

Off-Pump Versus On-Pump Coronary Artery Bypass Graft Surgery, prospective cohort study

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ABSTRACT

Introduction: Coronary artery bypass grafting is a surgical operation that bypasses atherosclerotic coronary vessels and restores blood flow to the ischemic zone of hearts. And two different conventional methods are ON-pump CABG, and Off-pump CABG. Altogether, the efficacy and safety of these two types of surgical procedures are still under debate. In this study, we aim to compare the efficacy, safety, and cost-effectiveness of these two different methods in admitted patients to Imam Reza Hospital in Mashhad in Iran during 2006 to 2016.

Materials and Method: In this prospective cohort study, 533 patients who underwent CABG in Imam Reza hospital in Mashhad during 2006 to 2016 were identified. The data was collected using hospital records including demographic data, chief complaint, history of previous disease, ejection fraction, number of graft, blood transfusion, time of anesthesia, time of surgery, days of hospitalization, days of ICU stay, needs for reoperation, post-operative complication, expenses of hospitalization.

Results: Of 533 patients were 347 patients of whom male. The mean age was 59.53 ± 10.21 and the mean BMI was 26.38 ± 5.4 . The most common chief complaint of the patients was chest pain. 38 patients of 533 cases underwent on-pump surgery and 495 underwent off-pump technique. There were no significant differences for age, and gender. The prevalence of HTN, diabetes, MI, and hyperlipidemia had no differences among two groups. Renal failure was more common in on-pump group; whereas, pulmonary disease was more common in off-pump group. On-pump surgery required significantly longer hospitalization and ICU care. Also needs for reoperation was more common among on-pump surgery. Total expenses were significantly higher in on-pump group. 10.5% of those who underwent on-pump surgery died after surgery. This rate was only 3.1% among off-pump group.

Conclusion: In this study we showed that, the patients who underwent on-pump surgery, required longer hospitalization, and ICU care. Total expenses were significantly higher in on-pump group. In addition, the mortality rate of on-pump group was significantly higher than the off-pump group. Also needs for reoperation was more common among on-pump surgery. Altogether, it seems that off-pump surgery is safer with low expenses than on-pump CABG.

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Introduction

Coronary artery bypass grafting (CABG) is a surgical operation that bypasses atherosclerotic coronary vessels and restores blood flow to the ischemic zone of hearts. Restoring the blood flow leads to improving heart function and relieving angina symptoms. Annually, near 400,000 CABG surgeries are performed in the world which makes it one of the most common surgical procedures globally (1). Initially, CABG was performed using cardiopulmonary bypass with Cardioplegic arrest. This surgical technique is called on-pump CABG. On-pump CABG showed its ability in relieving ischemic symptoms and increasing survival rates. However, this procedure was shown to be associated with some complications including cerebral dysfunction, hemodynamic instability, myocardial depression, and generalized systemic inflammatory responses. To overcome these limitations, off-pump CABG was developed on beating heart without using cardiopulmonary bypass (2). Several studies have been conducted to compare the efficacy, safety, and cost-effectiveness of these two different methods. Recent studies agreed with the previous hypothesis that off-pump overcomes the limitations and complications of on-pump CABG (3). In other hand, several studies showed that off-pump CABG was associated with higher mortality rates (2). This invaded the initial purpose of developing off-pump technique. On the contrary of two previous results, several studies did not show any significant differences in mortality rates, total expenses and quality lives of patients undergoing on-pump CABG with those undergoing off-pump CABG (4). These differences may be due to the study design, sample size and skills of participating surgeons. Altogether, the efficacy and safety of these two types of surgical procedures are still under debate.

Materials and Methods

In this study, we aim to compare the efficacy, safety, and cost-effectiveness of these two different methods in admitted patients to Imam Reza Hospital in Mashhad in Iran during 2006 to 2016.

Method and Materials

In this retrospective cohort study, the patients who underwent CABG in Imam Reza

hospital in Mashhad during 2006 to 2016 were identified. This study was approved by ethics committee of Mashhad university of medical science (approval code: IR.MUMS.FM.REC.1395.432). The inclusion criteria were all the patients underwent CABG and their documents were available. The data was collected using hospital records including demographic data, chief complaint, history of previous disease, ejection fraction, number of graft, blood transfusion, time of anesthesia, time of surgery, days of hospitalization, days of ICU stay, needs for reoperation, post-operative complication, expenses of hospitalization. The obtained data were analyzed in SPSS software 22.0 (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. The significance level was considered at $P < 0.05$.

