The Heart Surgery Forum #2015-1352
19 (2), 2016 [Epub April 2016]
doi: 10.1532/hsf.1352

Online address: http://journal.hsforum.com

Early Outcomes of Coronary Endarterectomy in Patients Undergoing Coronary Artery Bypass Surgery

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ABSTRACT

Background: Coronary endarterectomy (CE) is performed as an adjunct to coronary artery bypass surgery (CABG); however, the efficacy of this technique is still controversial. We aimed to evaluate the impact of CE combined with CABG when compared with isolated CABG.

Methods: Patients who underwent CABG between July 2007 and June 2014 were included. 70 of 2452 patients (2.8%) underwent CE in addition to CABG. Early results were compared with isolated CABG and predictors of adverse outcome were measured in stepwise multivariate logistic regression analyses.

Results: The incidence of comorbidities including prior myocardial infarction, diabetes mellitus, and three-vessel coronary disease in CE patients was higher; however, mortality (4.3% versus control 3.6%; $P = .762$) and postoperative complications were not significantly increased in this group of patients (except supraventricular arrhythmia). Although age greater than 70 years, impaired ejection fraction, intraoperative intraaortic balloon pump, and prolonged cardiopulmonary bypass time were important predictors of adverse outcomes, CE was not associated with increased mortality or postoperative morbidities.

Conclusion: Despite the higher risk profile of patients who underwent CE, this technique was not identified as an independent risk factor for adverse postoperative outcomes.

INTRODUCTION

The diffusely diseased coronary artery is a major challenge for cardiac surgeons. Moreover, with the progressive increase in the number of patients treated with percutaneous coronary intervention in recent decades, more patients with complex and diffuse coronary artery disease (CAD) are referred for coronary artery bypass grafting (CABG). Because of the diffuse disease, grafting of vessels may not be a feasible option and about 25% of patients with advanced CAD cannot be treated safely and successfully through isolated CABG [Santini 2002]. Hence, several procedures such as coronary endarterectomy (CE) have been suggested to develop surgical possibilities.

CE was first introduced as a treatment modality for diffuse CAD in 1957 [Bailey 1957]. Two techniques are usually employed by cardiac surgeons for CE. The open technique involves a long arteriotomy to remove the plaque under direct vision, while in the closed technique a smaller incision is made and the atheroma is removed via traction on the proximal plaque.

Although CE was initially shown to provide relief from angina, controversy still exists about the technique, operative risk, and efficacy. Earlier results were associated with high post-operative morbidity and mortality [Brenowitz 1988; Christakis 1993], but recent studies have shown promising results in selected patients [Finlay 1998; Byrne 2004], especially with diffuse distal disease. Many surgeons are still reluctant to perform CE due to increased mortality and postoperative morbidity as compared with isolated CABG [Byrne 2004; Minale 1989]. Moreover, most of the existing literature lacks identifying independent predictors of adverse outcome by evaluating multiple variables.

In this study, we have sought to evaluate the clinical outcome of isolated CABG compared to CE combined with CABG and to determine the predictors of either postoperative complications or early mortality in all patients.

PATIENTS AND METHODS

Patient Selection

This retrospective study was conducted between July 2007 and June 2014. All consecutive patients who underwent CABG at our institution were selected for analysis. Patients with additional concomitant procedures including valve repair or replacement, carotid intervention or left ventricular aneurysm resection were excluded. All data were collected from Shariati Hospital cardiac surgery database. Of 2452 patients, 70 (2.8%) underwent CE in addition to CABG and they were compared with the rest of the patients (who underwent isolated CABG) regarding pre-, intra- and postoperative characteristics. This study was approved by the ethics committee of the Tehran University of Medical Sciences (TUMS).

In all patients, we performed CE using the closed technique (limited incision and traction technique). All patients received antiplatelet agents (mainly aspirin and clopidogrel) postoperatively.

The preoperative data including sex, age, diabetes mellitus, previous myocardial infarction (MI), left ventricular ejection

Received July 21, 2015; received in revised form October 16, 2015; accepted November 28, 2015.

