A Comparison of Immediate Postoperative Complications in using Left Internal Mammary Artery + Vein Versus only Vein as Conduit in Patients Undergoing off-Pump Coronary Artery Bypass Grafting

Abstract

Objective: The objective of the study is to compare the immediate postoperative cardiac complications in patients undergoing off-pump coronary artery bypass grafting (OPCABG) using mixed (arterial and venous grafts) versus only venous grafts and to compare the requirement of packed red cell units and intra-aortic balloon pump (IABP) in both the groups. Materials and Methods: This was an observational, analytical, prospective study. Sample Size: Fifty new patients were included in the study. Inclusion/Exclusion Criteria: Patients diagnosed with triple-vessel coronary artery disease (CAD) undergoing OPCABG with an ejection fraction (EF) of more than 30%. Patients who have undergone prior CABG, EF <30%, preexisting valvular heart disease, any evidence pulmonary hypertension, preoperative IABP, any history of neurological dysfunction, left atrium size more than 5.5 cm, and history of coagulation disorder was excluded from the study. Results: The most common immediate postoperative cardiac complication observed was atrial fibrillation followed by ventricular arrhythmias in both the groups. There was no statistically significant difference in complication rate between the two groups. Postoperative requirement of IABP and requirements of blood products were also similar in both the groups. Conclusion: Patients undergoing off-pump CABG have similar immediate postoperative complications irrespective of the type of conduit used.

Keywords: Atrial fibrillation, blood transfusion, internal mammary artery, intra-aortic balloon pump, myocardial revascularization, off-pump coronary artery bypass grafting

Introduction

Adam Hammer in 1876 established pathophysiology of coronary artery disease (CAD), establishing that angina was caused by interruption of coronary blood supply and that myocardial infarction occurred after the occlusion of at least one coronary artery. Coronary artery bypass grafting (CABG) is a procedure where section of a blood vessel is grafted from the aorta to the coronary artery to bypass the blocked section of the coronary artery, thus improving the blood supply to the heart. In 2004, CAD was the leading cause of death in India, leading to 1.46 million deaths. There is always a debate between percutaneous coronary intervention (PCI) and surgical revascularization. The surgical revascularization provides better long-term results, thus favoring CABG over PCI for revascularization.

Preoperative clinical condition has also been associated with postoperative outcome and the preoperative presence of angina is a positive predictor of improved life expectancy despite impaired left ventricular (LV) function as compared to patients with heart failure symptoms and dyspnea.

CABG with the use of the left internal mammary artery (LIMA) and saphenous vein grafts is the standard and widely accepted surgical approach in the treatment of CAD.

Vasospasm of the arterial grafts is a serious perioperative complication and may result in IMA hypoperfusion syndrome with its high mortality. Harvesting of both right and left IMAs, particularly in the diabetic patient, is associated with an increased incidence of sternal wound infections because in the process ofIMA dissection, the sternal branches are sacrificed so sternal blood supply is jeopardized. CABG with the use of arterial conduits and the sequential
anastomotic techniques has been the trend. Harvesting of bilateral mammary arteries is more time-consuming and may result in increased operative time.\(^7\)

MORBIDITIES such as atrial fibrillation, ventricular arrhythmias, renal dysfunction, and stroke after CABG are more common in patient with poor LV function. Intensive care unit stay and mean hospital stay are also longer in these low ejection fraction (EF) patients and contribute to postoperative morbidity and mortality.\(^8\)

The use of IMA as a conduit has proven to be superior for its long-term patency rates, whereas saphenous vein graft being larger caliber vessel achieves superior flow dynamics in the early postoperative period.\(^9\)

Off-pump technique has reduced the complications associated with extracorporeal circulation and heart–lung machine, thus contributes to better surgical outcome.\(^10\)

Although many studies have demonstrated the long-term advantage of using mixed conduits (LIMA + vein) instead of only venous conduits in terms of graft patency, a very few studies have compared the incidence of postoperative cardiac complications. Our present study aims to compare the above-mentioned parameters in both the groups.

