

# Outcome of coronary endarterectomy with off-pump coronary artery bypass grafting: A retrospective study

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## Article Info

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## Abstract

In this study, we assessed the outcome of surgical revascularization technique, coronary artery bypass grafting (CABG) with or without coronary endarterectomy for patients with diffuse coronary artery disease in a single surgeon's practice on 2,189 patients from January 2009 and December 2016. The variables like intubation time, ICU stay, postoperative myocardial infarction, arrhythmia, renal impairment, stroke and ICU mortality were compared. Among these patients, 1,000 patients required coronary endarterectomy in addition to off-pump coronary artery bypass grafting (OPCABG). Initially, the mortality and incidence of postoperative blood transfusion were higher in the group of patients who had coronary endarterectomy in addition to CABG. However, postoperative combined use of heparin, warfarin and double anti-platelet agent was associated with decreased mortality significantly in our study. In comparison to other group, the patients in the combined coronary endarterectomy with CABG group had a higher incidence of male sex, past myocardial infarction and poor left ventricular function. Total myocardial revascularization is attainable when coronary endarterectomy is performed in addition to off-pump coronary artery bypass graft surgery in diffuse coronary artery disease.

## Introduction

In the late 1950s, coronary endarterectomy was described as a surgical technique for the myocardial revascularization.<sup>1</sup> Endarterectomy is the removal of the atheromatous plaque through a plane between the external media and adventitia layers, along these lines restoring the lumen to the supply distal part of artery. In patients with diffuse coronary artery disease, coronary endarterectomy is frequently performing to attain complete myocardial revascularization. In a patient with diffuse coronary artery disease, only coronary artery bypass graft (CABG) does not provide a satisfactory myocardial revascularization, bringing it about incomplete CABG.<sup>1</sup> However, inadequate revascularization does not influence the quick death rate, but rather increase the incidence of reoperations with significant obstruction in vessels, which influences the long-term cardiac function. The patient has repeated attack of angina, more frequent work absence rate, poor performance in stress tests and also need an early coronary re-intervention, but complete CABG group of patient has better survival rate.<sup>2,3</sup>

Ischemic heart disease patient, who is referred for CABG surgery is getting more complex with multiple comorbidities, like hypertension,

diabetes, renal impairment and peripheral artery disease, also a big portion of this group of patients have experienced previous coronary intervention angioplasty. Subsequently, complete myocardial revascularization with only CABG is getting difficult in the presence of complex coronary artery disease. However, coronary endarterectomy is the best alternative way to achieve better revascularization and post-operative results in coronary artery disease.<sup>4</sup>

This study evaluates the consequences of coronary endarterectomy in a single surgeon's practice at our institute and to provide details regarding our treatment strategies for patients experiencing diffuse coronary artery disease.

## Materials and Methods

Patients (n=2,189) were evaluated to CABG with or without coronary endarterectomy in a single surgeon's practice from January 2009 to December 2016 (Figure 1). We reviewed the outcome of study population by survival rate, post-operative cardiovascular and neurological event, re-intervention, hemodynamic instability, NYHA class and Canadian class for angina were researched. However, there was a measurable distinction in regard to the



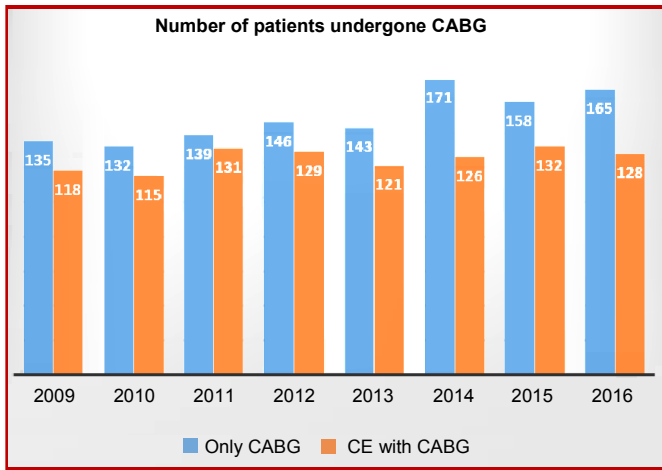


Figure 1: Bar-diagram showing number of patients undergone CABG surgery at different years

previous infarcted area is shown in Table I with the pre-operative variables from the patients. During this study, each patient was reached either during outpatient department visit or by phone call and data were recorded to a data sheet.

