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POSTOPERATIVE OUTCOMES IN OFF-PUMP CORONARY ARTERY BYPASS GRAFTING: A COMPARATIVE STUDY OF SINGLE VERSUS MULTIPLE TRANSFUSIONS

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ABSTRACT

Background: While blood transfusion is a common requirement during off-pump coronary artery bypass grafting (OPCAB), growing evidence points to a concerning association between higher transfusion volumes and poorer postoperative outcomes. **Objective:** Early postoperative complications were compared between OPCAB patients who received a single blood transfusion and those who required multiple transfusions. **Materials and Method:** This comparative cross-sectional study was conducted at Bangladesh Medical University, Dhaka, from July 2022 to June 2024. Sixty-eight patients undergoing OPCAB were enrolled and categorized into single transfusion (n=34) and multiple transfusion (n=34) groups. Using suitable statistical tests, baseline attributes, perioperative variables, and postoperative outcomes were thoroughly analyzed, with $p \leq 0.05$ set as the threshold for statistical significance. **Results:** No meaningful variances were observed between the two groups with respect to baseline demographic and clinical profiles. Patients receiving multiple transfusions required significantly higher blood volumes (3.15 ± 0.81 vs. 0.82 ± 0.20 units; $p<0.001$). The multiple transfusion group confirmed significantly higher rates of postoperative arrhythmia (33.33% vs. 12.12%; $p=0.039$), acute kidney injury (24.24% vs. 6.06%; $p=0.039$), coagulopathy (18.18% vs. 3.03%; $p=0.045$), and hypothermia (20.58% vs. 3.03%; $p=0.045$). Although infectious and pulmonary complications were more common, variances were not statistically significant.**Conclusion:**In patients undergoing OPCAB, exposure to multiple blood transfusions carries a significantly greater risk of postoperative morbidity, particularly arrhythmia, renal dysfunction, and coagulopathy. Optimizing perioperative blood management through restrictive transfusion strategies, as these findings suggest, could play a meaningful role in improving overall surgical outcomes.

Keywords: OPCAB, Blood transfusion, Postoperative complications, Cardiac surgery, Restrictive transfusion, Acute kidney injury.

INTRODUCTION

Among non-communicable diseases, coronary artery disease (CAD) occupies a central position in global health burden, contributing substantially to premature mortality and long-term disability. Cardiovascular conditions collectively responsible for nearly one-third of deaths worldwide, according to the estimate from World Health Organization, with ischemic etiologies driving a disproportionate share of this toll[1].

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Cardiovascular conditions collectively responsible for nearly one-third of deaths worldwide, according to the estimate from World Health Organization, with ischemic etiologies driving a disproportionate share of this toll[1]. In resource-constrained nations like Bangladesh, the epidemiological transition driven by industrialization, changing dietary habits, and rising cardiometabolic risk factor prevalence – notably diabetes, hypertension, and tobacco use – has accelerated the incidence of CAD considerably[2]. Coronary artery bypass grafting (CABG) remains the preferred surgical revascularization strategy for patients with extensive or anatomically complex CAD. Across multiple trials and registries, operative revascularization has yielded advantages in symptom control, survival, and overall quality of life over conservative pharmacotherapy or catheter-based approaches in appropriately selected individuals[3].

CABG continues to be one of the most important treatment options we have for patients dealing with advanced coronary artery disease – especially when multiple vessels are affected or when the coronary anatomy is too complex to address through other means.In carefully selected patients, surgical revascularization has repeatedly proven to outperform both medical therapy and percutaneous coronary intervention – not just in helping patients feel better day to day, but in meaningfully improving their quality of life and, perhaps most importantly, helping them live longer[4] . The off-pump variant of this procedure (OPCAB), which foregoes the use of an extracorporeal circuit, has attracted growing clinical adoption owing to its ability to mitigate bypass-related sequelae including systemic inflammation, neurological compromise, and hemostatic derangements[5] .

Despite the advantages of OPCAB, perioperative blood loss remains a significant concern, often necessitating blood and blood product transfusion. Cardiac surgery is among the highest consumers of blood transfusion world wide[6]. The requirement for transfusion is influenced by multiple factors, including patient-related variables such as preoperative anemia and coagulopathy, as well as procedure-related factors such as surgical complexity and intraoperative bleeding[7]. Despite its physiological necessity in restoring oxygen-carrying capacity and sustaining hemodynamic equilibrium, allogenic blood transfusion carries a well-recognized adverse risk profile.

