

Coronary artery disease (CAD) is a major cause of cardiovascular mortality globally, as well as in Iran (1). With advances in nonsurgical methods, patients with complex CAD are candidates for coronary artery bypass grafting (CABG) (2). Coronary endarterectomy (CE) as an adjunct technique to CABG can be used in patients with diffused CAD to attain complete revascularization (3, 4).

CE was introduced over 40 years ago to improve blood flow into the coronary arteries in patients with severe CAD (5). At first, the method was used to create a suitable location for distal anastomosis as an adjunct to CABG in patients with coronary artery atherosclerosis (6).

Today, many surgeons are still reluctant to use CE due to increased postoperative mortality and myocardial infarction (MI) rate compared with CABG alone (3). On the other hand, researchers have recently reported good perioperative outcomes, with varying results depending on the coronary vessel requiring endarterectomy (4).

Multi-vessel CE has been described, but the results are not desirable compared with single-vessel left anterior descending (LAD) CE (7). Although CE has become a safe method in recent years, adding a second CE dramatically worsens prognosis (3). With further refinement in methods over the past three decades, it has been found that patients treated with CABG and CE obtain more favorable results than patients treated with CABG alone (8-10). Although some studies, mainly since 1990, have reported increased mortality and in-hospital complications after CE (11-13), other research has reported acceptable perioperative results for CE (14, 15). Sirivella et al. (16) studied short-term and long-term outcomes in patients treated with CABG with or without CE. Their results showed that the short-term (30-day) mortality rate did not differ between groups in a statistically significant manner, although stay in the intensive care unit (ICU) of the hospital in CE patients was significantly longer. Tiruvoipati et al. reported a higher mortality rate and more postoperative compli-

cations in patients undergoing CE (13). However, most researchers have concluded that CE is a suitable method of treatment in patients with severe CAD who cannot undergo complete revascularization (11-17).

2. Objectives

Because there is some controversy about whether performing CE is optimal (18, 19), and also because CE tends to have a high rate of postoperative complications (19), hospital outcomes are of concern. Therefore we performed this study with the goal of comparing hospital mortality, complication rate, medical treatment and changes in blood biomarkers in patients undergoing off-pump CABG with and without CE.

3. Methods

This is a retrospective cross-sectional study. Data were collected from medical records from the Imam Ali hospital of Kermanshah University of Medical Science data bank. This study was approved by the ethics committee of the Kermanshah University of Medical Sciences. All of the patients operated on by a single surgeon between 2011 and 2012 were enrolled in this study. Any patients who had other procedures in addition to CABG, such as valve repair or replacement and left ventricular aneurysm resection, were excluded. The resulting study population comprised 478 patients who had CABG surgery. Of these 478 patients, 69 of them had CE in addition to CABG. The patients were divided into two groups: a CABG group and a CABG + CE group.

3.1. Data Collection

A standardized form for data collection included preoperative variables such as age, gender, body mass index (BMI), diabetes mellitus, hypertension, hypercholesterolemia, smoking history, family history of CAD, peripheral vascular disease, renal failure, pulmonary failure, hepatic failure, congestive heart failure, left ventricular EF, previous myocardial infarction, history of arrhythmia, prior percutaneous coronary intervention (PCI), angina, previous CABG, previous cardiopulmonary resuscitation (CPR), and left main coronary artery disease. Operative data consisted of number of grafts and vessel diseases. Postoperative variables were MI, arrhythmia, plural effusion, renal failure, respiratory complications, low cardiac output, dehiscence, reintubation, bleeding, arrest, tamponade, blood transfusion in the intensive care unit (ICU), total length of ICU stay, and hospital mortality.

Bleeding was considered when patients needed reoperation. Hospital mortality was defined as death occurring before discharge from the hospital.

3.2. Surgical Procedure

Although a preoperative prediction of whether CE should be performed can be obtained from the coronary angiogram, the final decision is made intraoperatively on the basis of technical considerations. We did not consider complete occlusion on the angiogram as a definite indication for CE. CE was considered when the vessel supplying a viable myocardium was not suitable for grafting and when multiple, discrete obstructing lesions or diffuse atherosclerosis that significantly compromised the internal lumen were exhibited. Surgery has improved through off-pump CABG and carried out according to internationally established techniques, using the Medtronic Octopus stabilizing device for coronary stabilization and deep pericardial traction sutures for cardiac displacement and presentation. Conventional immobilization techniques such as deep pericardial sutures, esmolol, and Octopus T-300 were used to provide better access to lateral and posterior target vessels. Heparin 100 mg/kg was administered to keep the activated clotting time (ACT) between 200 - 400 seconds. Before anastomosis, the target coronary artery was temporarily occluded proximally and distally by fine bulldog clamps or looped 5/0 Vilene suture. Phenylephedrin was administered intravenously to keep blood pressure between 70 - 90 mmHg. Left internal mammary artery and saphenous vein conduits were used whenever possible. After operation the patients were transferred to the ICU, and all patients received appropriate medical treatments and were checked for blood biomarkers.