**Materials and Methods**

The study was carried out over a period of 12 months. This is prospective, observational, analytical study. All patients attending our hospital for bypass surgery during the study period were considered as sample. During this period, 50 patients were selected for the study which fulfilled the following inclusion and exclusion criteria as follows:

**Inclusion criteria**

Patients diagnosed with triple-vessel CAD requiring off-pump surgical myocardial revascularization with a left ventricle EF (LVEF) of more than 30%.

**Exclusion criteria**

Prior cardiac surgery for myocardial revascularization, LVEF <30%, any preexisting valvular heart disease, any evidence of pulmonary hypertension, CABG with the use of cardiopulmonary bypass machine, preoperative IABP, patients with left atrium size more than 5.5 cm, or patients with a history of coagulation disorder.

All selected patients were divided into two groups alternatively to receive either mixed LIMA + veins or only veins as conduits. In the first Group A (mixed conduits group), pedicle LIMA and reverse saphenous vein were used as conduits. In Group B (venous conduits group), reverse saphenous vein only was used as conduit.

Demographic and anthropometric indices were recorded for all patients which included age, sex, and other demographic details. Preoperatively, all patients underwent routine blood and other investigations.

Antiplatelets (aspirin and clopidogrel) were stopped 3 days before surgery. Induction of anesthesia was carried out using standard high narcotic induction in all patients with an aim to minimize hemodynamic changes during induction of anesthesia as per the standard protocol of the institute. The procedure performed was off-pump CABG. All patients were given heparin after harvesting of conduits, and the same was reversed with protamine with a ratio of 1:1. At the end of surgery, pleural and mediastinal chest tubes were placed and drainage was carefully monitored and compared. Postoperatively, all patients underwent elective controlled ventilation with routine monitoring as for any cardiac surgical case. A note of certain complications was documented for study purpose which included atrial fibrillation, ventricular arrhythmias, and IABP requirement. Need for blood transfusion and actual unit transfused was noted down with a target of keeping the hemoglobin level more than 10 g\% or a hematocrit above 30. The duration of ventilation was depending on clinical condition, bleeding status, and fitness criteria for extubation as per institute protocols.

Continuous variables are presented as mean ± standard deviation, and categorical variables are presented as absolute numbers and percentage. The comparison of normally distributed continuous variables between the groups was performed using Student’s \(t\)-test. Nominal categorical data between the groups were compared using Chi-squared test or Fisher’s exact test as appropriate. \(P < 0.05\) was considered statistically significant.

**Results**

The mean age between the two groups was 58.88 ± 6.86 (Group A) and 63.04 ± 8.96 years (Group B) (\(P = 0.079\)). The mean body mass index (BMI) (kg/m\(^2\)) of Group A was 25.75 ± 4.06 kg/m\(^2\) while of Group B was 23.77 ± 3.03 kg/m\(^2\) (\(P = 0.056\)) [Table 1].

There were 80% males and 20% females in Group A and 88% males and 12% females in Group B, and gender distribution was comparable (\(P = 0.440\)).

The prevalence of diabetes was 44% in Group A and 32% in Group B (\(P = 0.556\)) while that of hypertension was 24% in Group A and 28% in Group B (\(P = 0.747\)).

It was observed that there were 24% patients in Group A and 44% patients in Group B with NYHA Class I and II symptoms, whereas there were 76% patients in Group A and 56% patients in Group B with Class III and IV symptoms (\(P = 0.136\)).