When delivered in escalating quantities, transfusion has been implicated in a spectrum of complications – ranging from immune-mediated reactions and volume overload to pulmonary injury and heightened infection susceptibility – transforming a life-sustaining intervention into a potential source of iatrogenic harm[8]. Furthermore, transfusion has been linked to acute kidney injury, prolonged mechanical ventilation, extended intensive care unit (ICU) stay, and increased hospital length of stay[7]. The underlying mechanisms are thought to involve immunomodulation, inflammatory responses, and reduced oxygen delivery due to storage-related changes in red blood cells[8]. These concerns have led to a pushed toward restrictive transfusion strategies in modern cardiac surgical practice.

In addition, A mounting body of evidence points to a volumetric gradient in transfusion-related harm – the greater the number of units administered, the higher the attendant risk of arrhythmic events, renal impairment, coagulation failure, and pulmonary complications in the postoperative period[9]. However, the majority of existing literature focuses on on-pump CABG or mixed cardiac surgical populations, and there remains a relative paucity of data specifically addressing the impact of multiple transfusions in patients undergoing OPCAB. Given the physiological differences between on-pump and off-pump techniques, extrapolation of findings from CPB-based studies may not be entirely appropriate.

Moreover, the pattern of blood utilization and perioperative management varies significantly across institutions, particularly in resource-limited settings like Bangladesh, where standardized transfusion protocols may not be uniformly implemented. This variability highlights the need for context-specific evidence to guide clinical decision-making and optimize patient outcomes. Understanding the relationship between the extent of blood transfusion and postoperative complications in OPCAB patients is therefore indispensable for developing rational transfusion strategies and improving perioperative care.

The current study was carried out to investigate the effect of perioperative blood transfusion on early postoperative outcomes in patients undergoing OPCAB. Specifically, the study pointed to compare the rate of postoperative complications between patients receiving a single unit of blood transfusion and those receiving multiple units. By addressing this clinically relevant issue, the study pursues to contribute to the growing body of evidence supporting judicious use of blood transfusion and to inform strategies aimed at minimizing transfusion-related morbidity in cardiac surgery.

MATERIALS AND METHOD

Study Design and Setting

A comparative cross-sectional design was employed for this investigation, carried out within the Cardiac Surgery unit of Bangladesh Medical University (BMU), Dhaka, over a 24-month window spanning July 2022 through June 2024.

Participants

The study prospectively enrolled a series of adult patients who were scheduled to undergo elective OPCAB for ischemic heart disease. Based on the volume of packed red blood cells (PRBC) transfused during the perioperative period, participants were categorized into two groups: those who received one unit of PRBC transfusion (Group A; n = 34) and those who received two or more units of PRBC transfusion (Group B; n = 34).

Eligibility criteria

Adult patients undergoing elective OPCAB were recruited in this study. Patients with pre-existing coagulation disorders were omitted, recent fibrinolytic therapy, preoperative anemia requiring transfusion, severe left ventricular dysfunction (ejection fraction <30%), recent myocardial infarction within 2 weeks, mechanical complications of myocardial infarction, concomitant valvular heart disease, or pre-existing renal or hepatic impairment, for reducing potential confounding.

Sample Size

The number of sampleswas estimated using a standard formula for comparison two proportions, based on previously reported differences in postoperative infection rates between transfusion groups[10]. The minimum required number was 34 patients per group (total n=68)[11].

Data Collection Procedure

A pre-tested semi-structured questionnaire and standardized checklist, both designed in English, were used for data collection. Information was gained from numerous sources, including direct patient interviews, hospital health records, operative notes, and relevant laboratory reports, to ensure data completeness and accuracy. The collected variables encompassed socio-demographic characteristics, baseline clinical profile and comorbidities, and detailed perioperative transfusion information. Data collection was performed prospectively during the hospital stay, with regular verification to maintain consistency and minimize recording errors.

Outcome Measurement

The occurrence of early postoperative complications within 10 days following surgery was the primary outcome. Patients were managed in the intensive care unit (ICU) and high-dependency unit (HDU) during the postoperative period. Arrhythmias were detected through continuous electrocardiographic monitoring up to the third postoperative day, with particular attention to patients receiving multiple units of packed red blood cells, as volume overload associated with higher transfusion volumes may increase the risk of cardiac rhythm disturbances. Acute kidney injury (AKI) was assessed using daily urine output and serial serum creatinine measurements on postoperative days 1, 3, and 7, considering the potential impact of larger-volume transfusions on renal function. Coagulopathy was evaluated using prothrombin time (PT) and activated partial thromboplastin time (aPTT) on postoperative days 2 and 5. Hypothermia was monitored daily using a standardized peripheral thermometer. Wound infections were assessed clinically on postoperative days 3 and 7 for signs of erythema, discharge, and swelling, while respiratory tract infections were evaluated through clinical examination supported by chest radiography. Transfusion-related acute lung injury (TRALI) was identified according to established clinical examination and a Chest X-ray (CXR) P/A view.