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Table 1. Patients' Baseline Characteristics

	CABG and CE (n = 70)	CABG Only (n = 2382)	*P*
Female, n (%)	13 (18.6)	663 (27.8)	.085
Mean age, y	57.7 ± 9.4	59.0 ± 10.0	.304
BSA, m^2	1.8 ± 0.3	1.8 ± 0.3	.250
CCS angina class 3-4, n (%)	12 (17.1)	440 (18.5)	.777
NYHA III & IV, n (%)	15 (21.4)	514 (21.6)	.976
Family history of CAD, n (%)	6 (8.5)	276 (11.6)	.436
Previous MI, n (%)	37 (52.9)	831 (34.9)	.002
LVEF	0.45 ± 0.10	0.47 ± 0.09	.159
LV dysfunction (LVEF < 0.30), n (%)	6 (8.6)	168 (7.1)	.649
Smoker, n (%)	20 (28.6)	405 (17.0)	.012
Diabetes mellitus, n (%)	33 (47.1)	826 (34.7)	.026
Hypertension, n (%)	30 (42.9)	1206 (50.6)	.233
Hypercholesterolemia, n (%)	32 (45.7)	1100 (46.2)	.860
Hypertriglyceridemia, n (%)	31 (44.3)	1060 (44.5)	.867
CVA, n (%)	2 (2.9)	66 (2.8)	.975
Renal failure, n (%)	3 (4.3)	72 (3.0)	.573
No. of diseased vessels, n (%)			
× 3	61 (87.1)	1629 (68.4)	.010
× 2	7 (10.0)	525 (22.0)	
× 1	2 (2.9)	206 (8.6)	
Unknown	0 (0.0)	22 (0.9)	

BSA indicates body surface area; CAD, coronary artery disease; CABG, coronary artery bypass grafting; CCS, Canadian Cardiovascular Society; CE, coronary endarterectomy; CVA, cerbrovascular accident; EF, ejection fraction; LV, left ventricle; LVEF, left ventricular ejection fraction; MI, myocardial infarction; NYHA, New York Heart Association.

fraction (LVEF), hypertension, and renal failure (elevated serum creatinine level more than 120 mmol/L) in addition to intraoperative findings such as number of grafts per patient, cardiopulmonary bypass (CPB) time, aortic cross-clamp time and intraaortic balloon pump (IABP) were measured.

Clinical Outcomes

Primary and secondary outcomes were defined as mortality rate in the first 30 days after surgery and morbidities that occurred during hospitalization, respectively. Significant postoperative morbidity was defined as deep sternal infection, septicemia, pulmonary complications such as pleural effusion or pneumothorax, prolonged ventilation, cardiac arrest, and other major morbidities. Furthermore, ventricular arrhythmia included premature ventricular contraction, ventricular tachycardia and fibrillation, while paroxysmal atrial tachycardia, atrial fibrillation and flutter made up the category of supraventricular arrhythmia.

Table 2. Patients' Operative Data

	CABG Only (n = 70)	CABG and CE (n = 2383)	*P*
Number of grafts/patients	3.3 ± 0.8	3.0 ± 1.1	.035
CPB time, min	96.4 ± 31.0	80.8 ± 26.7	<.001
Aortic cross-clamp time, min	52.6 ± 15.9	40.9 ± 25.3	.001
IABP, n (%)	7 (10.0)	93 (3.9)	.011
On-pump CPB, n (%)	59 (84.3)	1440 (60.5)	<.001

CABG indicates coronary artery bypass grafting; CE, coronary endarterectomy; CPB, cardiopulmonary bypass; IABP, intraaortic balloon pump.

Statistical Analysis

All statistical analyses were performed using SPSS version 16.0 (SPSS Inc, Chicago, IL, USA) software. The results are expressed as mean ± standard deviation (SD) and percentages for quantitative and categorical variables respectively. Student t test was performed on continuous variables, and chi-square test (or Fisher exact test, if required) was used to compare categorical variables. A *P* value of less than .05 was considered to have statistical significance.

In order to determine whether variables were associated independently with postoperative complications and mortality, univariate and multivariate analyses were used. The univariate variables, with a significance level of 0.2, were selected via stepwise backward selection and evaluated through multivariable logistic regression analyses to construct the final model. Results were expressed as odds ratio (OR) and 95% confidence intervals (CI).

RESULTS

Baseline Characteristics

A total number of 2452 patients (676 females; mean age 58.9 ± 10.0) who underwent CABG with and without CE were included in our study. The patients' baseline characteristics in each group are shown in Table 1. The CE group (who underwent CE in addition to CABG) had a higher incidence of prior MI (52.9% versus 34.9%; *P* = .002), diabetes mellitus (47.1% versus 34.7%; *P* = .026), smoking (28.6% versus 17.0%; *P* = .012) and three-vessel coronary disease (87.1% versus 68.4%; *P* = .010) as compared with the control group (who had only CABG).