#### Surgical procedure

Operation was done through standard median sternotomy, followed by harvesting of graft conduits with appropriate activated clotting time level. Activated clotting time was maintaining 350-400 sec by using heparin infusion. Commonly used conduits were left internal mammary artery, long saphenous vein, radial artery, and also right internal mammary artery. Almost all the operations were performed off pump CABG and a few cases required the assistance of cardiopulmonary by-pass, using a membrane oxygenator, utilizing the surgical procedures to acquire the graft. We utilized mechanical stabilizers, the compression type and suction type to immobilize the target coronary artery during grafting. Decision for coronary endarterectomy was done according to pre-operative findings, when the targeted coronary artery was totally occluded with long segment stenosis, multi-segmental lesion, or in presence of severely calcified plaques involving distal part of vessel.

In our study, closed technique for coronary endarterectomy was utilized and coronary endarterectomy was performed with the help of delicate ring forceps by slow, sustain, and continuous traction of atheromatous plaque, and trailed by reproduction with anastomosis with pre-planned graft. Arteriotomy incision was approximately 8-10 mm long, however that was extended out for another 5 mm in few cases, if complete removal of the plaque was not feasible. Exceptionally sensitive ring forceps were utilized to build-up a plane between the media lamina and the

atheroma. Usually, proximal traction of atheroma was avoided due to chance of competitive flow loss between endarterectomized artery and graft, but more concentration was provided to remove the distal part of the atheroma. Following extraction of plaque from native artery, atheroma specimen was properly inspected and a smooth distal taper end indicated complete removal of plaque. In addition to this, presence of back flow of blood from the distal part of endarterectomized artery indicated proper removal of the plaque and this is a special characteristic for standard OPCABG coronary endarterectomy. Every case was performed with single arteriotomy incision and longest atheroma was 14 cm in size removed from the right coronary artery.<sup>2</sup>

Each patient was closely observed postoperatively in ICU with ECG, arterial blood gas analysis, full blood count, S. creatinine, liver function test and chest X-ray. The CK-MB was performed where indicated. Every patient got heparin in early post-operative period for next 48 hours (usually 2-3 hours following surgery); bridging to warfarin from the first post-operative day for 3-6 months. We also used oral combination of clopidogrel with aspirin (75 mg) to anticipate acute thrombosis at the graft and in the native endarterectomized artery. Usually warfarin started with 10 mg daily for first three post-operative days followed by 2.5-5 mg till next 3-6 months post-operatively and dose was adjusted according to INR (targeted INR 1.5-2.5). However, post-operative CT angiogram was performed to demonstrate the graft patency rate in our study during follow-up period.

#### Results

Among the total 2,189 patients, 1,189 patients underwent only CABG (Group 1) and 1,000 patients underwent CABG with endarterectomy (Group 2) procedure. Twelve hundred endarterectomies were performed in Group 2. 16.5% of the patients required multiple endarterectomies (1.2 endarterectomies per patient). Of the 1200 endarterectomies, 75.1% in LCA territory, and only 24.9% was done in RCA territory. Mean number of graft were  $3.0 \pm 0.2$  in without endarterectomy group and  $3.3 \pm 0.3$  in coronary endarterectomy group. The mean follow-up period was  $8.5 \pm 3.5$  months (between of 6 to 24 months). The quantities of graft and endarterectomies are appeared in Table I. There were 18% conversions to on-pump CABG using cardiopulmonary bypass in coronary endarterectomy with CABG Group but only 2.8% conversions to on-pump CABG in only CABG Group. Post-operative ICU mortality rate was 1.7% without endarterectomy group and 1.8% in with endarterectomy group. There were no intra-operative mortalities in this study.

