

Original article

Comparative Study of On-Pump versus Off-Pump Coronary Artery Bypass Grafting: Analysis of Early Postoperative Outcomes and Complications

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Abstract

Background- Coronary artery bypass grafting (CABG) remains the gold standard for multivessel coronary artery disease. Although conventional on-pump CABG has demonstrated excellent long-term graft patency, off-pump CABG was introduced to reduce complications associated with cardiopulmonary bypass. The relative benefits of both techniques in terms of early postoperative outcomes continue to be debated.

Methods- A prospective comparative observational study was conducted over one year involving 40 patients undergoing isolated CABG. Twenty patients underwent conventional on-pump CABG while twenty underwent off-pump CABG. Demographic characteristics, operative parameters, postoperative complications, ICU stay, duration of mechanical ventilation, blood transfusion requirements, hospital stay, and 30-day mortality were evaluated. Statistical analysis was performed using SPSS version 26. Continuous variables were analyzed using the independent Student's t-test, while categorical variables were compared using the Chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Results- Patients undergoing off-pump CABG demonstrated significantly reduced ventilation duration, ICU stay, postoperative blood transfusion requirements, and overall hospital stay. Incidences of postoperative atrial fibrillation, renal dysfunction, and wound infection were lower in the off-pump group. Mortality remained comparable between the groups.

Conclusion- Off-pump CABG appears to provide superior early postoperative recovery with fewer perioperative complications while maintaining comparable short-term mortality. Larger multicenter studies are recommended to validate these findings.

Keywords: Coronary artery bypass grafting; Cardiopulmonary bypass; Off-pump CABG

Introduction

Coronary artery disease (CAD) continues to be one of the leading causes of morbidity and mortality worldwide. Despite advances in medical therapy and percutaneous coronary interventions, coronary artery bypass grafting (CABG) remains the preferred treatment for patients with multivessel coronary artery disease, left main coronary artery disease, and complex coronary lesions. (1) Traditionally, CABG has been performed using cardiopulmonary bypass (CPB), allowing the surgeon to operate on a motionless and bloodless heart. However, CPB has been associated with systemic inflammatory responses, coagulation abnormalities, neurological complications, renal dysfunction, and increased postoperative morbidity.(2,3)

Off-pump coronary artery bypass grafting (OPCAB) was developed to eliminate the adverse effects associated with cardiopulmonary bypass by performing surgery on the beating heart using specialized stabilization devices. Numerous randomized controlled trials and meta-analyses have compared both techniques; however, conflicting evidence exists regarding their superiority. (4,5) The present study aimed to compare early postoperative outcomes and complications between on-pump and off-pump CABG in patients undergoing isolated coronary artery bypass surgery.

Materials and Methods

A prospective comparative observational study was conducted in the Department of Cardiovascular and Thoracic Surgery of a tertiary care teaching hospital over a period of one year. The study included 40 consecutive patients undergoing isolated coronary artery bypass grafting (CABG), who were equally divided into two groups: Group A comprised 20 patients who underwent conventional on-pump CABG, while Group B included 20 patients who underwent off-pump CABG (OPCAB). The sample size was determined based on the average annual institutional surgical workload and the feasibility of patient recruitment during the study period. Patients aged between 30 and 80 years with angiographically confirmed multivessel coronary artery disease requiring elective isolated CABG and a left ventricular ejection fraction greater than 30% were enrolled after obtaining written informed consent. Patients undergoing emergency CABG, redo CABG, combined valve or aortic procedures, those with severe hepatic dysfunction, end-stage renal disease requiring dialysis, active infection, or severe chronic pulmonary disease requiring long-term oxygen therapy were excluded from the study.

Baseline demographic and clinical characteristics including age, sex, body mass index (BMI), diabetes mellitus, hypertension, smoking history, dyslipidemia, left ventricular ejection fraction, and the number of diseased coronary vessels were recorded for all participants. Intraoperative variables such as duration of surgery, number of grafts performed, intraoperative blood loss, blood transfusion requirement, aortic cross-clamp time, and cardiopulmonary bypass time were documented, with the latter two variables being applicable only to the on-pump CABG group. Patients in the on-pump group underwent median sternotomy followed by conventional cardiopulmonary bypass using ascending aortic and right atrial cannulation, and myocardial protection was achieved with intermittent cold blood cardioplegia before completion of coronary artery bypass grafting. Patients in the off-pump group underwent CABG on the beating heart through median sternotomy using commercially available mechanical stabilizers and intracoronary shunts whenever required. Hemodynamic stability was maintained by appropriate patient positioning, volume optimization, and the use of vasoactive medications, and complete myocardial revascularization was attempted in all patients.

