Off-Pump Coronary Artery Bypass Surgery in Severe Left Ventricular Dysfunction

Rasoul Azarfarin, Leili Pourafkari, Rezayat Parvizi, Azin Alizadehasl and Roghaiyeh Mahmoodian

Asian Cardiovascular and Thoracic Annals 2010 18: 44
DOI: 10.1177/0218492309354126

ORIGINAL ARTICLE

Off-Pump Coronary Artery Bypass Surgery in Severe Left Ventricular Dysfunction

Rasoul Azarfarin, MD, Leili Pourafkari, MD, Rezayat Parvizi, MD, Azin Alizadehasl, MD, Roghaiyeh Mahmoodian, MS

Cardiovascular Research Center
Tabriz University of Medical Sciences
Tabriz, Iran

ABSTRACT

Our aim was to examine hospital outcomes of coronary artery bypass surgery in patients with and without left ventricular dysfunction, with regard to the surgical technique (off- or on-pump). Between March 2007 and March 2008, 689 consecutive patients underwent isolated first-time coronary artery bypass; 127 had ejection fractions ≤30% (group 1) and 562 had ejection fractions >30% (group 2). Data of preoperative risk profiles and hospital outcomes were collected prospectively. Off-pump operations were performed in 49 (38.6%) patients in group 1 and 196 (34.9%) in group 2. The incidences of infectious, neurologic, and cardiac complications postoperatively were significantly higher in group 1. In multivariate analysis, preoperative ejection fraction ≤30% was found to be an independent risk factor for postoperative complications and hospital mortality. The subgroup of patients undergoing off-pump surgery in both groups had a significantly lower rate of total complications than those undergoing conventional on-pump operations, but no significant difference in mortality was observed between those undergoing off-pump or conventional surgery in either group. Off-pump surgery helped to limit the increased morbidity rate after coronary bypass in patients with ventricular dysfunction.

(Asian Cardiovasc Thorac Ann 2010;18:44–8)

KEYWORDS: Left Ventricular Dysfunction, Coronary Artery Bypass, Off-Pump, Hospital Mortality, Postoperative Complications

INTRODUCTION

Despite improvements in medical treatment and surgical techniques, the management of patients with coronary artery disease and left ventricular (LV) dysfunction is still debated.[1] Medical treatment has often been unsatisfactory with poor long-term survival.[2,3] Alternatives include heart transplantation, implantation of an LV assist device, and coronary artery bypass grafting (CABG).[1,4,5] The first 2 options are limited by the lack of organ donors and high costs. CABG has been shown to be superior to medical therapy alone for patients with LV dysfunction, although it still represents a technical challenge.[4,6–8] Surgical revascularization in these patients has historically been associated with high perioperative mortality and morbidity, making cardiologists reluctant to refer them for CABG, and surgeons hesitant to accept them.[5,9] Such patients are still considered to be at higher risk, with a higher mortality rate than those with normal LV function.[1,6,8] A low LV ejection fraction (EF) is associated with increased 30-day mortality.[1] However, recent studies have shown improved outcomes of CABG in patients with LV dysfunction, encouraging surgical revascularization in this high-risk group.[5,11] As increasing numbers of patients with LV dysfunction are being referred for CABG, more study is needed to identify the factors affecting surgical outcome. We investigated postoperative complications and hospital mortality in patients

Azin Alizadehasl, MD Tel: +98 411 3363880 Fax: +98 411 3344021 Email: alizadeasl@yahoo.com
Cardiovascular Research Center, Madani Heart Hospital, Tabriz University of Medical Sciences, Tabriz, Iran.
doi: 10.1177/0218492309354126

with and without severe LV dysfunction undergoing either off-pump coronary artery bypass (OPCAB) or conventional CABG on cardiopulmonary bypass (CPB).

