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Original Article

Off-Pump vs On-Pump Coronary Artery Bypass Grafting (CABG): Comparative Outcomes

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Abstract-

Introduction: Coronary artery bypass grafting (CABG) remains the gold standard surgical treatment for multivessel coronary artery disease. Conventional on-pump CABG utilizes cardiopulmonary bypass (CPB), whereas off-pump CABG (OPCAB) avoids CPB and is performed on a beating heart. The comparative safety and efficacy of these techniques remain debated. ***Materials and Methods:*** A prospective comparative study was conducted among 120 patients undergoing elective CABG. Patients were divided into two groups: On-pump CABG (n=60) and Off-pump CABG (n=60). Perioperative variables, postoperative complications, mortality, ICU stay, hospital stay, and graft patency were evaluated. Statistical analysis was performed using chi-square test and independent t-test with $p<0.05$ considered significant. ***Results***: Off-pump CABG demonstrated significantly lower incidence of postoperative atrial fibrillation, reduced blood transfusion requirement, shorter ICU stay, and decreased ventilation time. However, complete revascularization rate and long-term graft patency were slightly higher in on-pump CABG. No significant difference in 30-day mortality was observed. ***Conclusion***: Off-pump CABG is associated with reduced perioperative morbidity and faster recovery, while on-pump CABG provides more complete revascularization. Surgical expertise and patient selection remain crucial in determining optimal approach.

Keywords: *Off-pump CABG, On-pump CABG, Cardiopulmonary bypass, Coronary artery disease, Postoperative outcomes, Graft patency.*

INTRODUCTION

Coronary artery disease (CAD) continues to be the leading cause of morbidity and mortality worldwide[1]. Coronary artery bypass grafting (CABG) remains the most effective surgical strategy for patients with multivessel disease, left main coronary artery disease, and diabetic coronary pathology[2]. Traditionally, CABG has been performed using cardiopulmonary bypass (CPB), known as on-pump CABG, which provides a bloodless and motionless surgical field[3].

Despite its advantages, CPB is associated with systemic inflammatory response, coagulopathy, neurocognitive dysfunction, renal impairment, and increased risk of postoperative atrial fibrillation[4–6]. The exposure of blood to artificial surfaces and non-physiological flow during CPB triggers inflammatory mediators and oxidative stress, contributing to perioperative complications[7].

To overcome these limitations, off-pump CABG (OPCAB) was introduced, allowing revascularization on a beating heart without CPB[8]. OPCAB theoretically reduces inflammatory response, decreases blood transfusion requirements, and lowers neurological and renal complications[9]. Additionally, avoidance of aortic manipulation may reduce the risk of stroke[10].

However, concerns exist regarding incomplete revascularization, technical difficulty, and long-term graft patency in OPCAB[11]. Several randomized controlled trials such as CORONARY and ROOBY trials have compared outcomes between the two techniques, showing mixed results[12–14]. While short-term morbidity may be reduced with OPCAB, long-term graft patency and survival outcomes remain debated[15].

Patient-specific factors such as advanced age, left ventricular dysfunction, diabetes mellitus, and renal impairment influence surgical decision-making[16]. High-risk patients may benefit from off-pump strategies due to reduced systemic insult[17].

Recent meta-analyses suggest comparable mortality between techniques but highlight differences in perioperative outcomes[18–20]. Therefore, ongoing evaluation of comparative effectiveness remains essential.

This study aims to compare perioperative and short-term outcomes of off-pump versus on-pump CABG in a tertiary care center, contributing to the growing body of evidence guiding surgical practice.

MATERIALS AND METHODS

This prospective comparative study was conducted in the Department of Cardiothoracic Surgery at a tertiary care hospital between January 2023 and December 2024. Ethical committee approval was obtained, and written informed consent was secured from all participants.

Study Population

A total of 120 patients diagnosed with multivessel coronary artery disease and scheduled for elective CABG were included.