3.3. Statistical Analysis

Numerical variables are presented as mean $\pm$ SD. Discrete variables were summarized by percentages. Student's t-test was used to evaluate the significant differences in normal distribution between the two groups, and the Mann-Whitney U test was used to analyze the statistical differences between the groups since these were not normally distributed. For checking whether there was a normal distribution, the Kolmogorov-Smirnov test was used. The categorical variants were evaluated using Pearson's chi-square or Fisher's absolute value chi-square test, and the results were considered to be statistically significant with a $P < 0.05$. To identify the impact of variables on length of ICU stay, variables were further analyzed by multiple logistic regression. For this purpose, patients were divided into two groups, ≤ 48 and > 48 stay in the ICU. A stepwise backward selection method was used to select the

univariate variables with a significance level of 0.2 for entry, and a significance level of 0.05 for staying in the model. The results are expressed as odds ratios (OR) with associated 95% confidence intervals. All data were analyzed using the SPSS statistical package (IBM SPSS Statistics, version 20).

4. Results

4.1. Preoperative Data

Between March 2011 and February 2012, 478 patients underwent CABG in our hospital. Of these patients, 69 (14.4%) required CE in addition to CABG. The preoperative demographic and clinical characteristics of these two groups of patients are shown in Table 1. All of the variables were similar in both groups except female gender, renal failure, previous CABG, and arrhythmia, which were higher in the CABG + CE group, and history of smoking, which was higher in the CABG group.

4.2. Operative Data

Operative data are summarized in Table 2. The most common artery to undergo CE was the right coronary artery (RCA). Forty-four patients (63.8%) underwent RCA endarterectomy, 9 patients (13%) underwent left anterior descending artery (LAD) endarterectomy, 4 patients (5.8%) underwent posterior left ventricular (PLV) endarterectomy, 11 patients (15.9%) underwent posterior descending artery (PDA) endarterectomy, 2 patients (2.9%) underwent diagonal branch endarterectomy, 14 patients (20.3%) underwent obtuse marginal 1 (OM1) endarterectomy, and 1 (2.2%) patient underwent right ventricular (R.V.) branch endarterectomy.

4.3. Hospital Outcomes

In-hospital mortality was 0.7% (3 patients) for the CABG, compared with 0% for the CABG + CE group ($P > 0.05$). Of the patients who died in the CABG group, 2 of them were female and 1 was male. They had 3 vessel occlusions, including LAD, RCA, and OM1. It is interesting to note that in this analysis, CE was not associated with increased mortality and there was not any significant difference between these two groups.

As illustrated in Table 3, postoperative MI, arrhythmia, atrial fibrillation, ventricular fibrillation, pleural effusion, renal failure, gastrointestinal system complications, respiratory complications, intra-aortic balloon pump insertion, reintubation, low cardiac output, bleeding leading to reoperation, arrest, tamponed, ICU stay and hospital mortality were similar in both groups. The difference between groups was not significant before surgery for CPK ($P = 0.472$), CPK-MB ($P = 0.616$), Ca ($P = 0.459$), troponin ($P = 0.910$), and creatinine ($P = 0.304$), or after surgery for CPK ($P = 0.196$), CPK-MB ($P = 0.993$), Ca ($P = 0.554$), troponin ($P = 0.995$), and creatinine ($P = 0.930$).

Table 4 shows medical treatment before and after operation on the patients in this study. Compared with the CABG group, the use of calcium channel blockers was significantly ($P = 0.020$) higher before operation in the CABG + CE group. Nitrate consumption was significantly ($P < 0.001$) higher in the CABG group. There was no significant difference in the use of aspirin, antiplatelet medication, beta-blockers, statins, or non-statin cholesterol lowering medication between the groups. During the ICU stay, the use of inotropes and antiplatelet medication was higher in the CABG + CE group, but there was no significant difference in the use of aspirin and beta-blockers between the groups.

Table 5 shows factors predictive of a longer ICU stay according to a binary logistic regression model. The analysis showed that the following variables were likely to increase length of stay in the ICU: left main coronary artery disease, LAD surgery, CE surgery, respiratory complication, and amount of blood transfusion.