It was observed that under in Group A, mean hemoglobin value was 12.18 (±1.95) gm\%, whereas in Group B, it was 12.46 (±1.99) g%. Mean creatinine levels were 1.01 ± 0.30 and 0.95 ± 0.28, respectively, in both the groups. It was observed that there was no significant
Table 1: Illustrations of anthropometric indices, routine blood investigations, comparison of complications, blood loss, and blood products requirement

|                         | Group A            | Group B            | P    |
|-------------------------|--------------------|--------------------|------|
| Age (years)             | 58.88±6.85         | 63.04±8.96         | 0.079|
| Gender (%)              |                    |                    |      |
| Female                  | 20                 | 12                 | 0.44 |
| Male                    | 80                 | 88                 | 0.44 |
| BMI                     | 25.75±4.06         | 23.77±3.03         | 0.056|
| Hb                      | 12.18±1.95         | 12.46±1.99         | 0.622|
| TLC                     | 8.55±2.76          | 9.86±3.99          | 0.186|
| Creatinine              | 1.01±0.30          | 0.95±0.28          | 0.450|
| Bilirubin               | 0.66±0.58          | 0.68±0.33          | 0.874|
| FBS                     | 109.32±26.55       | 110.68±31.93       | 0.871|
| DM (%)                  | 40                 | 32                 | 0.556|
| Hypertension (%)        | 24                 | 28                 | 0.747|
| Angina (Class III, IV) (%) | 76               | 56                 | 0.136|
| Preoperative LVEF (%)   | 44.92±6.82         | 44.28±6.76         | 0.74 |
| LVEF after surgery (%)  | 49.72±5.78         | 51.60±5.94         | 0.262|
| LVEF at 6 weeks (%)     | 51.96±5.30         | 56.16±4.13         | 0.002|
| Drain output (ml)       | 295.56±145.45      | 265.20±144.60      | 0.463|
| Atrial fibrillation (%) | 36                 | 16                 | 0.196|
| Ventricular arrhythmias (%) | 12             | 8                  | 1    |
| IABP requirement (%)    | 8                  | 8                  | 1    |
| PRBC requirement (%)    | 4                  | 3.2                | 0.556|
| Mortality               | Nil                | Nil                | -    |

Hb: Hemoglobin, BMI: Body mass index, TLC: Total lymphocyte count, LVEF: Left ventricle ejection fraction, IABP: Intra-aortic balloon pump, PRBC: Packed red blood cell, DM: Diabetes mellitus, FBS: Fasting blood glucose

difference in routine investigations between the two groups.

The mean drain output (blood loss) in the first 24 h of Group A was 295.56 ± 145.45 ml while that of Group B was 265.20 ± 144.60 ml, although the drain output was more in Group A, the difference was not statistically significant between the two groups (P = 0.463).

The most common complication in both the groups was atrial fibrillation (AF) with the incidence of 36% in Group A and 16% in Group B (P = 0.196). It was followed by ventricular arrhythmias (12% and 8%, respectively, with P = 1.000). The most common ventricular arrhythmias seen were ventricular premature beats, bigeminy rhythm, or nonsustained short runs of ventricular tachycardia. Most of these were treated with correction of electrolytes and occasional bolus dose of IV lignocaine. Reexploration was done in one case in Group A who was on antiplatelets for acute chest pain, while there was no incidence of reexploration in Group B. IABP was required in two patients in each group with low EF and AF and they recovered eventually. Requirement of packed red blood cell units was also similar in both the groups. It was observed that there was no mortality in either group.

Discussion

In 1910, Alexis Carrel was the first to describe CABG procedure. Goetz R in 1960 first reported CABG using the IMA in humans. From 1962 to 1967, human CABG using autogenous saphenous vein grafts was performed by cardiac surgical groups by, namely, Sabiston D (1962), Garrett H (1964), Kahn D (1966), and Favaloro R (1967) and many more. Thoracoscopic harvesting of the LIMA was reported in 1998 by Duhaylongsod et al. and in the present scenario, more and more surgeons are moving toward minimally invasive and robotic surgical approaches.

