

# Off-Pump Versus On-Pump Coronary Artery Bypass Graft Surgery Outcomes During 6 Years: A Prospective Cohort Study

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**Abstract-** Given the ongoing controversy over the risks and benefits of on-pump versus off-pump coronary artery bypass graft surgery (CABG), we aimed to compare time trends in off- and on-pump CABG long-term outcomes. In this prospective cohort study, the patients who underwent primary isolated non-emergent CABG in Imam Reza Hospital in Mashhad, Iran, in 2006 were followed for 6 years. The patients were contacted to obtain long-term follow-up data such as death, rehospitalization, myocardial infarction, and normal physical activity. The obtained data were analyzed in SPSS software (V: 16) using *t*-test, Fisher's Exact, chi-square, and Mann-Whitney tests, and relative risk. The significant level was set at  $P < 0.05$ . The study included 61 patients of whom  $n=40$  (65.6%) underwent off-pump CABG. The mean age of the patients was  $59.0 \pm 11.31$  years, and  $n=43$  (70.5%) were men. No significant differences were found between the two groups in terms of outcomes during the 6 years (e.g., death, rehospitalization, myocardial infarction, and normal physical activity). There was 1 (5.0%) death, overall. Risk-adjusted death did not differ significantly between the off-pump and on-pump groups during the 6 years (RR, 0.952; 95% CI 0.866 to 1.048). According to the results, the outcomes were similar between off-pump and on-pump CABG in patients who underwent primary isolated non-emergent CABG during the 6-year follow-up phase.

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**Keywords:** Off-pump; On-pump; Coronary artery bypass; Outcomes

## Introduction

Numerous studies have been conducted to compare the outcomes of on-pump and off-pump coronary artery bypass graft surgery (CABG). These outcomes include short-term and long-term mortality, need for subsequent revascularization, cognitive function, renal function, wound infection, stroke, arrhythmia, quality of life, and costs (1-5).

Off-pump CABG is technically more demanding than on-pump CABG. On the other hand, several studies have suggested superior outcomes for off-pump CABG, particularly with regard to short-term and long-term mortality rates and complications. Nonetheless, other studies have found no significant differences between

the two techniques (2,3,6,7). In fact, the relative benefits and risks of performing off-pump CABG, as compared with on-pump CABG, are not firmly established. Furthermore, the effect of off-pump CABG on long-term outcomes is poorly investigated. Therefore, we aimed to compare off-pump and on-pump CABG outcomes during a 6-year follow-up period.

## Materials and Methods

In this prospective cohort study, the patients who underwent primary isolated non-emergent CABG in Imam Reza Hospital in Mashhad in 2006 were identified. The inclusion criteria were patients older than 21 years of age who were hospitalized for isolated, first-

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time coronary-artery surgery. From among them, those whose contact information was available in their hospital recordings and who were willing to participate in the study were selected. Demographic characteristics and medical information were extracted from their files. The follow-up phase started in November 2006 and lasted up to November 2012 by phone.

Emergent CABG patients, conversion from off- to on-pump CABG, and mitral regurgitation cases were excluded.

The two groups (off-pump and on-pump) were matched for baseline characteristics whereby no significant differences were found.

Each operation was performed by a surgeon with expertise in the specific type of surgery which the patient was assigned to receive.

The data was collected using hospital recordings. Postoperative data and adverse events were recorded for all patients, including number of grafts, type of graft, surgery time (skin incision to skin closure), postoperative hospital stay, need for transfusion, CPR, type of arrhythmia, and death.

For 6 years, the patients were contacted to obtain long-term, follow-up data (e.g., death, rehospitalization, myocardial infarction, and normal physical activity). From among the 61 patients under study, the information about 8 participants were unreachable because they changed their address or phone number.

The obtained data were analyzed in SPSS software (IBM Incorporation, Chicago, IL). Normality of the quantitative variables was determined by the Kolmogorov-Smirnov test. Categorical variables were analyzed using chi-square or Fisher's exact test. Mann-Whitney test and independent t-test were used for comparison of continuous variables. We calculated the relative risk (RR) with 95% confidence intervals (CI) to compare the death between off-pump and on-pump CABG. The significance level was considered at  $P < 0.05$ .