5. Discussion

The results of the current study suggest that performing CABG in addition to CE yields acceptable results compared with performing CABG alone. With improvement in therapy, most patients referred for surgery have diffused or multiple CAD (20). CE as an adjunct technique can be used to achieve complete revascularization. However, due to high morbidity and mortality, this procedure has a low frequency of use. The current study found that good clinical outcomes can be obtained with CE. Multiple factors affect improvement in clinical outcomes, like accurate patient selection, good anesthetic and operative technique, and appropriate postoperative management.

One of the most important variables for evaluating hospital outcomes is mortality. The current study found no significant difference in the hospital mortality rate between the CABG + CE and CABG groups. This rate of mortality is acceptable compared to other studies, in which mortality rates ranged from 2.0% - 6.5% (10, 13, 15, 21, 22). In our study, we found that the significant risk factors for hospital mortality were old age at the time of operation, female gender, and three vessel diseases following revascularization by CABG. Multiple factors have been reported to predict hospital mortality, such as postoperative MI, age, and female gender (10, 17). Some other studies have found similar results. Shapira et al. (22) showed that there was not any significant difference in hospital mortality between CE and

Table 1. Preoperative Patients' Characteristics

Variable	CABG + CE (n = 69)	CABG (n = 409)	P Value
Age, y	59.13 ± 1.26	58.43 ± 0.47	0.574
Gender			0.011
Male	42 (60.9)	311 (76.2)	
Female	27 (39.1)	97 (23.8)	
Cardiac risk factors			
BMI	27.64 ± 0.69	26.96 ± 0.21	0.306
Diabetes mellitus	22 (31.9)	105(25.7)	0.304
Hypertension	38 (55.1)	179 (43.9)	0.090
Hypercholesterolemia	27 (39.7)	130 (31.8)	0.211
Smoking history	21 (30.9)	180 (44)	0.047
Family history of CAD	15 (21.7)	120 (29.3)	0.247
Noncardiac morbidities			
Peripheral vascular disease	0	3 (0.7)	1
Renal failure	4 (5.8)	4 (1)	0.018
Pulmonary failure	1 (1.4)	10 (2.4)	1
Hepatic failure	0	1 (0.2)	1
Cardiac profile			
Congestive heart failure	3 (4.3)	40 (9.8)	0.176
Left ventricular EF	44.31 ± 1.3	44.41 ± 0.56	0.944
Previous myocardial infarction	7 (10.1)	40 (9.8)	1
History of arrhythmia	3 (4.3)	3 (0.7)	0.042
Prior PCI	2 (2.9)	9 (2.2)	0.665
Angina	14 (20.3)	116 (28.4)	0.189
Previous CABG	2 (2.9)	0	0.021
Previous CPR	0	2 (0.05)	1
Left main coronary disease	10 (14.5)	85 (20.9)	0.256
Laboratory investigations:			
Peak creatinine, mg/dL	2.51 ± 1.30	1.16 ± 0.017	0.304
Peak CPK, IU/mL	146.39±24.7	128.37 ± 8.7	0.472
Peak CPK-mb	28.11 ± 9.3	24.29 ± 2.7	0.616
Peak Ca, mg/dL	9.39±0.16	9.97±0.31	0.459
Peak troponin, ng/dL	1.53±1.04	1.98±0.96	0.910

Abbreviations: BMI, body mass index; EF, ejection fraction; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft; CPR, cardiopulmonary resuscitation; CPK, creatine phosphokinase; CPK-mb, Creatine phosphokinase-mb; Ca, Calcium.

non-CE patients. Tiruvoipati et al. (13) reported that postoperative mortality and complications were higher in the CE group. However, these differing reported outcomes might be due to associated comorbidities rather than CE.

In our study, CE was performed on 14.4% of the patients in one year. In most studies, this percentage has been less than or equal to 10% (4, 6, 15, 22, 23). In this study, all of the operations in the both groups were performed off-pump. It has been reported that the off-pump technique yields good postoperative outcomes in endarterectomized patients (24, 25). However, the off-pump technique is mostly used in cases with few numbers of grafts (4, 24-27). Other studies have been reported that off-pump CABG for multivessel myocardial revascularization reduces perioperative morbidity (28, 29). In our study, patients with 3 or 4 diseased vessels were operated on with acceptable outcomes. These results may be due to use of arterial graft for endarterectomized vessels. In this study we used LIMA in the graft on the LAD. In several studies, good patency for LIMA-LAD grafting has been reported (16, 17, 30).