Table I

## Characteristics of study population

Variable	Coronary artery bypass grafting		
	Without endarterectomy (n = 1,189)	With endarterectomy (n = 1,000)	
<i>Pre-operative</i>			
Age (year)	59.8 ± 2.5	62.5 ± 3.5	
Sex	Male	780	
	Female	220	
Risk factors	Hypertension	820	
	Dyslipidemia	768	
	Smoking	720	
	Diabetes	350	
	Family history of IHD	550	
Previous myocardial infarction	875	720	
Angioplasty		158	
	EF >50%	765	550
Left ventricular ejection fraction	EF 30-50%	347	322
	EF <30%	77	128
NYHA functional class	1 - 2	405	325
	3 - 4	784	675
CCS Class	1 - 2	431	333
	3 - 4	758	667
EuroSCORE	5.6 ± 1.2	5.8 ± 1.6	
<i>Operative</i>			
Number of graft	X <sub>2</sub>	212	110
	X <sub>3</sub>	773	540
	X <sub>4</sub>	172	310
	X <sub>5</sub>	32	40
Use of internal mammary artery	Left	1175	1000
	Right	387	430
Cardiopulmonary bypass	On pump	33	185
	Off pump	1156	815
Left main disease		128	115
Operative criteria	Emergency	28	11
	Urgent	196	184
	Elective	965	805
Territory of endarterectomy	Left anterior descending artery		436
	Obtuse marginal		47
	Diagonal		268
	Right coronary artery		162
	Posterior descending artery		87
<i>Post-operative</i>			
Ventilation time (hours)	9.2 ± 1.8	9.5 ± 2.5	
ICU stay (hours)	36.2 ± 5.1	36.5 ± 7.1	
ICU mortality	20	18	
Hospital stay (days)	10 ± 1	10 ± 2	
Late mortality (>6 months)	3	9	
New onset atrial fibrillation	125	150	
Post-operative acute myocardial infarction	17	33	
Renal failure	26	25	
Respiratory failure	14	12	
Neurological complications	9	15	
Use of intra-aortic balloon pump	6	8	
Post-operative blood transfusion (units)	1.3 ± 0.5	1.5 ± 0.5	
Back to theater	5	8	

A mean of  $1.5 \pm 0.5$  units of blood was transfused post-operatively in CABG with endarterectomy group, which is more than without endarterectomy group, where  $1.2 \pm 0.5$  units of blood was transfused. About 91% patients were in regular follow-up in Group 1, whereas 92.7% patients were in regular follow-up in Group 2. At median follow-up of 2.5 years, 91.8 and 88.5% of patients were angina free in CABG without endarterectomy group and with endarterectomy group respectively. The rest of the post-operative characteristics including mortality and morbidity are listed in Table I. Only 1.2% patient of coronary endarterectomy with CABG group presented with chest pain and was hospitalized. But there was no ECG changes in favor of acute MI, however a coronary angiogram was done which demonstrate lesion in a small obtuse marginal artery. The major post-operative morbidity and mortality were compared between two group. There was no significant difference in term of post-operative outcome like MI, renal failure, respiratory failure, neurological complication and use of post-operative IABP.

## Discussion

This study evaluated outcomes of CABG with or without coronary endarterectomy and shown that the complete revascularization of diffuse coronary artery disease enhanced the early and late post-operative outcomes following CABG. The mean age of study population was  $59.8 \pm 2.5$  and  $62.5 \pm 3.5$  in only CABG group and coronary endarterectomy with CABG group respectively. In this review, 16.5% of the patients required multiple endarterectomies in coronary endarterectomy with CABG group i.e. 1.2 endarterectomies per patient. Out of total endarterectomies, 75.1% in LCA territory, and only 24.9% was done in RCA territory. The mean graft number were  $3.0 \pm 0.2$  and  $3.3 \pm 0.3$  in only CABG group and coronary endarterectomy with CABG group respectively. There were 18% conversions to on-pump CABG using

cardiopulmonary bypass in coronary endarterectomy with CABG Group. Post-operative ICU mortality rate was 1.7% in Group 1, and 1.8% in Group 2. There were no intra-operative mortalities in this study. The mean follow-up period was  $8.5 \pm 3.5$  months (between of 6 to 24 months). In our study, a mean of more blood was transfused post-operatively in coronary endarterectomy with CABG group rather than only CABG group. At median follow-up of 2.5 years, 91.8 and 88.5% of patients were angina free in only CABG group and coronary endarterectomy with CABG group respectively.