Operative Data

The mean number of bypass grafts per patient was comparable between the groups (CE, 3.3 ± 0.8 versus only CABG, 3.0 ± 1.1; *P* = .035) with low level of significance (Table 2). The higher proportion of patients in the CE group underwent on-pump CPB (84.3% versus 60.5%; *P* < .001) and IABP (10.0% versus 3.9%; *P* = .011). Moreover, CE patients had longer CPB time (96.4 ± 31.0 versus 80.8 ± 26.7; *P* < .001) and aortic cross-clamp time (52.6 ± 15.9 versus 40.9 ± 25.3; *P* = .001) in comparison with the control group.

Table 3. Postoperative Outcomes

Characteristic, n (%)	CABG and CE (n = 70)	CABG Only (n = 2383)	*P*
Mortality	3 (4.3)	85 (3.6)	.762
Deep sternal infection	1 (1.4)	13 (0.5)	.334
Septicemia	1 (1.4)	8 (0.3)	.136
Prolonged mechanical ventilation	6 (8.6)	169 (7.1)	.651
Pleural effusion	1 (1.4)	8 (0.3)	.139
Pneumothorax	1 (1.4)	23 (1.0)	.704
Renal dialysis	1 (1.4)	20 (0.8)	.604
Cardiac arrest	1 (1.4)	58 (2.4)	.582
Gastrointestinal complications	1 (1.4)	17 (0.7)	.495
Supraventricular arrhythmia	12 (17.1)	230 (9.7)	.041
Ventricular arrhythmia	15 (21.4)	401 (16.8)	.313
Brady arrhythmia	5 (7.1)	111 (4.7)	.344
Complete heart block	1 (1.4)	10 (0.4)	.217

CABG indicates coronary artery bypass grafting; CE, coronary endarterectomy.

Coronary endarterectomy was performed in the right coronary artery of 38 patients (54.3%) followed by the left anterior descending coronary artery and left circumflex coronary artery of 22 (31.4%) and 10 (14.3%) patients, respectively.

Postoperative Outcomes

As shown in Table 3, the incidence of postoperative complications was not significantly increased in the CE group except supraventricular arrhythmia (17.1% versus 9.7%; *P* = .041). Moreover, the two groups did not differ significantly in the mortality rate (4.3% versus 3.6%; *P* = .762).

Multivariable logistic regression analyses revealed that age greater than 70 years, impaired LVEF (less than 0.60), hypertension, prolonged CPB time, and intraoperative IABP are significantly associated with increased postoperative complications in all (CABG with and without CE) patients (Table 4). The mortality in isolated CABG as well as CABG and CE patients was associated with female sex, age greater than 70 years, Canadian Cardiovascular Society angina class 3 or 4, renal failure, impaired LVEF (less than 0.60), on-pump CPB, intraoperative IABP, and prolonged CPB time. However, CE was not associated with an increase in either postoperative complications (OR = 0.9; 95% CI = 0.54-1.62; *P* = .812) or early mortality (OR = 1.73; 95% CI = 0.39-7.76; *P* = .472).

Table 4. Multivariate Analysis for Predictors of Adverse Outcomes in All (CABG with and without Coronary Endarterectomy) Patients

Variable	OR	95% CI	*P*
Postoperative Complication			
Age >70 y	1.04	1.03-1.05	<.001
Hypertension	1.30	1.07-1.57	.009
Impaired LVEF	0.98	0.96-0.99	<.001
CPB time, min	1.01	1.01-1.02	<.001
Intraoperative IABP	3.56	2.20-5.74	<.001
CE	0.93	0.54-1.62	.812
Mortality			
Female	2.21	1.35-3.62	.002
Age >70 y	1.05	1.03-1.08	<.001
CCS angina class 3-4	1.94	1.16-3.25	.011
Renal failure	4.35	1.85-10.24	.001
CVA	2.34	0.95-5.72	.063
Impaired LVEF	0.97	0.94-1.00	.029
On-pump CPB	2.52	1.44-4.41	.001
Intraoperative IABP	4.97	2.59-9.55	<.001
CPB time, min	1.02	1.01-1.02	<.001
CE	1.73	0.39-7.76	.472

CAD indicates coronary artery disease; CCS, Canadian Cardiovascular Society; CE, coronary endarterectomy; CI; confidence interval; CPB, cardiopulmonary bypass; CVA, cerbrovascular accident; IABP, intraaortic balloon pump; LV, left ventricle; LVEF, left ventricular ejection fraction; OR, odds ratio.