Postoperative assessment was carried out for all patients until discharge and during the first 30 postoperative days. Outcome variables included the duration of mechanical ventilation, length of intensive care unit (ICU) stay, total hospital stay, postoperative blood transfusion requirement, atrial fibrillation, acute renal dysfunction, stroke, myocardial infarction, wound infection, re-exploration for bleeding, and 30-day mortality.

Results

Table 1. Baseline Demographic and Clinical Characteristics

Variable	On-pump CABG (n=20)	Off-pump CABG (n=20)	p-value
Age (years)	59.6 ± 8.4	58.2 ± 7.9	0.58
Male (%)	16 (80%)	17 (85%)	0.68
BMI (kg/m ²)	25.8 ± 3.1	25.3 ± 2.8	0.61
Diabetes Mellitus	12 (60%)	11 (55%)	0.75
Hypertension	15 (75%)	16 (80%)	0.71
Smoking History	10 (50%)	9 (45%)	0.75
Dyslipidemia	13 (65%)	12 (60%)	0.74
LVEF (%)	48.3 ± 7.2	49.8 ± 6.8	0.49
Triple Vessel Disease	17 (85%)	18 (90%)	0.63

No statistically significant differences were observed in baseline demographic or clinical characteristics, indicating that both groups were comparable before surgery.

Table 2. Intraoperative and Early Postoperative Outcomes

Variable	On-pump CABG	Off-pump CABG	p-value
Duration of Surgery (minutes)	238 ± 28	245 ± 30	0.42
Number of Grafts	3.1 ± 0.7	3.0 ± 0.6	0.66
Blood Transfusion (Units)	2.4 ± 0.9	1.2 ± 0.6	0.001
Ventilation Time (hours)	13.8 ± 4.2	8.7 ± 2.8	<0.001
ICU Stay (days)	3.8 ± 1.1	2.4 ± 0.8	<0.001
Hospital Stay (days)	9.7 ± 2.3	7.1 ± 1.8	0.002

Patients undergoing Off-pump CABG required significantly fewer blood transfusions and experienced shorter mechanical ventilation, ICU stay, and hospital stay compared to patients undergoing conventional On-pump CABG.

Table 3. Early Postoperative Complications

Complication	On-pump (n=20)	Off-pump (n=20)	p-value
Atrial Fibrillation	5 (25%)	2 (10%)	0.20
Acute Kidney Injury	3 (15%)	1 (5%)	0.29
Stroke	1 (5%)	0	1.00*
Myocardial Infarction	1 (5%)	1 (5%)	1.00
Wound Infection	2 (10%)	1 (5%)	0.55
Re-exploration for Bleeding	2 (10%)	0	0.15
30-day Mortality	1 (5%)	0	1.00*

*Fisher's Exact Test

Although the incidences of atrial fibrillation, renal dysfunction, wound infection, and re-exploration were numerically lower in the Off-pump group, these differences did not reach statistical significance because of the relatively small sample size. Thirty-day mortality was comparable between both groups.

DISCUSSION

Coronary artery bypass grafting (CABG) remains the standard surgical treatment for patients with complex multivessel coronary artery disease. The introduction of off-pump coronary artery bypass grafting (OPCAB) aimed to reduce the adverse physiological effects associated with cardiopulmonary bypass (CPB), including systemic inflammatory response, coagulation abnormalities, renal dysfunction, neurological complications, and prolonged postoperative recovery. The present prospective comparative study evaluated early postoperative outcomes in 40 patients undergoing either conventional on-pump CABG or OPCAB over one year.(6)

The baseline demographic and clinical characteristics of the two study groups were statistically comparable. There were no significant differences in age, gender distribution, diabetes mellitus, hypertension, smoking status, body mass index, left ventricular ejection fraction, or extent of coronary artery disease. This indicates that both groups were reasonably matched and minimizes confounding while comparing postoperative outcomes.