## Results

The study included 61 patients of whom 40 (65.6%) underwent off-pump CABG. The mean age of the patients was  $59.0 \pm 11.31$  years, and 43 (70.5%) of them were men. No significant differences were observed between the two groups in baseline characteristics. The two groups matched for age, gender, occupation, smoking, creatinine, and ejection fraction. The demographic and medical characteristics of the 61 patients are shown in Table 1.

No significant differences were observed between the two groups in intraoperative characteristics (Table 2). Table 3 shows the postoperative data and adverse events. No significant differences were observed between the two groups in terms of postoperative data and adverse events (such as postoperative hospital stay, need for transfusion, CPR, type of arrhythmia, and death).

The mean chest tube drainage 48 hours after the operation was not significantly different between the two groups ( $P = 0.668$ ) (84.5 ml in the on-pump group and 77.5 ml in the off-pump group).

Table 4 shows the outcomes during the 6 years. No significant differences were found between the two groups in outcomes after the 6 years (e.g., death, rehospitalization, myocardial infarction, and normal physical activity). There was one death incidence after 6 years. Risk-adjusted death did not differ significantly between the off-pump and on-pump groups during the 6 years (RR, 0.952; 95% CI 0.866 to 1.048).

*LAD*= left anterior descending; *OM*= obtuse marginal; *RCA*= right coronary artery; *D*=diagonal; *PLV*=posterior left ventricle; *PDA*=posterior descending artery; *RAM*=right acute margin; *RVB*=right ventricle branch.

**Table 1. The demographic and medical characteristics of the 61 patients participated in the study.**

Characteristic	All patients (n=61)	Off-Pump CABG (n=40)	On-Pump CABG (n=21)	P	
Age: mean±SD	61	58.0 ± 11.97	61.0 ± 9.89	0.318 *	
Gender	Male	31 (77.5%)	12 (57.1%)	0.098**	
	Female	9 (22.5%)	9 (42.9%)		
Occupation	Disabled	1 (3.7%)	3 (18.8%)	0.502***	
	Retired	4 (14.8%)	1 (6.2%)		
	Worker	1 (3.7%)	1 (6.2%)		
	Homemaker	8 (29.6%)	7 (43.8%)		
	Business	1 (3.7%)	0 (0.0%)		
Smoker	yes	14 (35.0%)	11 (52.4%)	0.190**	
	no	26 (65.0%)	10 (47.6%)		
Creatinine, mg/dL	<1.5	29 (80.6%)	12 (85.7%)	0.627****	
	1.5–3.0	5 (13.9%)	2 (14.3%)		
	>3.0	2 (5.6%)	0 (0.0%)		
Ejection fraction, %	<20	1 (2.5%)	0 (0.0%)	0.111****	
	20–29	0 (0.0%)	3 (17.6%)		
	30–39	57	6 (15.0%)		3 (17.6%)
	40-49	9 (22.5%)	4 (23.5%)		
	≥50	24 (60.0%)	7 (41.2%)		
	HTN	4 (10.0%)	1 (4.8%)		
	HLP	6 (15.0%)	3 (14.3%)		
	DM	0 (0.0%)	1 (4.8%)		
	CVA+MI	1 (2.5%)	0 (0.0%)		
	MI+DM	1 (2.5%)	0 (0.0%)		
Accompanying diseases	HTN+HLP	8 (20.0%)	0 (0.0%)	0.090***	
	HTN+HLP+ DM	5 (12.5%)	3 (14.3%)		
	CKD+ HTN+HLP+ DM	61	1 (2.5%)		7 (33.3%)
	HLP+ DM	2 (5.0%)	1 (4.8%)		
	CVA + HTN+HLP+ DM	0 (0.0%)	4 (19.0%)		
	HTN+DM	2 (5.0%)	1 (4.8%)		
	CVA+HTN	1 (2.5%)	0 (0.0%)		
	CVA+ HLP	1 (2.5%)	0 (0.0%)		
	not present	8 (20.0%)	0 (0.0%)		
	Present	0 (0.0%)	0 (0.0%)		
IABP	61	40 (100.0%)	21 (100.0%)	1.000 ***	

\*t-test

\*\*chi-squared

\*\*\* Fisher's Exact Test

\*\*\*\*Mann-Whitney

CVA= Cerebrovascular accident; HLP=hyperlipidemia; HTN= Hypertension; DM= Diabetes Mellitus; MI= Myocardial Infarction; CKD =Chronic kidney disease

Table 2. Intraoperative characteristics of the patients.

