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Platelet Count Dynamics after Cardiopulmonary Bypass in Patient Undergoing Single Valve Replacement Surgery

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ABSTRACT

Background

Cardiopulmonary Bypass is a standard procedure used during valve surgery to provide circulatory support and allow surgical intervention to replace a malfunctioning or diseased heart valve. Cardiac Surgery involving cardiopulmonary bypass may lead to alterations in platelet count, affecting hemostasis and patient outcome adversely. A study was conducted with the objective of investigating the effect of cardiopulmonary bypass on pre-operative and post-operative platelet count and the factors predicting the circulating platelet count after single valve replacement surgery with the use of cardiopulmonary bypass.

Methods

An analytical cross-sectional study was conducted Manmohan Cardiothoracic Vascular and Transplant Center, Kathmandu, Nepal from September 2023 to February 2024. All the patients undergoing single valve replacement for rheumatic heart disease were included in the study. The perioperative platelet counts were compared to study the alteration in platelet count dynamics. Data was analyzed using SPSS 16.

Results

A total of eighty patients were studied. The median platelet count decreased to 170933.75 cells/µL from the pre-operative median platelet count of 235856.25 cells/µL, within 24 hours of operation. Similarly, after 24 hours of operation, the median platelet counts further decreased to 159753.75 cells/µL (n =80). Incidence of thrombocytopenia ($<150\times10^4$/µL) was observed in 37.5% of patients within 24 hours and 41.3% after 24 hours post-operation.

Conclusions

The significant decrease in platelet counts following single valve replacement surgery with cardiopulmonary bypass underscores the impact of cardiac surgery on platelet count dynamics. Pre-operative platelet count, age, and bypass time emerged as independent predictors of postoperative platelet count.

Keywords: cardiopulmonary bypass; platelet count dynamics; single valve replacement surgery; thrombocytopenia

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INTRODUCTION

A decline in platelet count after on-pump cardiac surgery is mostly caused by hemodilution by the crystalloid fluid used to prime the cardiopulmonary bypass (CPB) circuit.[1] Various factors considered to have effect on platelet count alteration and platelet dysfunction are bypass time, ischemic time and use of anticoagulants. Longer duration of bypass causes platelet dysfunction by initiating plasmin generation.[2] The risk factors for post-operative thrombocytopenia include age > 60 years, body surface area (BSA), pre-operative thrombocytopenia and CPB time.[3] Heparin induced thrombocytopenia occurs postoperatively in nearly 3% of patients following CPB.[4] However, a transient and benign reactive thrombocytosis has also been described to occur frequently after cardiac surgery using CPB.[5,6] The underlying mechanism for postoperative thrombocytosis is not yet fully understood.[7] This study was conducted to investigate the effect of CPB on perioperative platelet count and the factors predicting the platelet count after single valve replacement.

METHODS

An analytical, cross-sectional study with non-probability sampling technique of convenience sampling was carried out from September 2023 to February 2024 in Department of Cardiothoracic and Vascular Surgery at Manmohan Cardiothoracic Vascular and Transplant Center. Data like age, gender, BSA, co-morbidity, platelet counts before surgery, bypass time, ischemic time and platelet count after surgery were reviewed. All patients underwent a standard anesthesia technique as per the cardiac anesthesia unit protocol. CPB was initiated through a median sternotomy, with cannulation of the superior and inferior vena cava for venous return and the ascending aorta for arterial return. Del Nido cardioplegia solution was used to arrest the heart. The lowest core temperature during CPB varied from 30°C to 37°C, as per the surgeon's preference. The CPB circuit was primed with 500 ml of Gelofusine (Succinylated gelatin 40g/L, Sodium 154mmol/L, Chloride 120ml/L), 500 ml of Plasmalyte, 50 ml of sodium bicarbonate, and 100 ml of 20% mannitol. In addition, 5000 IU of heparin was used as an anticoagulant. Rollers pumps were employed, and the oxygenator was a Sorin 6F (Sorin Group Italia, Italy). The target pump flow was set between 2.0 and 2.4 l/min/m^2, and the target mean arterial pressure was maintained above 60 mm Hg. Initially, the gas flow and FiO_2 were set to 2 l/min and 70%, respectively, to ensure an arterial oxygen pressure greater than 150 mm Hg and an arterial carbon dioxide pressure between 35- and 45-mm Hg. SPSS 16 software were used for statistical analysis. Results were expressed as median (range) or standard deviation for quantitative data. Comparisons between pre-operative and post-operative value were made with Wilcoxon's matched pair test, paired t-test and multiple regression analysis was done to test the influence of various clinical and demographic factors on platelet count. Categorical data was compared using chi-square test. A p-value of <0.05 was considered statistically significant.