Patients and Methods

This was a single institutional observational study at Tabriz Madani Heart Center, a tertiary referral center in the northwest of Iran, between March 2007 and March 2008, on 689 consecutive patients who underwent isolated first-time CABG. Of these, 127 (18.4%) patients had EF ≤30% (group 1), and 562 (81.6%) had EF >30% (group 2). An off-pump technique was used in 49 (38.6%) operations in group 1, and 196 (34.9%) in group 2. All data were collected prospectively during hospitalization, including demographic characteristics, risk factors and comorbidities, operative and postoperative data. Patients with a body mass index >30 kg m^{-2} were considered obese, and those >75-years old were categorized in the advanced age group. Prolonged aortic crossclamp time and pump time were defined as >90 min, and >120 min, respectively. Infectious complications included pneumonia, wound infection, urinary tract infection, and sepsis. Cardiac complications were defined as life-threatening arrhythmias, severe hemodynamic disturbance (>30% decrease in mean arterial pressure vs. baseline), myocardial infarction, use of 2 or more inotropics, and intraaortic balloon pump insertion. Patients who had associated cardiac surgical procedures, such as aneurysmectomy or concomitant valvular surgery, and those who had prior CABG or moderate to severe mitral regurgitation were excluded from this study.

Preoperative angiography and echocardiography were performed in all patients in our center or in the referring center. EF was determined preoperatively by angiography and echocardiography. All patients underwent CABG (on- or off-pump) through a full median sternotomy. In the 444 patients who had conventional CABG, CPB with hypothermia (systemic temperature of 30°C–34°C) was instituted after routine anesthesia. In the 245 patients who had OPCAB, stabilization of the target vessels was carried out using a tissue stabilizer, and heparin was administered. Intraluminal shunts were used when deemed necessary by the operating team. The decision for OPCAB was made on the basis of the preference of the surgeon and with regard to associated preoperative morbidities and coronary artery anatomy. OPCAB was preferred to reduce CPB-related complications in patients who were considered at high risk for CPB due to comorbidities, and also in those with noncalcified coronary vessels with non-intramuscular courses, and target arteries >1.5 mm in size.

Continuous data are expressed as median and interquartile range, and categorized data as percentages. Patient characteristics and hospital outcomes were compared by univariate analysis using the *t* test for continuous variables and the chi-squared or Fisher's exact test for categoric variables. Multivariate analysis with logistic regression was used to determine independent risk factors for hospital mortality and postoperative complications. The nonparametric Mann-Whitney *U* test was used to assess the significance of differences between means with unequal sample sizes. A p value <0.05 was considered statistically significant. SPSS statistical software version 16.0 (SPSS, Inc., Chicago, IL, USA) was used for all analyses.

Results

Baseline characteristics of the study groups are shown in Table 1. There were no significant differences between the 2 groups in terms of age and sex distribution. Group 2 had higher incidences of diabetes mellitus, hypertension, obesity, and smoking history, but there was no difference in the prevalence of advanced age. Operative data are shown in Table 2. Patients in group 1 required prolonged CPB time significantly more often. Postoperative complications are summarized in Table 3. The incidences of cardiac complications, neurologic events, and infections were significantly higher in patients with ventricular dysfunction, reflected in longer ventilation time, intensive care unit stay, and hospitalization. Postoperative data according to the method of surgery are shown in Table 4. The subgroup

Table 1. **Baseline characteristics of patients with (group 1) and without (group 2) ventricular dysfunction**

Variable	Group 1	Group 2	*p* Value
No. of patients	127	562	
Age (years)	57.8 ± 9.9	58.4 ± 9.5	0.553
Sex (male/female)	104/23	422/140	0.114
Ejection fraction	27.0% ± 4.1%	48.2% ± 7.8%	
Diabetes mellitus	102 (80%)	174 (31%)	0.0001
Hypertension	101 (80%)	298 (53%)	0.0001
Smoker	107 (84%)	258 (46%)	0.0001
Obese	20 (16%)	179 (32%)	0.0001
Age >75 years	10 (8%)	60 (11%)	0.372
3-vessel disease	93 (73%)	401 (71%)	0.673

Table 2. **Operative data in patients ± ventricular dysfunction undergoing coronary artery bypass**

Variable	Group 1	Group 2	*p* Value
No. of patients	127	562	
Off-pump surgery	49 (38.6%)	196 (34.9%)	0.503
Crossclamp time >90 min	16 (12.6%)	33 (5.9%)	0.073
Pump time >120 min	50 (39.4%)	109 (19.4%)	0.0001

of patients undergoing OPCAB surgery in both groups had a significantly lower total complication rate than those undergoing CABG under CPB. Patients with severe LV dysfunction had a significantly higher hospital mortality rate. The causes of death in group 1 patients were cardiogenic shock in 8, arrhythmia in 1, and sepsis in 2. The causes of death in group 2 were cardiogenic shock in 6 patients, mediastinitis in 1, multiorgan failure in 2, and arrhythmia in one. In multivariate analysis with logistic regression, preoperative EF ≤ 0.3 was found to be an independent risk factor for postoperative complications ($p = 0.042$) and hospital mortality ($p = 0.001$) after CABG. Patients undergoing OPCAB, regardless of EF, had lower rates of cardiac complications and total complications, and shorter mechanical ventilation times.