Characteristic	All Patients (n=61)	Off-Pump CABG (n=40)	On-Pump CABG (n=21)	P
<b>No. of grafts</b>	61	3.0 ± 0.87	3.0±0.94	0.835*
LAD+OM1+RCA		6 (15.0%)	4 (19.0%)	
LAD+ RCA+OM2		4 (10.0%)	1 (4.8%)	
LAD+OM1+RCA+D+PLV+PDA		0 (0.0%)	1 (4.8%)	
LAD+OM1+RAM		0(0.0%)	1 (4.8%)	
LAD+ RCA+D+ OM2		3 (7.5%)	1 (4.8%)	
LAD+OM1+RCA+D		7 (17.5%)	3 (14.3%)	
LAD+OM1+ OM2		1 (2.5%)	0 (0.0%)	
LAD+OM1+RCA+ RAM+D		1 (2.5%)	0 (0.0%)	
LAD+OM1+ OM2+RVB		1 (2.5%)	1 (4.8%)	
LAD+ OM2		1 (2.5%)	1 (4.8%)	
LAD+OM1+RCA+ OM2		1 (2.5%)	0 (0.0%)	
<b>Type of grafts</b>	61			0.679*
LAD+OM1+D		2 (5.0%)	0 (0.0%)	
LAD+OM1		3 (7.5%)	0 (0.0%)	
LAD+ RCA+OM3		0 (0.0%)	1 (4.8%)	
LAD+OM1+ RVB		0 (0.0%)	1 (4.8%)	
LAD		0 (0.0%)	1 (4.8%)	
LAD+ RAM		1 (2.5%)	0 (0.0%)	
RCA+ RAM		1 (2.5%)	0 (0.0%)	
LAD+ RCA		1 (2.5%)	2 (9.5%)	
LAD+ RCA+RAMUS		2 (5.0%)	0 (0.0%)	
LAD +D		3 (7.5%)	1 (4.8%)	
LAD+ RCA+D+RAMUS		0 (.00%)	1 (4.8%)	
LAD+ RCA+D		2 (5.0%)	1 (4.8%)	
<b>Surgery time (skin incision to skin closure) (hr)</b>	55	4.8 ± 0.81	4.8± 0.78	0.930*
<b>Type of arrhythmia</b>				
Atrial fibrillation		1 (2.5%)	0 (0.0%)	
Premature ventricular contraction	61	1 (2.5%)	0 (0.0%)	1.000 **
not present		38(95.0%)	21(100.0%)	
Used		10(25.0%)	9 (42.9%)	
<b>Packed cells</b>				
Not used	61	30(75.0%)	12 (57.1%)	0.152***
Present		0 (0.0%)	0 (0.0%)	
<b>IABP</b>				
Not present	61	40(100.0%)	21(100.0%)	1.000 **

\*Mann-Whitney

\*\*Fisher's Exact Test

\*\*\*Chi-square

Table 3. Postoperative data and adverse events of the patients.

Off-pump versus on-pump coronary artery bypass graft

Variable		All patients (n=61)	Off-pump CABG (n=40)	On-pump CABG (n=21)	P
Death	Present	61	2 (5.0%)	1 (4.8%)	1.000 *
	Not present		38 (95.0%)	20(95.2%)	
CPR	Present	61	0 (0.0%)	2 (9.5%)	0.115 *
	Not Present		40(100.0%)	19(90.5%)	
	Atrial fibrillation		2 (5.0%)	2 (9.5%)	
	Premature Atrial Contraction		1 (2.5%)	1 (4.8%)	
Type of arrhythmia	Premature ventricular contraction	61	2 (5.0%)	1 (4.8%)	0.523 *
	Junctional Rhythm		0 (0.0%)	1 (4.8%)	
	Not present		35 (87.5%)	16(76.2%)	
Median postoperative hospital stay-days		54	7.8 ± 2.98	8.1 ± 3.16	0.297**
Packed cells	Used	61	29 (72.5%)	16(76.2%)	0.756***
	Not used		11 (27.5%)	5 (23.8%)	
Sternum wound infection	Present	61	0 (0.0%)	0 (0.0%)	1.000 *
	Not present		40(100.0%)	21(100.0%)	
Pneumonia	Present	61	0 (0.0%)	0 (0.0%)	1.000 *
	Not present		40(100.0%)	21(100.0%)	
Myocardial Infarction	Present	61	1 (2.5%)	0 (0.0%)	1.000 *
	Not present		39 (97.5%)	21(100.0%)	

\*Fisher's Exact Test

\*\*Mann-Whitney

\*\*\*Chi-square

Table 4. Off-pump and On-pump CABG outcomes during a 6-year follow-up period.