Coronary endarterectomy with off-pump CABG surgery provide better postoperative outcome, reduce the incidence of postoperative morbidity and mortality and also the duration of hospital stay.<sup>5,6</sup> In a study, Smith et al. observed that majority of patients are belongs to 61 to 70 years age group, which is similar to our study.<sup>7</sup> Islamoglu et al. shows that total myocardial revascularization improves LV function postoperatively.<sup>8</sup> Complete revascularization especially left coronary (LCA) territory has been identified as a most critical values that influences post-operative patient's recovery.<sup>9-11</sup> Vigorous myocardial contraction in the LAD territory helps in extraction of the distal atheroma by close traction technique coronary endarterectomy more easily as compared to the RCA region.<sup>2,12,13</sup> This study also showed that it is easier to remove atheroma from LAD than RCA, which is also described in other article. Though coronary endarterectomy procedure is as yet a matter of controversy, but the low incidence of readmission to the intensive care unit (ICU), chest re-open for bleeding, infection, transient ischemic attack, and stroke in this CABG with endarterectomy group contrasts positively with published OPCABG articles.<sup>9,14,15</sup>

Following coronary endarterectomy, anticoagulation therapy with heparin infusion used in order to prevent graft thrombosis, bridging to oral warfarin for next 3-6 months provide best post-operative outcome, which is also similar to this study results.<sup>2,11,16,17</sup> In a study, Djalilian et al. shows only 9% of their patients got angina at  $46 \pm 19$  months follow-up, though Gill et al. observed that 15% patients having angina at a mean follow-up of  $36 \pm 16$  months.<sup>12,16</sup> In this study, only 0.8% and 1.5% patients had transient ischemic attack with full recovery in CABG without endarterectomy group and with endarterectomy respectively, which also supported by another study.<sup>18</sup> However, Vohra et al. observed only 10% recurrence of angina following OPCABG with coronary endarterectomy which is similar to our study.<sup>19</sup> But, in a study Christakis et al. observed 35% recurrence rate of angina at 5 years follow-up in their study, which is significantly higher than our study.<sup>20</sup> However, multiple published literature shows that acute MI is

a noteworthy complication following coronary endarterectomy caused by acute graft thrombosis and the incidence rate is 1.5 to 19%.<sup>13,21-23</sup>

In this study, the mortality rate in both study group was associated with aging process, specially age more than 70 years, emergency or urgent CABG surgery, pre-operative renal function impairment, multiple comorbidities like diabetes mellitus, peripheral vascular disease, and LV dysfunction, which is supported by other authors.<sup>14,19,24</sup> In a study following coronary endarterectomy with OPCABG, Erylimaz et al. shows no mortality at 1-year follow-up<sup>21</sup> but Naseri et al. who compared coronary endarterectomy with both on pump and off pump CABG, described 2.2% mortality rate in a study involving 44 patients.<sup>18</sup> Though Vohra et al. observed 1-year survival rate is 91.5%, and 5-year survival rate is 87.9% are amazing as compared to others study result.<sup>19</sup> Many authors describe the incidence of early mortality after coronary endarterectomy with OPCABG is 2-15%.<sup>20,22</sup> But interestingly with regards to coronary endarterectomy with OPCABG, Careaga et al. revealed a 30-day mortality of 0% in their small series study.<sup>25</sup> Despite the advancement of medical science, the morbidity and mortality following coronary endarterectomy with CABG is more prominent than with CABG alone.<sup>11,13,15,25</sup> However, Atik et al. observed in a study that female sex, previous MI, left main disease, diabetes mellitus, and a low ejection fraction (<35%) to be related with higher incidence of early mortality which also supported by other published articles.<sup>23,26,27</sup> But, the consequences of the present review are not concordance with these discoveries as in the both study group patients had a lower mortality in our review probably due to prompt anticoagulation therapy in early post-operative days.

This study shows that only CABG surgery is sufficient to provide total myocardial revascularization in uncomplicated coronary artery disease. However, in complex coronary artery disease like diffuse lesion, stent restenosis, and LV dysfunction, we need to do concurrent coronary endarterectomy with CABG to achieved good distal run-off and better post-operative outcome. Though in coronary endarterectomy with CABG group comprises higher risk population, but postoperative outcome was similar to only CABG group population. Endarterectomy of the circumflex artery is unnecessary when the vessel is small, in presence of diffuse disease and severe calcification of vessel. However, post-operative anticoagulation therapy and surgical skills remains the key stream in our study and coronary endarterectomy was not found to be independently associated with mortality in the analysis for the predictors of mortality.

## Conclusion

In diffuse coronary artery disease, coronary endarterectomy with off-pump coronary artery bypass graft surgery provides total myocardial revascularization and better postoperative outcome. However, surgical skill, patient's selection and post-operative anticoagulation therapy are main stream for better outcome despite the higher risk group, severe LV dysfunction, and diffuse coronary lesion.

## Conflict of interest

No potential conflict of interest with the respect of authorship, research or publication of this article.

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