In our study there was a longer ICU stay in the CABG + CE group. To determine factors affecting longer ICU stay, we divided patients into two groups, $\leq$ 48 hours and > 48 hours, and used a binary logistical regression (31). As illustrated in Table 5, left main coronary disease, LAD surgery, CE surgery, respiratory complications, and amount of blood transfusion were factors leading to stay in ICU > 48 hours.

Table 2. Operative Data

Variable	CABG + CE (n = 69)	CABG (n = 409)	P Value
Number of grafts	3 ± 0.072	2.69 ± 0.034	0.001
Number of vessels diseased			0.005
I	1 (1.4)	29 (7.1)	
II	9 (13)	93 (22.8)	
III	48 (69.6)	260 (63.7)	
IV	11 (15.9)	26 (6.4)	
Vessels			
LAD	66 (95.7)	403 (99)	0.066
RCA	55 (79.7)	283 (69.5)	0.087
PDA	12 (17.4)	27 (6.6)	0.007
PLV	7 (10.1)	4 (1)	0
Diagonal	2 (2.9)	48 (11.8)	0.031
OM1	53 (76.8)	295 (72.5)	0.557
OM2	7 (10.1)	24 (5.9)	0.189
OM3	1 (1.5)	1 (0.2)	0.266
R.V Branch	0	5 (1.2)	1

Abbreviations: RCA, right coronary artery; LAD, left anterior descending artery; PLV, posterior left ventricular; PDA, posterior descending artery; OM, obtuse marginal; RV branch, right ventricular branch.

Table 3. Postoperative Outcomes

Variable	CABG + CE (n = 69)	CABG (n = 409)	P Value
MI	0	17 (4.2)	0.148
Arrhythmia	6 (20.7)	23 (79.3)	0.278
Atrial fibrillation	1 (1.5)	10 (2.5)	1
Ventricular fibrillation	0	2 (0.05)	1
Pleural effusion	0	1 (0.2)	1
Renal failure	2 (2.9)	7 (1.7)	0.623
Gastrointestinal system complications	2 (2.9)	2 (0.5)	1
Respiratory complications	2 (2.9)	5 (1.2)	0.265
Intra-aortic balloon pump insertion	1 (1.5)	1 (0.2)	0.267
Low cardiac out put	7 (10.3)	21 (5.2)	0.101
Dehiscence	2 (2.9)	0	0.02
Reintubation	1 (1.5)	3 (0.7)	0.458
Bleeding leading to reoperation	3 (4.5)	30 (7.4)	0.603
Arrest	1 (1.5)	3 (0.7)	0.463
Tamponade	0	1 (0.2)	1
Total blood transfusions (packed red cells)	640.76 ± 109	325.99 ± 22	0.006
ICU stay (days)	51.26 ± 5.51	37.31 ± 0.88	0.015
Hospital mortality	0	3 (0.7)	1
Laboratory investigations:			
Peak creatinine, mg/dL	1.31 ± 0.74	1.28 ± 0.93	0.930
Peak CPK, IU/mL	311.8 ± 113.8	497.2 ± 46.1	0.196
Peak CPK-mb	36.1 ± 3.1	36.2 ± 1.32	0.993
Peak Ca, mg/d	9.33 ± 0.15	9.62 ± 0.19	0.554
Peak Troponin, ng/dL	1.82 ± 0.44	1.82 ± 0.55	0.995

Abbreviations: MI, myocardial infarction; ICU, intensive care unit; CPK, creatine phosphokinase; CPK-mb, creatine phosphokinase-mb; Ca, Calcium.

Table 4. Medical Treatment Before and After Operation

Variable	CABG + CE (n = 69)	CABG (n = 409)	P Value
Medical therapy before operation			
Aspirin	65 (94.2)	360 (88.9)	0.282
Antiplatelet			
No	58 (84.1)	348 (85.3)	0.244
Ticlopidine	2 (2.9)	2 (0.5)	
Clopidogrel	5 (7.2)	31 (7.6)	
Others	4 (5.8)	27 (6.6)	
Beta-blockers	52 (75.4)	307 (75.6)	1
Calcium channel blocker	16 (23.5)	49 (12)	0.020
Statins	66 (14.3)	396 (85.7)	0.465
Non-statin cholesterol-lowering (Ezetimibe)	1 (1.4)	2 (0.5)	0.375
Nitrates	59 (85.5)	393 (96.6)	0.001
Medical therapy after operation			
Use of inotropes			
No	58 (85.3)	365 (89.7)	0.030
Adrenalin	7 (10.3)	40 (9.8)	
obutamine	1 (1.5)	1 (0.2)	
Epinephrine	2 (2.9)	1 (0.2)	
Aspirin, No. (%)	63 (92.6)	396 (97.5)	0.05
Antiplatelet			
No	58 (85.3)	395 (97.3)	00.01
Ticlopidine	3 (4.4)	5 (1.2)	
Clopidogrel	2 (2.9)	3 (0.7)	
Others	5 (7.4)	3 (0.7)	
Beta-blockers	39 (57.4)	237 (58.4)	0.895