Similar results were observed by Edwards et al. Majority of patients in their study were in age group of 50–70 years. Their study had 79% male and 21% female patients in mixed group whereas 69% males and 31% females in venous group. In a study conducted by Jegaden et al., the average age in LIMA group was 66 years and in venous group was 68 years. The mean age in their study in both the groups was higher as compared to our study, probably because higher prevalence of CAD in Indian population and also at a younger age. In patients <70 years, the incidence of CAD-related deaths in India is 50%, whereas only 22% in Western countries.

The mean BMI (kg/m²) of Group A was 25.75 ± 4.06 kg/m² while of Group B was 23.77 ± 3.03 kg/m² (P = 0.056), representing similar characteristics of patients in both groups, similar observation was in the studies conducted by Jegaden et al. and Mehsood et al. with no difference in BMI in both the groups.

In our study, the prevalence of diabetes was 44% and 28% and the prevalence of hypertension was 24% and 48% in Group A and B, respectively, (P = 0.239 and 0.077, respectively). Edwards et al. noticed the prevalence of diabetes were 22.02% patients in LIMA group and 20.25% patients in non-LIMA group. About 48.70% were hypertensive in mixed group and 45.45% were hypertensive in venous group.

The prevalence of diabetes and hypertension was 24.7% and 50.7%, respectively, in IMA and venous groups (P = 0.99) in study conducted by Jegaden et al. These findings are in contrast to the results of our study.

Mehsood et al. in his study observed that there were 26% diabetic patients in both mixed and venous groups (P = 1.000) and there were 50% hypertensives in mixed group and 34% hypertensives in venous group (P = 0.105). This observation is in contrast with our study where we observed that number of hypertensives were more in venous group.

Jegaden et al. and Mehsood et al. in their studies observed that mean blood loss was significantly more in those patients where LIMA was harvested as conduit.
Choudhary et al. and Sethi et al. also observed similar results in their studies. These are in contrast to our results as there was no significant difference in chest tube drainage between the two groups. LIMA harvesting leaves a raw bed under the chest wall that has the potential to bleed after the chest is closed, and furthermore, there are chances of bleeding from intercostal branches of the LIMA.

The most common complication in our study in both the groups was AF with the incidence of 36% in Group A and 16% in Group B (P = 0.196). There was no statistically significant difference in the incidence of AF between the two groups. The AF was reverted with amiodarone and/or with beta-blocker.

For the incidence of AF, our results were comparable to those observed by Choudhary et al. and Hwang et al. They also conducted a comparative study to find the difference in the incidence of postoperative AF in patients operated using either arterial or venous conduits and found the incidence of AF ranged from 14% to 36% in both the groups. They found that there was no difference between the two groups.[18,20]

Mariscalco et al. published an observational study of 1878 consecutive participants undergoing CABG and found that postoperative AF was the most common adverse events that occurred in 20%–50% of the patients. They noted that post-CABG AF was associated with a fourfold increased risk of disabling cerebrovascular accident and threefold increased risk of cardiac-related death.[21] We also had the similar observation that the incidence of AF was more in elderly age group patients with low EF.[15,20]

Ergünes et al. also reported that morbidities such as postoperative AF were more common among patients with low EF.[22]

In our study, ventricular arrhythmias were noted in 12%–8% of cases in Groups A and B, respectively. Similar results were noted in a study by Skorpil et al., as they also found ventricular arrhythmia incidence of 5%.[23]

Mehsood et al. noticed higher rate of ventricular arrhythmias in venous group, that is, 18% compared to LIMA group 14%.[17]

The incidence of reexploration in our study was 4% in Group A whereas no reexploration was done in Group B. Jegaden et al., Karthik et al., and Hwang et al. in their studies found that the incidence of reexploration was similar in both the groups (around 2%–4%).[15,20,24] Results obtained in our study were comparable with these studies. Edwards et al. and Cosgrove et al. also reported similar observations.[14,25]

In contrast, Choudhary et al. and Mehsood et al. concluded that SVG group had lesser incidence of bleeding, blood transfusion, and less frequent reexploration as compared to IMA group.[17,18]

Bleeding after CABG surgery is a concern to all practicing cardiac surgeons. Some surgeons believe that taking down the LIMA leaves a raw bed under the chest wall that has the potential to bleed after the chest is closed. In addition, there is the possibility of bleeding from intercostal branches of the LIMA itself. The chance of bleeding increases if patient is on platelet inhibitors.[26]

In our study, IABP was required in two patients (8%) in each group who had low EF and AF (they recovered eventually following IABP placement).