Variable		All Patients (n=53)	Off-Pump CABG (n=33)	On-Pump CABG (n=20)	P
Death	Present	53	0 (0.0%)	1 (5.0%)	0.354*
	Not present		33(100.0%)	19(95.0%)	
Myocardial infarction	Present	53	2 (6.1%)	0 (0.0%)	0.521*
	Not present		31 (93.9%)	20(100.0%)	
Rehospitalization	Present	53	3 (9.1%)	2 (10.0%)	1.000 *
	Not present		30 (90.9%)	18 (90.0%)	
Normal Physical Activity	Present	53	11 (33.3%)	9 (45.0%)	0.396**
	Not present		22 (66.7%)	11 (55.0%)	
CVA	Present	53	0 (0.0%)	0 (0.0%)	1.000 *
	Not present		33 (100.0%)	20(100.0%)	
adherence to drug regimen	Present	53	25 (75.8%)	10 (50.0%)	0.055**
	Not present		8 (24.2%)	10 (50.0%)	

\*Fisher's Exact Test

\*\*Chi-square

Discussion

Numerous studies in the literature have compared outcomes of off-pump and on-pump CABG. However, their results are contradictory, and the cons and pros of the two methods are not clearly stated (1,4,8,9). As an example, a meta-analysis (2012) incorporating 59 randomized trials on a total of 8961 patients showed no difference in death or myocardial infarction following off-pump or on-pump CABG; however, off-pump CABG was associated with reduced risk of stroke (10). In a meta-analysis of mid- and long-term outcomes (2014), off-pump CABG confers similar mid-term survival to on-pump CABG. On-pump CABG was associated with a significant trend towards a long-term survival advantage (6). In the Swedish Nationwide Cohort Study, the long-term survival rate was similar between off-pump and on-pump CABG in patients undergoing non-emergent primary isolated CABG from 1998 to 2008 (3).

However, in the complete cohort with 11629 off-pump cases out of 65097 operations, it was concluded that off-pump CABG might be associated with decreased long-term survival. The authors suggested that further studies are needed to identify the reasons behind this finding (2).

In our study, no significant differences were observed between the two groups in the postoperative data and adverse events such as postoperative hospital stay, need for transfusion, CPR, type of arrhythmia, and death. Moreover, no significant differences were observed between the two groups in terms of outcomes during the 6 years such as death, rehospitalization, myocardial infarction, CVA, adherence to the drug regimen, and normal physical activity.

Perhaps the difference between the two groups in these studies can be attributed to the fewer number of grafted coronary arteries in the off-pump group. According to some resources, the benefit of off-pump CABG is thought to be greater when more grafts are performed and when a contemporary technique is used (10). On the other hand, fewer grafted coronary arteries may indicate less complete revascularization in the off-pump CABG group and might be associated with poorer long-term outcomes (2,11,12). Therefore, completeness of revascularization depends on the number of grafts needed as well as the number of grafts performed. In our study, the number of grafted coronary arteries was similar in both groups.

Another reason for the difference between the two groups in previous studies can be due to the type of graft used or the fact that it was used only in one group. As an example, in Grau's study (2015), bilateral internal

mammary artery yielded better outcomes than single internal mammary artery when used in CABG (13). However, in our study, no significant differences were observed between the two groups in the type of graft used.

A further reason for the difference between the two groups in previous studies can be due to the difficulty of using off-pump CABG in health centers, whereas in our study, off-pump cases overrode on-pump instances. Successful performance of off-pump CABG seems more dependent on initial technical risks than on-pump CABG because, inherently, performing delicate anastomoses on a beating heart is difficult and the potential degree of complete revascularization or its quality low (14,15).

As a limitation, the number of patients in this study is small; therefore, it would be better to perform a similar study with a larger sample size for a more definite conclusion. In addition, this study must be performed multi-centrally.

In summary, the findings of this research showed that the outcomes were similar between off-pump and on-pump CABG in patients who underwent primary isolated non-emergent CABG in Imam Reza Hospital in Mashhad in 2006.

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