Table 5. Predictors of Adverse Outcomes in ICU Stay (Multivariate Analysis)

Variable and Risk	OR	95% CI	P Value
LAD surgery	16.85	3.309 - 85.82	0.001
Left main coronary disease	0.397	0.180 - 0.876	0.022
Respiratory complications	0.115	0.019 - 0.685	0.017
Coronary endarterectomy surgery	0.404	0.172 - 0.951	0.038
Total blood transfused (packed red cells)	1.001	1.001 - 1.002	0.001

Abbreviations: ICU, intensive care unit; LAD, left anterior descending artery; OR, odds ratio; CI, confidence interval.

In our study, the rate of postoperative MI was not significant in either group. Vohra et al. (25) reported a postoperative MI rate of 4.3%. Nurozler et al. (32) reported a perioperative MI rate of 6.2%. In both of these studies, off-pump technique was used for CE and the majority had single vessel CE to RCA. In our study, the majority of patients had RCA (63.2%), followed by OM1 (20.6%) and LAD (13.2%) endarterectomy. As illustrated in Table 3, there was no significant difference between cardiac enzyme levels in the two groups in our study. Newall et al. (33) reported that release of cardiac enzymes following CABG was related to one-year all-cause mortality. Domanski et al. (34) reported that increase of CK-MB or troponin levels have an independent relationship with increasing risk of mortality. In our study there was no significant difference between the groups in changes of cardiac enzyme levels and mortality.

One common postoperative complication is thrombosis. To prevent this, patients should be given antiplatelet and anticoagulant regimens. In our study, as illustrated in Table 4, the amount of antiplatelet medication administered was higher in the CABG + CE group. Another study (19) reported that CE vessels are prone to thrombosis in

the first postoperative week. The best way to avoid this is drug therapy. Livesay et al. (18) and Chesebro et al. (35) recommended postoperative use of acetylsalicylic acid and dipyridamol, whereas Ferraris et al. (23) recommended use of warfarin for 3 months after surgery. Gill et al. (36) recommended intravenous heparin infusion for the first 48 hours postoperatively, followed by use of thienopyridine derivatives (ticlopidine and clopidogrel). At our facility, we prefer to administer clopidogrel and ticlopidine followed by acetylsalicylic acid on the first postoperative day. It has been reported that in order for antiplatelet therapy to be effective, it should be started within a few hours after surgery (18, 21).

In our study, use of inotropic drugs was more frequent in the CABG + CE group (P = 0.030), but the need for a postoperative balloon pump was similar in both groups.

Postoperative MI and mortality did not differ between the groups. Moreover, blood transfusion and duration of ICU stay were significantly higher in the CABG + CE patients. Postoperative atrial fibrillation was similar between these groups. The use of inotropic drugs was higher in the CABG + CE group, but the need for a postoperative balloon pump was similar in both groups. All this evidence shows that CE performs better than incomplete revascularization. With careful patient selection, improved anesthesia, myocardial protection, advanced surgical technique, and better postoperative management, we could get good results.

The limitations of our study were the retrospective design, the small number of patients in each group, the lack of postoperative angiography to assess graft patency in endarterectomized and non-endarterectomized coronary arteries, and echocardiography results for assessing postoperative EF.

The current study demonstrates that results of CE are acceptable with respect to hospital outcomes. CABG and adjunctive CE offer a valuable surgical option for patients who complete revascularization for them could not be obtained. With careful selection of patients, a well-judged and well-executed surgical technique, and close postoperative care, excellent results can be obtained.

Footnotes

Authors' Contribution: Study concept and design: Feridoun Sabzi; acquisition of data: Fahimeh Ghasemi and Atefeh Asadmobini; analysis and interpretation of data: Feridoun Sabzi and Atefeh Asadmobini; drafting of the manuscript: Atefeh Asadmobini and Feridoun Sabzi; critical revision of the manuscript for important intellectual content: Feridoun Sabzi and Atefeh Asadmobini; statistical analysis: Atefeh Asadmobini; administrative, technical and material support: Feridoun Sabzi; study supervision: Feridoun Sabzi and Atefeh Asadmobini.

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