Follow-up

All patients were followed prospectively for 10 postoperative days in the ICU and HDU.

Bias Control

To limit selection bias, a consecutive enrolment approach was adopted. Pre-defined eligibility criteria were strictly applied to limit for potential confounders, and all outcomes were measured using uniform, pre-specified clinical protocols.

Statistical Analysis

All analysis were executed using IBM SPSS version 27.0 following systematic data entry and quality verification. Continuous parameters are summarized as mean ± SD; categorical data are presented as counts and percentages. Group differences were evaluated by the independent-samples t-test for continuous outcomes, whereas the Pearson chi-square or Fisher's exact test was employed for categorical comparisons depending on expected cell frequencies. For defining statistical significance, a two-tailed α threshold of 0.05 was considered.

Ethical Considerations

Prior to participant recruitment, approval was secured from the Institutional Review Board of BMU (Reference No: BSMMU/2024/5780). Informed consent form was signed from each participant before enrolment, personal data were handled with full anonymization, and all individuals retained unrestricted freedom to discontinue participation at any point without bearing any negative repercussions.

RESULTS

Baseline Attributes of the Study Population

Before treatment began, both groups were largely comparable in terms of their baseline demographic characteristics and clinical backgrounds, supporting group homogeneity at enrollment. Patients aged 50–65 years predominated in both arms, and age distributions were statistically indistinguishable (p=0.478). Mean ages were near-identical (Group A: 54.32±8.17 years; Group B: 53.82±9.09 years; p=0.409). Males made up the larger share of participants in

both groups, groups with no significant inter-group sex difference (p=0.523). Furthermore, the rates of major cardiovascular risk factors, including diabetes mellitus, hypertension, dyslipidemia, and chronic obstructive pulmonary disease (COPD), were similarly distributed across both groups, confirming that the study cohorts were well-balanced and comparable right from the start.

Table 1: Comparison of Baseline Attributes between two groups of the Study Population

Variable	Category	Group A (n=34) f (%)	Group B (n=34) f (%)	*p* value
Age Group (years)	20–29	1 (2.94%)	2 (5.88%)	
	30–49	12 (35.30%)	12 (35.30%)	0.478
	50–65	21 (61.76%)	20 (58.82%)	
	Total	34 (100%)	34 (100%)	
Age (years)	Mean ± SD	54.32 ± 8.17	53.82 ± 9.09	0.409
Sex	Male	26 (76.47%)	28 (82.35%)	0.523
	Female	8 (23.52%)	6 (17.64%)	
	Total	34 (100%)	34 (100%)	
Risk Factors	Diabetes mellitus	14 (42.42%)	15 (45.45%)	0.803
	Hypertension	20 (58.82%)	24 (70.58%)	0.306
	Dyslipidemia	18 (54.55%)	15 (45.45%)	0.461
	COPD	4 (12.12%)	3 (9.09%)	0.691

n=number of subjects in each group.

Blood and Blood Product Transfusions During the Perioperative Period

The volume of perioperative packed red blood cell (PRBC) transfusion differed significantly between the two cohorts. Group B patients received nearly four times more PRBC units compared with Group A patients (3.15 ± 0.81 vs. 0.82 ± 0.20 units; $p < 0.001$), reflecting a substantially greater transfusion burden in the multiple-transfusion group.

Table 2: Comparison of Perioperative Blood and Blood Product Transfusion Between Group A and Group B

Variable	Group A (n=34) Mean ± SD	Group B (n=34) Mean ± SD	p value
Blood & blood product transfusion in perioperative period (units)	0.82 ± 0.20	3.15 ± 0.81	<0.001 s

Postoperative Complications

Patients in Group B experienced a notably higher rate of complications after surgery compared to those in Group A (Table 3).Significant variations were observed in the incidence of post-operative arrhythmia (33.33% vs. 12.12%; p=0.039), acute kidney injury (24.24% vs. 6.06%; p=0.039), coagulopathy (18.18% vs. 3.03%; p=0.045), and hypothermia (20.58% vs. 3.03%; p=0.045). While wound infections, respiratory tract infections, and transfusion-related acute lung injury all occurred more frequently in Group B, none of these differences were large enough to be considered statistically significant. Overall, the results demonstrate a heavier burden of postoperative morbidity in Group B.