Edwards et al. and Choudhary et al. in their study observed that IABP requirement was 5.53%–12.9% in LIMA group and 10.18%–17.2% in venous group.[14,18] Results obtained in our study were comparable with their study. Karthik et al. observed that in patients undergoing CABG, the IABP support postoperatively was required in 2.4% patients in LIMA group and 2.2% in non-LIMA group.[24] In contrast to their study, IABP requirement in our study was higher. Jegaden et al. in their study also observed that there was no difference in IABP requirement in arterial or venous group.[15]

In a study conducted by Topkara et al., patients were stratified into four groups according to EF. They concluded that requirement of IABP and LV assist device (during or after surgery) was significantly higher in patients with low EF. In our study also, we found that postoperative requirement of IABP was more in patients with low EF in both the groups.[27]

Conclusion
We conclude that the most common immediate postoperative cardiac complication was AF followed by ventricular arrhythmias in both the groups. There was no statistically significant difference between the complications compared. Postoperative requirement of IABP and requirements of blood products were also similar in both the groups. Further studies with long-term follow-up are required to confirm the above findings.

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Conflicts of interest
There are no conflicts of interest.

References
1. Westaby S. The foundations of cardiac surgery. Landmarks in Cardiac Surgery. Oxford University Press, Oxford, United Kingdom; 1997. p. 1-47.
2. Huffman MD. Coronary Heart Disease in India. Center for Chronic Disease Control. Indian Council of Medical Research. Available from: http://www.icmr.nic.in/biomarkers/biomarkers.htm. [Last accessed on 2009 Sept 29].
3. SoS Investigators. Coronary artery bypass surgery versus percutaneous coronary intervention with stent implantation in patients with multivessel
coronary artery disease (the stent or surgery trial): A randomised controlled trial. Lancet 2002;360:965-70.

4. Di Carli MF, Maddahi J, Rokhsar S, Schelbert HR, Bianco-Battles D, Brunken RC, et al. Long-term survival of patients with coronary artery disease and left ventricular dysfunction: Implications for the role of myocardial viability assessment in management decisions. J Thorac Cardiovasc Surg 1998;116:997-1004.

5. Taggart DP, Lees B, Gray A, Altman DG, Channon K, et al. Protocol for the arterial revascularisation trial (ART). A randomised trial to compare survival following bilateral versus single internal mammary grafting in coronary revascularisation [ISRCTN46552265]. Trials 2006;7:7.

6. Jones EL, Lattouf OM, Weintraub WS. Catastrophic consequences of internal mammary artery hypoperfusion. J Thorac Cardiovasc Surg 1998;98:902-7.

7. Kououchoukos NT, Wareing TH, Murphy SF, Pelate C, Marshall WG Jr. Risks of bilateral internal mammary artery bypass grafting. Ann Thorac Surg 1990;49:210-7.

8. Magee MJ, Herbert MA, Dewey TM, Edgerton JR, Prince S, et al. Atrial fibrillation after coronary artery bypass grafting surgery: Development of a predictive risk algorithm. Ann Thorac Surg 2007;83:1707-12.

9. Akasaka T, Yoshikawa J, Yoshida K, Hozumi T, Nasu M, et al. Flow capacity of internal mammary artery grafts: Early restriction and later improvement assessed by doppler guide wire. Comparison with saphenous vein grafts. J Am Coll Cardiol 1995;25:640-7.