Results

Data of 533 patients were extracted. 347 patients of whom were male. The mean age was 59.53 ± 10.21 and the mean BMI (weight (kg) / [height (m)]²) was 26.38 ± 5.4 . The most common chief complaint of the patients was chest pain. Following chest pain, dyspnea was the next common complaint. Abdominal pain, nausea and vomiting, and lower limb paralysis were the rare chief complaint of our cases. Altogether, these rare presentations account for only 1.4%. Most cases showed history of hypertension, diabetes and hyperlipidemia. Renal disease, vascular disease, pulmonary disease, and neurological disease were rare in past medical history of patients (Table 1). 38 patients of 533 cases underwent on-pump surgery and 495 underwent off-pump technique. There were no significant differences for age, and gender. The prevalence of HTN, diabetes, MI, and hyperlipidemia had no differences among two groups. However, the prevalence of renal failure, and pulmonary disease were significantly different. Renal failure was more common in on-pump group; whereas, pulmonary disease was more common in off-pump group (Table 2).

Table 1-Demographic data

Demographic factors		N=533
gender	Male	347 (65.1%)
	Female	186 (34.9%)
Mean age		59.53±10.21
Mean BMI		26.38±5.4
Job status	Employee	268 (51.3%)
	unemployed	213 (48.7%)
Marital status	single	17 (3.2%)
	married	516 (96.8%)
Chief complaint	Chest pain	348 (65.3%)
	Dyspnea	82 (15.4%)
	Chest pain and dyspnea	67 (12.6%)
	Lower limb paralysis	1 (0.2%)
	Nausea and vomiting and sweating	3 (0.6%)
	Abdominal pain	3 (0.6%)
History of	Hypertension	206 (38.6%)
	Diabetes	159 (29.8%)
	Hyperlipidemia	148 (27.8%)
	Smoking	81 (15.2%)
	Opium consumption	56 (10.5%)
	Renal disease	9 (1.7%)
	Vascular disease	6 (1.1%)
	Pulmonary disease	7 (1.3%)
	Neurological disorders	4 (0.8%)
	Stroke	67 (12.6%)
Ejection fraction		45.69±10.69

Table 2: Pre-operative characteristics

	On-pump N=38	Off-pump N=95	P value
age	62.23±9.89	59.32±10.21	0.99
Gender	male	20 (52.6%)	0.073
	female	18 (47.4%)	
Immediate refer	6 (15.8%)	42 (8.5%)	0.13
Blood pressure (HTN)	17 (44.7%)	189 (38.2%)	0.42
Diabetes	15 (39.5%)	144 (29.1%)	0.17
hyperlipidemia	14 (36.8%)	134 (27.1%)	0.19
History of renal failure	3 (7.9%)	6 (1.2%)	0.021
History of pulmonary disease	3 (7.9%)	4 (0.8%)	0.01
History of MI	70 (18.4%)	60 (12.1%)	0.3
Ejection fraction	41.17±13.6	46.01±10.33	0.63

Off-pump surgery needed significantly more grafts ($p=0.01$). IABP was mostly applied in on-pump group. On-pump group required endarterectomy significantly more than off-pump group. Also, on-pump group received more blood volume than the other one ($p=0.02$). Anesthesia duration was significantly longer on-pump group. Also, surgery duration was significantly longer in

on-pump group. Table 3 shows intraoperative characteristics. On-pump surgery required significantly longer hospitalization and ICU care. Also needs for reoperation was more common among on-pump surgery. Total expenses were significantly higher in on-pump group. Table 4 shows post-operative characteristics

Table 3: intra-operative characteristics

	On pump	Off pump	P value
Number of graft	1 3 (7.9%)	13 (2.6%)	0.01
	2 10 (26.3%)	63 (12.8%)	
	3 14 (36.8%)	238 (48.2%)	
	4 10 (26.3)	166 (33.6%)	
	5 0	14 (28%)	
IABP	9 (23.7%)	55 (11.1%)	0.028
endarterectomy	4 (10.5%)	14 (2.8%)	0.033
Blood transfusion	1.5±0.66	1.1±0.45	0.027
Time of anesthesia (h)	4.98±1.18	4.46±0.92	0.004
Time of surgery	3.15±0.78	2.91±0.86	0.042

Table 4: Postoperative data and adverse events of the patients

	On pump	Off pump	P value
Days of hospitalization	11.58±4.68	9.51±3.79	0.004
Days of ICU	7.17±6.8	3.7±3.1	0.001
Needs for re-operation	7 (18.4%)	28 (5.7%)	0.008
Neurologic complication	1 (2.6%)	1 (0.2%)	0.13
infection	4 (10.5%)	17 (3.4%)	0.055
Plural effusion	4 (10.5%)	6 (1.2%)	0.003
Ejection fraction	40.62±14.76	43.31±12.08	0.39
Intubation time	7.09±3.77	7.05±4.67	0.96
Volume of blood transfusion	1 st day 1.59±0.83	1.33±0.81	0.82
	2 nd day 1.29±0.68	1.27±0.76	0.87
	3 rd day 1.50±0.75	1.28±0.74	0.38
Total expenses	71073725.9±64980160.1	24669431.8±61776912.8	0.0001