DISCUSSION

This study illustrates that there was no significant difference in early mortality and postoperative complications (except supraventricular arrhythmia) between the two groups; however, the patients who underwent CE and CABG had a higher incidence of associated comorbidities and risk factors as compared with isolated CABG. Moreover, CE was not distinguished as an independent risk factor for either postoperative morbidities or early mortality.

Although CE has been performed over the past 5 decades as an adjunct to myocardial revascularization, the incidence of performing CE combined with CABG varies between 3.7 to 42%, reflecting a lack of uniformity for its indication [Atik 2000; Qureshi 1985]. In our study, only 2.8% of patients were scheduled for CE in combination with CABG. This low incidence of performing CE represents reluctance among surgeons to use this procedure due to increased mortality and postoperative complication reported in the literature [Byrne 2004; Minale 1989]. Moreover, incidence of early mortality in 4.3% of patients in this study is similar to the 2% to 6.3% rates in previous reports [Brenowitz 1988; Byrne 2004; Qureshi 1985; Djalilian 1995; Christakis 1993; Goldstein 1991; Tiruvoipati 2005; Sirivella 2005; Sundt 1999; Beretta 1992; Gill 1998].

Although CE was largely abandoned at first due to fears of side branch obstruction (snowplow phenomenon) [Qureshi 1985], recent results are promising because of the refinements in patient selection and operative techniques, improved myocardial protection methods, advances in the management of CPB, and better postoperative management. However, the incidence of mortality and postoperative complications, in spite of all these advances, increased in previous studies whether significantly or not [Tiruvoipati 2005]. Recently, by analyzing twenty observational studies, Soylu et al found that early mortality remained significantly higher in patients who underwent CE compared with isolated CABG [Soylu 2014a]. However, the results of the present study revealed that early mortality was not significantly greater in the CE group. Moreover, CE was not found to be independently associated with either mortality or morbidity using a stepwise multivariate logistic regression analysis.

Djalilian et al found a higher incidence of mortality in patients with preoperative MI [Djalilian 1995]. Although our results showed an increased incidence of preoperative MI in the CE group, this was not identified as a predictor factor for adverse outcomes, including mortality. Moreover, although the incidence of smokers in the CE group was higher than in the control group, unlike previous study by Tiruvoipati et al [Tiruvoipati 2005], the analysis for the predictors of adverse effects showed that this was not independently associated with either early mortality or postoperative complications.

Aortic cross-clamp and CPB times were significantly longer in the CE group owing to the time required to perform coronary endarterectomy itself, as well as the need for more grafts per patient. Although prolonged CPB time was identified as a predictor factor for both mortality and morbidity in the present study, as well as previous studies, aortic cross clamp time was not [Minale 1989; Qureshi 1985; Sirivella 2005].

Soylu et al, in another study, found that off-pump CPB is a safe and feasible option for diffuse CAD as compared with results of on-pump CPB [Soylu 2014b]. Similarly, our result showed that on-pump CPB is one of the independent predictors for mortality. Moreover, the present study revealed that intraoperative IABP was not only significantly higher in patients who required CE but also increased the rate of early mortality and morbidity.

Atik et al reported female sex, MI, left main disease, diabetes mellitus, and LVEF less than 0.35 as risk factors for early mortality [Atik 2000].. Tiruvoipati et al found female sex, impaired LVEF (less than 0.60), nonelective surgery, peripheral vascular disease, and renal impairment to be associated with early mortality in patients who underwent CABG, whether accompanied by CE or not [Tiruvoipati 2005]. This study revealed that independent risk factors for early mortality are age greater than 70 years, female sex, Canadian Cardiovascular Society angina class 3 or 4, impaired LVEF (less than 0.60), renal failure, on-pump CPB, intraoperative IABP, and prolonged CPB time in this group of patients. Moreover, age greater than 70 years, hypertension, impaired LVEF (less than 0.60), intraoperative IABP, and prolonged CPB time was associated with postoperative complications.

The retrospective nature of our study is one of the study limitations. In addition, the small number of patients versus the control group in the present study may have affected study power. However, we applied a stepwise multivariate logistic regression model to offset any confounding effects.

Conclusion

In conclusion, the present findings revealed that CE is not an independent risk factor for postoperative adverse outcomes despite the higher risk profile of this group of patients. Moreover, the higher incidence of mortality and morbidities in the CE group is related to comorbidities of these patients rather than CE itself.

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