Discussion

It has been shown that CABG provides a survival benefit over medical therapy alone in patients with LV dysfunction and coronary artery disease.[2,3] Alternatives to CABG, such as implantation of LV assist devices and transmyocardial laser revascularization, are restricted; therefore, CABG offers the only feasible chance of improved survival for most patients with severe LV dysfunction.[7,12] Nevertheless, the outcomes have often been controversial and depend on patient selection, baseline workup, and critical decision-making.[8] In a systematic review of CABG trials, Nalysnyk and colleagues[10] identified low EF, history of stroke, myocardial infarction, or heart surgery, and the presence of diabetes or hypertension with increased 30-day mortality. Morrison and colleagues[13] found higher early mortality in patients with severe LV systolic dysfunction, in a review of prospective and retrospective registries including more than 2,000 patients. OPCAB has gained popularity in recent years, and may improve the outcome in cases of severe LV dysfunction.[12] Gurbuz and colleagues[14] reported that experienced surgeons can perform OPCAB with similar rates of adverse cardiac events to conventional CABG. Elderly patients with multiple comorbidities may benefit most from OPCAB.[15] Al Ruzzeh and colleagues[16] noted that OPCAB in high-risk patients with multivessel disease had a similar 30-day mortality but fewer major complications than CABG.

Patients with LV dysfunction constituted 18.4% of our study population, in contrast to 4%–17% in other studies.[1,7,14,17] The higher incidence of low EF in our study could be explained in part by the fact that our institution is a tertiary referral center. In addition, with ongoing improvements in percutaneous techniques, the number of low-risk patients offered CABG as primary revascularization has decreased. Our 2.2% hospital mortality in patients with EF >30% compares favorably with similar studies. Hospital mortality has been reported as 2.7%–3% in patients with EF of 31%–40%, and 1.4%–1.6% in those with EF >40%.[1,7] The mortality rate of 9.5% in patients with LV dysfunction in our study was higher than expected, probably due to multiple factors. Unlike some previous series, we did not exclude urgent and emergency operations. Also, the more restricted definition of LV dysfunction as EF <30%, rather than higher cut-off points of 35% or 40% in some studies, might be somewhat responsible.[4,18,19] The higher incidence of comorbidities in the LV dysfunction group might also be a factor (e.g. 80% had diabetes).[1,5–8] Operative mortality in 141 patients with EF <25% was 7% in a study by Bouchart and colleagues.[6] Shapira and colleagues[5] did not identify low EF per se as a predictor of hospital mortality, but found it was associated with a higher incidence of postoperative complications; they concluded that CABG should be considered a safe and effective treatment for patients with LV dysfunction. In contrast, we found that preoperative EF $\leq$30% was an independent risk factor for postoperative complications and hospital mortality. A large study on 55,515 patients undergoing CABG concluded that those with low EF were sicker at baseline and had more than 4-times higher mortality than patients with normal EF.[1] We found significantly higher rates of

Table 3. **Postoperative data in patients ± ventricular dysfunction**

Variable	Group 1	Group 2	*p* Value
Cardiac complications	45 (35.4%)	106 (18.9%)	0.0001
Neurologic events	7 (5.5%)	9 (1.6%)	0.042
Infectious complications	7 (5.5%)	5 (0.9%)	0.033
Inotropic use	40 (31.5%)	99 (17.6%)	0.041
Intraaortic balloon pump	13 (10.2%)	2 (0.4%)	0.001
Ventilation time (h)	10.3 (6.3–19.0)	6.0 (5.0–9.5)	0.0001
Intensive care (days)	4.0 (3.0–5.0)	3.0 (2.0–4.0)	0.0001
Hospital stay (days)	14.0 (9.0–22.0)	7.0 (6.0–8.0)	0.0001
Mortality	12 (9.4%)	12 (2.1%)	0.001

Table 4. **Postoperative data according to operative technique and left ventricular ejection fraction**