10. Rastan AJ, Bittner HB, Gummert JF, Walther T, Schewick CV, Girdauskas E, et al. On-pump beating heart versus off-pump coronary artery bypass surgery-evidence of pump-induced myocardial injury. Eur J Cardiothorac Surg 2005;27:1057-64.

11. Shumacker HB. The evolution of cardiac surgery. Bloomington, Indiana: Indiana University Press; 1992.

12. Duhaylongsod FG, Mayfield WR, Wolf RK. Thoracoscopic harvest of the internal thoracic artery: A multicenter experience in 218 cases. Ann Thorac Surg 1998;66:1012-7.

13. Prasad SM, Ducko CT, Stephenson ER, Chambers CE, Damiano RJ Jr. Prospective clinical trial of robotically assisted endoscopic coronary grafting with 1-year follow-up. Ann Surg 2001;233:725-32.

14. Edwards FH, Clark RE, Schwartz M. Impact of internal mammary artery conduits on operative mortality in coronary revascularization. Ann Thorac Surg 1994;57:27-32.

15. Jegaden O, Bontemps L, de Gevigney G, Eker A, Montagna P, Chatel C, et al. Does the extended use of arterial grafts compromise the myocardial recovery after coronary artery bypass grafting in left ventricular dysfunction? Eur J Cardiothorac Surg 1998;14:353-9.

16. Gaziano TA. Economic burden and the cost-effectiveness of treatment of cardiovascular diseases in Africa. Heart 2008;94:140-4.

17. Mehsood DK, Khan MA, Iqbal MA, Janjua AM, Kiani MR. Vein grafts to left anterior descending (lad) in emergency coronary artery bypass graft (cabg) of elderly—does it merit? Pak Armed Forces Med J 2015;65Suppl 1:S11-5.

18. Choudhary AK, Singh C, Padia A, Sood AK, Singh R. Abstracts of the 59th annual conference of IACTS. Indian J Thorac Cardiovasc Surg 2013;29:57-81.

19. Sethi GK, Copeland JG, Moritz T, Henderson W, Zadina K, Goldman S, et al. Comparison of postoperative complications between saphenous vein and IMA grafts to left anterior descending coronary artery. Ann Thorac Surg 1991;51:733-8.

20. Hwang HY, Kim JS, Kim KB. Angiographic equivalency of off-pump saphenous vein and arterial composite grafts at one year. Ann Thorac Surg 2010;90:516-21.

21. Mariscalco G, Klersy C, Zanobini M, Banach M, Ferraresi S, Borsani P, et al. Atrial fibrillation after isolated coronary surgery affects late survival. Circulation 2008;118:1612-8.

22. Ergünes K, Yurekli I, LaFlam B, Gokalp O, Akyuz M, Yetkin U, et al. Coronary surgery in patients with low ejection fraction: Mid-term results. Asian Cardiovasc Thorac Ann 2013;21:137-41.

23. Skorpil J, Bráť R, Docelkal B, Motyka O. Myocardial revascularisation in patients with severe left ventricular dysfunction. Early and midterm results. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub 2004;148:55-8.

24. Karthik S, Srinivasan AK, Grayson AD, Jackson M, Mediratta NK. Left internal mammary artery to the left anterior descending artery: Effect on morbidity and mortality and reasons for nonusage. Ann Thorac Surg 2004;78:142-8.

25. Cosgrove DM, Loop FD, Lyle BW, Goormastic M, Stewart BW, Gill CC, et al. Does coronary artery grafting increase surgical risk? Circulation 1985;72:1170-4.

26. Leavitt BJ, O’Connor GT, Olmstead EM, Morton JR, Maloney CT, Dacey LJ, et al. Use of the internal mammary artery graft and in-hospital mortality and other adverse outcomes associated with coronary artery bypass surgery. Circulation 2001;103:507-12.

27. 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;112:1344-50.