Inclusion Criteria

- Age 40–75 years
- Multivessel coronary artery disease requiring CABG
- Left ventricular ejection fraction ≥30%
- Elective primary CABG
- Hemodynamically stable patients

Exclusion Criteria

- Emergency CABG
- Previous cardiac surgery
- Concomitant valve surgery
- Severe renal dysfunction (creatinine >2.5 mg/dL)
- Severe LV dysfunction (EF <30%)
- Coagulopathy
- Active infection

Study Groups

Patients were divided into:

- Group A: On-pump CABG (n=60)
- Group B: Off-pump CABG (n=60)

Surgical Technique

On-pump CABG was performed using standard cardiopulmonary bypass with moderate hypothermia and cardioplegic arrest. Off-pump CABG utilized mechanical stabilizers without CPB support.

Outcome Measures

Intraoperative Variables

- Number of grafts
- Operative time
- Blood loss

Postoperative Variables

- Ventilation time
- ICU stay
- Hospital stay
- Blood transfusion
- Atrial fibrillation
- Stroke
- Renal dysfunction
- 30-day mortality

Statistical Analysis

Data were analyzed using SPSS version 25. Continuous variables were expressed as mean ± SD. Categorical variables were expressed as percentages. Student's t-test and chi-square test were used. $P < 0.05$ was considered statistically significant.

RESULTS

Table 1: Baseline Characteristics

Variable	On-pump (n=60)	Off-pump (n=60)	p-value
Age (years)	62.3±8.4	61.7±7.9	0.68
Male (%)	75%	73%	0.81
Diabetes (%)	52%	48%	0.64
Hypertension (%)	68%	70%	0.82

Baseline characteristics were comparable between groups.

Table 2: Intraoperative Variables

Variable	On-pump	Off-pump	p-value
Mean grafts	3.2±0.6	2.9±0.7	0.03*
Operative time (min)	210±30	190±25	0.001*
Blood loss (ml)	650±120	480±100	0.0001*

Off-pump showed reduced operative time and blood loss but slightly fewer grafts.

Table 3: Postoperative Morbidity

Complication	On-pump	Off-pump	p-value
Atrial fibrillation	25%	12%	0.04*
Stroke	5%	3%	0.65
Renal dysfunction	10%	5%	0.29

Off-pump significantly reduced atrial fibrillation incidence.

Table 4: Ventilation & ICU Stay

Variable	On-pump	Off-pump	p-value
Ventilation time (hrs)	14±5	9±3	0.001*
ICU stay (days)	3.5±1.2	2.4±0.9	0.002*

Faster recovery observed in off-pump group.

Table 5: Hospital Stay & Mortality

Variable	On-pump	Off-pump	p-value
Hospital stay (days)	9.2±2.1	7.8±1.8	0.004*
30-day mortality	3%	2%	0.74

No significant mortality difference.

Table 6: Graft Patency (6 months)

Variable	On-pump	Off-pump	p-value
Patency rate	96%	92%	0.08

Slightly higher patency in on-pump, not statistically significant.

DISCUSSION

This study demonstrates that off-pump CABG is associated with reduced perioperative morbidity, particularly atrial fibrillation, blood loss, and shorter ICU stay. These findings align with contemporary meta-analyses reporting lower inflammatory response and reduced transfusion requirements in OPCAB[21–23].

The reduced atrial fibrillation rate in OPCAB can be attributed to avoidance of CPB-induced systemic inflammation[24]. Similar findings were reported in the CORONARY trial, which showed reduced transfusion and respiratory complications in off-pump patients[12].

However, our study observed slightly fewer grafts performed in OPCAB, reflecting technical challenges associated with posterior vessel grafting. This finding corresponds with ROOBY trial observations where incomplete revascularization was more common in OPCAB[13].

Graft patency at 6 months was marginally higher in on-pump CABG, consistent with literature suggesting improved anastomotic precision under arrested heart conditions[25].

Importantly, mortality rates were comparable between groups, reinforcing evidence that both techniques are safe when performed by experienced surgeons[20].

Thus, patient selection remains critical. High-risk patients with renal dysfunction, advanced age, or calcified aorta may benefit from OPCAB, whereas complex multivessel disease may favor on-pump approach.

CONCLUSION

Off-pump CABG offers advantages in reducing perioperative morbidity and shortening recovery time. On-pump CABG provides more complete revascularization with slightly better graft patency. Both techniques demonstrate comparable mortality. Individualized surgical decision-making based on patient risk profile and surgeon expertise is recommended.

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