	Ejection Fraction ≤30%			Ejection Fraction >30%			Total		
Variable	Off-Pump	On-Pump	*p* Value	Off-Pump	On-Pump	*p* Value	Off-Pump	On-Pump	*p* Value
No. of patients	49	78		196	366		245	444	
Cardiac complications	11 (22.4%)	34 (43.6%)	0.022	28 (14.3%)	78 (21.3%)	0.010	39 (15.9%)	112 (25.2%)	0.021
Neurologic events	2 (4.1%)	5 (6.4%)	0.658	2 (1.0%)	7 (1.9%)	0.173	4 (1.6%)	12 (2.7%)	0.265
Infectious complications	3 (6.1%)	4 (5.1%)	1.000	0	5 (1.4%)	0.171	3 (1.2%)	9 (2.0%)	0.473
Total morbidity*	13 (26.5%)	36 (46.2%)	0.043	22 (11.2%)	103 (28.1%)	0.001	35 (14.3%)	139 (31.3%)	0.001
Death	3 (6.1%)	9 (11.5%)	0.603	2 (1.0%)	10 (2.7%)	0.405	5 (2.0%)	19 (4.3%)	0.134
Ventilation time (h)	8.0 (6.0–12.0)	12.0 (6.0–20.3)	0.039	6.0 (5.0–8.0)	6.0 (5.0–10.0)	0.087	7.0 (5.0–9.5)	7.0 (5.0–12.6)	0.036
Intensive care (days)	3.0 (2.0–6.0)	4.0 (3.0–5.0)	0.561	3.0 (2.0–3.0)	3.0 (2.0–4.0)	0.009	3.0 (2.0–4.0)	3.0 (2.0–4.0)	0.073
Hospital stay (days)	12.0 (8.0–22.0)	15.0 (9.0–22.0)	0.392	6.0 (5.0–7.0)	7.0 (5.0–8.0)	0.122	7.0 (6.0–10.0)	7.0 (6.0–10.0)	0.401

*Some patients had > 1 complication.

postoperative cardiac complications, neurologic events, and infections, intraaortic balloon pump and inotropic support in patients with LV dysfunction. Few studies have addressed this issue.[1,6]

The rate of total complications in our study was significantly lower in patients undergoing OPCAB in both groups. Arom and colleagues[20] reported operative mortality of 4.4% for OPCAB in patients with EF <30%, compared to 7.5% in the on-pump population, and suggested that OPCAB could be a viable alternative to conventional CABG on CPB, particularly for patients with LV dysfunction. In a study on the effect of CPB on outcomes of myocardial revascularization in patients with low EF, Darwazeh and colleagues[4] found a lower mortality rate after OPCAB (6.1% vs. 10.7%) in spite of a higher preoperative predicted risk score. Our patients with low EF undergoing OPCAB had a mortality rate of 6.1% vs. 11.5% in those undergoing conventional CABG, in agreement with the results of previous studies.

The present study has some limitations that deserve mention. One pertains to the restriction of clinical outcomes to postoperative morbidity and hospital mortality, with no follow-up beyond these endpoints. Further studies to investigate long-term outcomes are necessary. Another limitation is that we did not categorize low EF patients on the basis of symptoms (failure predominant or angina predominant) or routinely perform myocardial viability evaluations. Patients with LV dysfunction and anginal symptoms with larger proportions of viable myocardium may benefit more from CABG than those with symptoms of cardiac failure in the absence of angina.[6] A further limitation is that we used EF for the definition of LV dysfunction. Although most similar studies used the same definition, it may not be reliable because it overlooks other important parameters such as LV dilation and extent of akinetic scars.[8] Also, we did not investigate completeness of revascularization; there have been concerns regarding incomplete revascularization in OPCAB compared to conventional CABG.[4]

Patients with compromised LV function more frequently experience postoperative complications, and hospital mortality remains higher than those without LV dysfunction. This increased mortality risk is not prohibitively high in patients who stand to benefit significantly from surgical revascularization, but it emphasizes the need for careful patient selection and preoperative attention in this high-risk group. Our data support a reduction by OPCAB of the higher postoperative morbidity in patients poor LV function; however, there was no improvement in hospital mortality.