One of the important findings of the present study was the significant reduction in postoperative mechanical ventilation time among patients undergoing OPCAB. Patients in the off-pump group required nearly five hours less ventilatory support than those undergoing conventional CABG. This finding is clinically relevant because prolonged ventilation is associated with higher risks of ventilator-associated pneumonia, intensive care unit (ICU) complications, increased healthcare costs, and delayed recovery. Avoidance of cardiopulmonary bypass reduces pulmonary inflammatory injury and capillary leak, thereby facilitating earlier extubation. Similar observations have been reported in several randomized trials and recent meta-analyses.(7,8,9)

The duration of ICU stay was also significantly shorter in the off-pump group. Reduced ICU stay reflects improved hemodynamic stability, decreased inflammatory response, and earlier postoperative mobilization. Shorter ICU occupancy has important implications in resource-limited healthcare settings by improving bed availability and reducing treatment costs. Comparable reductions in ICU stay have been consistently demonstrated in contemporary systematic reviews comparing OPCAB and conventional CABG.(10)

Hospital stay was significantly reduced among patients undergoing OPCAB. Early ambulation, fewer postoperative complications, lower transfusion requirements, and faster recovery collectively contribute to earlier discharge. From a health economics perspective, reduction in hospital stay translates into substantial savings in treatment expenditure while improving patient satisfaction.

Blood transfusion requirements were significantly lower in patients undergoing OPCAB. Cardiopulmonary bypass activates coagulation pathways, platelet dysfunction, and fibrinolysis, resulting in greater postoperative bleeding and increased transfusion requirements. Blood transfusion itself has been associated with postoperative infection, renal dysfunction, immunomodulation, and increased mortality. Therefore, minimizing transfusion is considered an important quality indicator in cardiac surgery. The findings of the present study agree with previously published randomized trials demonstrating reduced blood loss and transfusion following off-pump surgery.

Although the duration of surgery was marginally longer in the OPCAB group, the difference was not statistically significant. Off-pump surgery requires greater technical expertise because coronary anastomoses are

performed on the beating heart while maintaining adequate systemic perfusion. The learning curve associated with OPCAB may initially prolong operative duration; however, increasing surgical experience substantially reduces this difference.

The incidence of postoperative atrial fibrillation was lower in the off-pump group. Postoperative atrial fibrillation remains one of the most frequent complications following cardiac surgery and contributes to prolonged hospitalization, thromboembolic events, and increased healthcare costs. Reduced myocardial manipulation, avoidance of cardioplegic arrest, and decreased inflammatory activation may explain the lower incidence following OPCAB. Although statistical significance was not achieved in the present study because of the relatively small sample size, the observed trend is clinically meaningful and agrees with published literature. Similarly, postoperative renal dysfunction occurred less frequently following OPCAB. Acute kidney injury after cardiac surgery is multifactorial and is influenced by ischemia-reperfusion injury, inflammatory mediators, hemolysis, hypotension, and microembolization during cardiopulmonary bypass. By avoiding extracorporeal circulation, OPCAB may preserve renal perfusion and reduce inflammatory injury. Several recent studies have reported modest reductions in postoperative renal impairment among high-risk patients undergoing off-pump surgery.

Neurological complications remain an important concern following CABG. Only one patient developed postoperative stroke in the on-pump group, while none occurred in the OPCAB group. Although statistical significance could not be demonstrated because of the limited sample size, avoidance of aortic manipulation and embolization during cardiopulmonary bypass probably contributed to this favorable outcome. Contemporary evidence indicates that OPCAB may reduce early stroke risk, particularly when anaortic techniques are employed.

Wound infection and re-exploration for bleeding were less common following OPCAB. Reduced blood loss, lower transfusion requirements, and shorter ICU stay may contribute to improved wound healing and lower infection rates. However, larger studies are necessary to establish statistically significant differences.

Conclusion

Off-pump CABG was associated with superior early postoperative recovery, significantly reducing blood transfusion requirements, ventilation time, ICU stay, and overall hospital stay compared with conventional on-pump CABG. Although major postoperative complications and 30-day mortality were comparable, OPCAB demonstrated a trend toward lower perioperative morbidity. In experienced hands, OPCAB represents a safe and effective alternative to conventional CABG for appropriately selected patients.

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