RESULTS

During the study period, a total of 130 patients underwent valve replacement surgery at MCVTC. Among them, 40 patients underwent double valve replacement surgery, while 2 patients were under the age of 15, and 8 cases were redo surgeries. Consequently, the focus of the study was on 80 patients who underwent single valve replacement surgery. Among the total 80 patients, 37 (46.3%) patients were males and 43(53.8%) female patients. The age of the patients ranged from 15 to 82 years.

The causes of valvular heart disease were Rheumatic Heart Disease (RHD) in 76 (95%) patients, degenerative heart disease in 2 (2.5%) patients and bicuspid aortic valve disease in 2 (2.5%) patients. Mitral Valve Replacement (MVR) was performed in 64 (80%) individuals. Aortic Valve Replacement (AVR) was performed in 16(20%) patients. The Wilcoxon Signed Ranked Test revealed a statistically significant decrease in platelet count both within 24 hours and after 24 hours post-operation compared to pre-operative platelet counts ($p<0.001$). Within 24 hours post-operation, the median platelet count

decreased to 170933.75 cells/μL(n =80) from the pre-operative median of 235856.25 cells/μL. Similarly, after 24 hours post-operation, the median platelet count further decreased to 159753.75 cells/μL (Table 1).

Table 1. Comparison of pre-operative platelet count with platelet count post-operatively within 24 hours and after 24 hours.

Variable	Negative ranks			Positive rank			Test statistics		
	n	Mean rank	Sum of rank	n	Mean rank	Sum of rank	Ties	z	p-value
(Pre-operative platelet count) - (Post-operative platelet count) within 24 hours	74	41.49	3070.5	5	17.9	89.5	1	-7.284[b]	<0.01*
(Pre-operative platelet count)- (Post-operative platelet count) after 24 hours	73	43.01	3140	7	14.29	100	0	-7.290[b]	<0.01*

Analysis of post-operative platelet count revealed that 37.5% of patients had platelet count below the reference value of 15×10^4/μL within 24 hours post-operation. This proportion increased to 41.3% after 24 hours post-operation, indicating a trend towards thrombocytopenia in the postoperative period. No significant differences were observed in post-operative platelet counts within 24 hours and after 24 hours based on gender, body surface area (BSA), or comorbidity status (Table 2 and Table 3).

Table 2. Comparison of baseline characteristics of patients with and without post-operative thrombocytopenia defined as a platelet count within 24 hours of 15×104/μL.

Variable	Platelet count <150000 within 24 hours n=30 (37.5%)	Platelet count >150000 within 24 hours n=50(62.5%)	p-value
Gender			
Male	17 (45.9 %)	20(54.1%)	0.14
Female	13 (30.2 %)	30 (69.7 %)	
BSA	1.54	1.57	0.61
HTN	6 (50%)	6(50%)	0.33
DM	5(62.5%)	3(37.5%)	0.12

BSA-Body surface area, HTN-Hypertension, DM-Diabetes mellitus.

However, significant independent predictors for platelet count after CPB within 24 hours and after 24 hours are shown in Table 4 and 5. Pre-operative platelet count, age and bypass time were independent factors for platelet count after CPB within 24 hours (p-value <0.05). Pre-operative platelet count was independent predictive factor for platelet count after CPB after 24 hours.