References

1. Topkara VK, Cheema FH, Kesavaramanujam S, Mercando ML, Cheema AF, Namerow PB, et al. Coronary artery bypass grafting in patients with low ejection fraction. Circulation 2005;112(Suppl I)344–50.
2. Alderman EL, Fisher LD, Litwin P, Kaiser GC, Myers WO, Maynard C, et al. Results of coronary artery surgery in patients with poor left ventricular function (CASS). Circulation 1983;68:785–95.
3. Pigott JD, Kouchoukos NT, Oberman A, Cutter GR. Late results of surgical and medical therapy for patients with coronary artery disease and depressed left ventricular function. J Am Coll Cardiol 1985;5:1036–45.
4. Darwazah AK, Abu Sham'a RA, Hussein E, Hawari MH, Ismail H. Myocardial revascularization in patients with low ejection < or = 35%: effect of pump technique on early morbidity and mortality. J Card Surg 2006;21:22–7.
5. Shapira OM, Hunter CT, Anter E, Bao Y, DeAndrade K, Lazar HL, et al. Coronary artery bypass grafting in patients with severe left ventricular dysfunction: early and mid-term outcomes. J Card Surg 2006;21:225–32.
6. Bouchart F, Tabley A, Litzler PY, Haas-Hubscher C, Bessou JP, Soyer R. Myocardial revascularization in patients with severe ischemic left ventricular dysfunction. Long-term follow-up in 141 patients. Eur J Cardiothorac Surg 2001;20:1157–62.
7. Trachiotis GD, Weintraub WS, Johnston TS, Jones EL, Guyton RA, Craver JM. Coronary artery bypass grafting in patients with advanced left ventricular dysfunction. Ann Thorac Surg 1998;66:1632–9.
8. Ascione R. Severe left ventricular dysfunction: a continuous surgical challenge. J Card Surg 2006;21:233.
9. Mitropoulos FA, Elefteriades JA. Myocardial revascularization as a therapeutic strategy in the patient with advanced ventricular dysfunction. Heart Fail Rev 2001;6:163–75.
10. Nalysnyk L, Fahrbach K, Reynolds MW, Zhao SZ, Ross S. Adverse events in coronary artery bypass graft (CABG) trials: a systematic review and analysis. Heart 2003;89:767–72.
11. Ascione R, Narayan P, Rogers CA, Lim KH, Capoun R, Angelini GD. Early and midterm clinical outcome in patients with severe ventricular dysfunction undergoing coronary artery surgery. Ann Thorac Surg 2003;76:793–9.
12. Nishi H, Miyamoto S, Takanashi S, Minamimura H, Ishikawa T, Shimizu Y. Complete revascularization in patients with severe left ventricular dysfunction. Ann Thorac Cardiovasc Surg 2003;9:111–6.
13. Morrison D. What is the evidence for percutaneous coronary intervention or coronary artery bypass graft in ischemic cardiomyopathy [Review]? Am Heart Hosp J 2005;3:175–81.
14. Gurbuz AT, Zia AA, Cui H, Sasmazel A, Ates G, Aytac A. Predictors of mid-term symptom recurrence, adverse cardiac events and mortality in 591 unselected off-pump coronary artery bypass graft patients. J Card Surg 2006;21:28–34.
15. Salzberg SP, Adams DH, Filsoufi F. Coronary artery surgery: conventional coronary artery bypass grafting versus off-pump coronary artery bypass grafting [Review]. Curr Opin Cardiol 2005;20:509–16.
16. Al-Ruzzeh S, Nakamura K, Athanasiou T, Modine T, George S, Yacoub M, et al. Does off-pump coronary artery bypass (OPCAB) surgery improve the outcome in high-risk patients? a comparative study of 1398 high-risk patients. Eur J Cardiothorac Surg 2003;23:50–5.
17. Salomon NW, Page US, Bigelow JC, Krause AH, Okies JE, Metzdorff MT. Coronary artery bypass grafting in elderly patients. Comparative results in a consecutive series of 469 patients older than 75 years. J Thorac Cardiovasc Surg 1991;101:209–18.
18. Pocar M, Moneta A, Grossi A, Donatelli F. Coronary artery bypass for heart failure in ischemic cardiomyopathy: 17-year follow-up. Ann Thorac Surg 2007;83:468–74.
19. Soliman Hamad MA, Peels K, Van Straten A, Van Zundert A, Schönberger J. Coronary artery bypass surgery in patients with impaired left ventricular function. Predictors of hospital outcome. Acta Anaesthesiol Belg 2007;58:37–44.
20. Arom KV, Emery RW, Flavin TF, Kshettry VR, Petersen RJ. OPCAB surgery: a critical review of two different categories of pre-operative ejection fraction. Eur J Cardiothorac Surg 2001;20:533–7.