10.5% of those who underwent on-pump surgery died after surgery. This rate was only 3.1% among off-pump group. The cause of high mortality in on-pump groups versus off-pump CABG seems be reoperations (18.4% versus 5.7%) and higher neurologic complication (2.6% versus 0.2%) and more

Common endarterectomy (10.5% versus 2.8%) and higher use of IABP (23.7% versus 11.1%). The most prevalent cause of death in each group was cardiac arrest. (Table5)

Table 5 :Mortality rate of patients

Cause	On pump N= 4 (10.5%)	Off pump N= 8 (3.1%)	P value = 0.03
Pneumonia and respiratory failure	1(25%)	2(25%)	
MI and bradycardia	0	1(12.5%)	
Bleeding and heart failure	0	1(12.5%)	
Hypovolemic shock	0	1(12.5%)	
Death at operation room	3(75%)	3(37.5%)	

Discussion

In this study we showed that, the patients who underwent on-pump surgery, required longer hospitalization, and ICU care. Also needs for reoperation was more common among on-pump surgery. Total expenses were significantly higher in on-pump group. In addition, the mortality rate of on-pump group was significantly higher than the off-pump group. Several studies have compared the efficacy and safety of on-pump and off-pump surgery (4, 5). Amouzeshi et al. conducted his study on patients who underwent primary isolated non-emergent CABG. He showed there was no difference between on-pump and off-pump CABG. Amouzeshi and his collaborators reported only three deaths among 61 patients(6). In Amouzeshi study was no difference in post-operative complication. However, our study showed that plural effusion was significantly higher in on-pump group. This finding may not be the consequence of on-pump surgery, as we showed that the pulmonary diseases were significantly more prevalent among on-pump group. In fact, the post-operative pulmonary complication may be the result of history of pulmonary disease. In addition, our study showed that post-operative infection was more common among on-pump group; however, it did not reach significance ($p=0.055$). another study conducted by straka et al in the Czech republic showed that, there was no difference in mortality rate and post-operative complication including MI, stroke, atrial fibrillation, wound infection, and renal failure between on-pump and off-pump group(7). Confirming our result, straka showed that, total blood loss was lower in off-pump CABG. Our study showed that on-pump group needed significantly higher volume of blood transfusion during the surgery; however, there was no different in blood transfusion in the first, second, and third days after surgery. Length of ICU stay and hospitalization had no differences between groups. However, on the contrary, our study showed on-pump CABG required longer ICU care and hospitalization. Also, Straka showed, despite the same length of hospitalization and ICU care, off-pump CABG had significantly lower expenses. This

finding was confirmed in our study. Two previous studies, declared that both off-pump and on-pump surgery are safe equally. However, Several studies have supported this idea that off-pump CABG may be associated with lower mortality and post-operative complication(8). As an example. Le bivic et al. showed that off-group were significantly associated with lower rate of myocardial damage in thirty days after CABG surgery. In addition, in a follow-up of 7.6 years, off-pump CABG had significantly better survival rate (9). Scott et al. also concluded that on-pump CABG was associated with higher expenses. In scott study, they found that undergoing off-pump CABG was significantly associated with shorter time to tracheal extubation, lower volume of blood transfusion, shorter length of hospital stays and ICU care. Post-operative complication was not significantly different between off-pump and on-pump group, except for bleeding. That was the reason of higher volume of blood transfusion in on-pump group (10). In addition to bleeding, velioglu reported that Atrial fibrillation was the other post-operative complication after on-pump CABG (8). In a meta-analysis conducted by Takagi in eight RCTs of on-pump versus off-pump CABG, it was shown that off-pump CABG significantly increased the mortality rate (11). Takagi hypothesized that this result may be the consequence of graft occlusion; as it was previously shown by Zhang et al. that off-pump CABG was associated by increased risk of occlusion in all grafts (12).The efficacy and safety of off-pump and on-pump CABG is still under debate. The successful outcome of CABG is completely depended on surgeon performance. On the other hand, medical history of the patients may affect the successful outcome of CABG; as it was shown in our study that on-pump CABG was associated with plural effusion. In addition, the pulmonary disease was more prevalent in on-pump group. Also, number graft may have influence on the outcome of CABG. Off-pump CABG is thought to be more successful when more grafts are performed(13). The main limitation of this study is that both groups did not match in medical history. Also, the experience of surgeons and number

of grafts did not consider as independent variables to be compared between the groups.

Conclusion

In conclusion, findings of this study showed that the patients who underwent on-pump surgery, required longer hospitalization, and ICU care. Also needs for reoperation was more common among on-pump surgery. Total expenses were significantly higher in on-pump group. In addition, the mortality rate of on-pump group was significantly higher than the off-pump group. Altogether, it seems that off-pump surgery is safer with low expenses than on-pump CABG.

Conflict of interest: None

Acknowledgments

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