Table 3: Comparison of Postoperative Complications Between Group A and Group B

Postoperative Complication	Group A (n=34) f (%)	Group B (n=34) f (%)	*p* value
Post-operative arrhythmia	4 (12.12%)	11 (33.33%)	0.039
Acute kidney injury (AKI)	2 (6.06%)	8 (24.24%)	0.039
Coagulopathy	1 (3.03%)	6 (18.18%)	0.045
Wound infection	2 (5.88%)	3 (9.09%)	0.302
Respiratory tract infections (RTIs)	2 (6.06%)	5 (15.15%)	0.231
Hypothermia	1 (3.03%)	7 (20.58%)	0.045
Transfusion-related acute lung injury (TRALI)	1 (3.03%)	3 (9.09%)	0.302

DISCUSSION

Adequate group homogeneity at baseline – spanning age, sex, and major cardiovascular comorbidities – lends credibility to the observed between-group outcome differences by limiting the contribution of demographic confounders. The male-dominant, middle-aged profile of the study cohort mirrors the well-established clinical epidemiology of surgically revascularized CAD populations[12].

A key finding of the present study was that patients receiving two or more units of packed red blood cells (PRBCs) during the perioperative period experienced significantly higher rates of postoperative complications than those receiving a single unit. Arrhythmia, acute kidney injury (AKI), coagulopathy, and hypothermia were all significantly more common in the two-or-more-unit PRBC group. The increased occurrence of these complications may reflect the physiological consequences of larger transfusion volumes, including volume overload, inflammatory responses, and transfusion-related organ dysfunction. Collectively, these findings support a dose-dependent association between perioperative PRBC transfusion and adverse postoperative outcomes, in line with existing evidence[13,14] .

The underlying mechanisms may involve transfusion-related inflammatory and immunomodulatory responses leading to endothelial dysfunction and organ injury[15]. Stored red blood cells undergo structural and biochemical changes ("storage lesions") that impair microcirculation and oxygen delivery[16]. Additionally, coagulation disturbances, platelet dysfunction, volume overload, and inflammatory responses may contribute to coagulopathy, arrhythmias, and renal dysfunction, explaining the increased postoperative morbidity.

The findings align with earlier studies reporting higher rates of renal dysfunction, infection, and arrhythmia with increased transfusion exposure in cardiac surgery[17-20]. Yet, some studies have stated no significant association, particularly when restrictive transfusion strategies are applied[21,22]. Such variability may be attributed to variances in transfusion thresholds, perioperative management, surgical techniques, and patient choice. Additionally, confounding by indication remains a consideration, as patients requiring two or more transfusions may have greater operative complexity or blood loss.

Although wound infection, respiratory tract infection, and transfusion-related acute lung injury were more frequently observed among patients who received two or more units of PRBC, these variancesdid not reach statistical significance, possibly due to limited sample size and reduced statistical power. Nevertheless, the observed trends are clinically relevant and consistent with prior literature. These findings accentuate the importance of a judicious and evidence-based approach to transfusion in off-pump coronary artery bypass grafting, where minimizing unnecessary transfusion through optimized perioperative blood management and restrictive strategies may help reduce postoperative complications.

This study is subject to several limitations. The relatively small sample size may limit both the statistical power and the generalizability of the results. As an observational cross-sectional study, it cannot establish causal relationships, and residual confounding may still be present. Additionally, the lack of post-discharge follow-up constrains the assessment of long-term outcomes.

RECOMMENDATIONS

Drawing from what this study has found, a more judicious and evidence-based approach to perioperative PRBC transfusion is strongly recommended in patients undergoing OPCABG. The practice of a single unit of blood should be prioritized, whenever feasible, as it may help minimize transfusion-related complications. Unnecessary or multiple-unit transfusions should be avoided unless clinically indicated, in order to reduce postoperative morbidity and resource utilization. Implementation of strict transfusion protocols, along with regular auditing and clinician awareness, may further help prevent the imprudent use of blood products and improve overall surgical outcomes.

CONCLUSION

The present investigation establishes that multi-unit perioperative transfusion in OPCAB patients carries a meaningfully elevated risk of early postoperative morbidity compared to single-unit exposure. Patients receiving multiple transfusions experienced a higher incidence of complications, including arrhythmia, acute kidney injury, coagulopathy, and hypothermia, along with an overall less favorable recovery profile. These findings accentuate the significance of a restrictive and judicious transfusion strategy to optimize postoperative outcomes in OPCAB surgery.

AUTHOR STATEMENTS

Ethical approval

Ethical approval for this study was secured by the Institutional Review Board of BMU (Memo No: BSMMU/2024/5780).

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CONFLICT OF INTEREST

There is no conflict of interest.

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