Table 3. Comparison of baseline characteristics of patients with and without post-operative thrombocytopenia defined as a platelet count after 24 hours of 15×10^4/μL.

Variable	Platelet count <150000 after 24 hours n=33 (41.3%)	Platelet count >150000 after 24 hours n=47 (58.8%)	p-value
Gender			
Male	17 (45.9 %)	20(54.1 %)	0.42
Female	13 (30.2 %)	30 (69.7 %)	
BSA	1.52	1.57	0.31
HTN	7 (58.3 %)	5(41.7%)	0.19

Table 4. Independent Predictive Factors for platelet count within 24 hours after CPB.

Variable	Unstandardized coefficient		Standardized Coefficient	t	p-value
	B	SE	Beta		
(Constant)	91661.8	24351.98	-	3.76	<0.001
Pre-op platelet count	0.58	0.06	0.74	9.67	<0.001
Age	-669.23	320.69	-0.16	-2.09	0.04
Bypass time	-395.96	192.61	-0.16	-2.06	0.04

R^2=0.585

Table 5. Independent Predictive Factors for platelet count after 24 hours after CPB.

Variable	Unstandardized coefficient		Standardized Coefficient	t	p-value
	B	SE	Beta		
(Constant)	70739.97	14410.66	-	4.91	<0.001
Pre-op platelet count	0.38	0.058	0.596	6.562	<0.001

R^2=0.356

DISCUSSION

The present study aimed to investigate the dynamics of platelet count in patients undergoing single valve replacement surgery, specifically focusing on the impact of CPB on platelet count changes after surgery. Our study demonstrated that there was a significant decrease in platelet count within 24 hours and after 24 hours post operation compared to pre-operative platelet counts. Platelet count decline is common in patients after cardiac surgery with CPB and many patients' platelet counts declined below the normal reference value after CPB.

Various studies have shown the decrease in platelet count ranging from 30-50% from the baseline value in 24 hours to 36 hours following surgery.[8,9] In our study, drop in platelet count was more after 24 hours following the surgery. The drop in platelet count following cardiac surgery could coincide with significant levels of platelet-derived chemokines, which have been linked to multi-organ damage.[10,11] The non-CPB patients had significantly lower rates of post-operation decrease in platelet count, when compared to CPB patients, which suggested that CPB has an adverse effect on platelets.[12] A decrease in platelet count is higher in hypothermic CPB than in normothermic CPB.[13] Excess use of a cardiotomy sucker creates shear at the air-fluid interface activating platelets. Following administration of protamine, transient decrease in platelet count occurs due to formation of transient aggregates that sequestrate in the lungs.[14] Antiplatelet agents such as prostaglandin C1, prostacyclin, and dipyridamole has been shown to preserve platelet count and function after CPB both experimentally and clinically.[15-18] Inhalation of nitric oxide gas from the oxygenator also assists in the preservation of platelet count and function after CPB.[19] Since platelet activation during CPB results from platelet-surface interactions, heparin coated surface might help to promote the maintenance of platelet counts and function during CPB.

A significant decrease in the platelet count in the postoperative period can be hazardous to the patient with increased risk of mediastinal, gastrointestinal, cerebral and subarachnoid bleeding. In order to manage these bleeding, platelet transfusion may be required, which is associated with various adverse effects like transfusion related acute lung injury, infection, allergic reactions. Hence it is better to try and avoid significant thrombocytopenia. The perioperative considerations like preoperative correction of low platelet count, avoidance of prolonged hypothermia, shortening of cardiopulmonary bypass time are recommended.

CONCLUSIONS

Our study demonstrated a significant decrease in platelet count within 24 hours and after 24 hours following surgery as compared to pre-operative platelet counts. Age, preoperative platelet counts and CPB time were predictors for post-operative decrease in platelet count within 24 hours and only preoperative platelet count was a predictor for post-operative decrease in platelet count after 24 hours.

Limitations

Our study consisted of only eighty patients. Larger sample size can help us generalize the findings significantly and look for various other factors affecting platelet count after the use of cardiopulmonary bypass.

Conflict of interest: None

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