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Original research article

IS THERE ANY SIGNIFICANT IMPACT OF TWO DIFFERENT BIO-COMPATIBLE COATED CARDIOPULMONARY BYPASS CIRCUITS ON CIRCULATING PLATELET DROP

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Abstract: *Bleeding is common in cardiopulmonary bypass (CPB) surgery due to malfunctioning platelets. This study investigated the effect of a phosphorylcholine (PC)-coated CPB circuit and a balanced CPB circuit on platelet function. We conducted a descriptive, randomized trial at the Punjab Institute of Cardiology with 50 patients undergoing coronary artery bypass graft (CABG) surgery (n=34), valve surgery (n=10), and CABG plus valvular replacement (n=6) using CPB. The patients were divided into groups 1, which had phosphoryl-coated CPB, and 2, which had balanced-coated CPB. We measured and recorded pre-operative and post-operative levels of platelet count, white blood cells, and hemoglobin for both groups. We used the Student's t-test to make comparisons among groups, and the P values for both groups were less than 0.05 at a 95% confidence interval, indicating a significant impact of biocompatible coated CPB circuits on circulating platelet drop. Cohen's d formula showed that group 1 (Phosphoryl choline coating) had a more substantial effect on platelet drop than group 2 (Balanced coating). Blood component conservation, particularly platelet conservation, depends on the non-endothelium biocompatible surface used; the better the character, the more blood cells may be conserved. We looked at two coatings, phosphoryl coating, and balanced coating, to see if they substantially influenced platelet drop. According to the findings of our investigation, phosphoryl-coated CPB had a more significant influence on platelet drop than balanced coating.*

Keywords: Cardiopulmonary bypass, phosphorylcholine coating, Balanced coating, Platelet drop

Introduction

John Gibbon's discovery and deployment of the heart-lung machine was a breakthrough in cardiac surgery, enabling open heart surgeries to be conducted with some degree of control (Tesler, 2020). Cardiac operations have become an essential part of the treatment of a variety of cardiac disorders, including congenital heart disease, ischemic heart disease, and severe valve abnormalities. (Vervoort et al., 2020).Aside from off-pump cardiac procedures, cardiopulmonary bypass is commonly used to replace cardiopulmonary functions; however, the heart and lungs are stopped throughout the surgery. During cardiopulmonary bypass(Rana, 2021), blood is taken from the superior vena cava, inferior vena cava, and right atrium and delivered to the heart and lung machine for oxygen as well as carbon dioxide release before it enters the blood pump to resume blood circulation. When blood flows via the CPB circuit, it activates each complement system and the intrinsic route of the coagulation cascade.(Sniecinski and Chandler, 2011). Platelets are also triggered by the extracorporeal circuit's artificial surface, resulting in decreased platelet count and poorer function following CPB (Wang et al., 2021). Furthermore, the requirement for a crystalloid priming solution results in hem dilution, which lowers hematocrit and oxygen supply during CPB. These abnormalities can result in coagulopathy and substantial post-operative bleeding, which has been related to the use of blood products. (Downey and Faraoni, 2023)
The coagulation cascade is primarily initiated during cardiopulmonary bypass (CPB) by the reentry of suction blood combined with tissue factor.(Anastasiadis et al., 2013)
Platelets are the tiniest blood cells and have been shown to activate during cardiac bypass. They are involved in a number of connected problems. Platelet abnormalities, both quantitative and qualitative, have been documented, resulting in microvascular bleeding and thromboembolism.(Anastasiadis et al., 2013) Platelet alterations are influenced by a variety of variables related to CPB. Examples are physical variables (such as hypothermia and shear stresses), contact with artificial surfaces, external medications, and the release of endogenous substances.
Extracorporeal technology advancement has been made to mitigate the detrimental effects of CPB through lower prime volumes and increased biocompatibility. Many facilities have attempted to optimize standard CPB by using biocompatible coated circuits and oxygenators with integrated artery filters, centrifugal pumps, and shorter tubing. Several types of biocompatible coating are used in CPB. The main aim of this study is to find the impact of phosphoryl coating and balanced affinity coating on platelet drop as a result of cardiopulmonary bypass.

Methodology

A descriptive study including 50 patients was conducted at Punjab Institute of Cardiology from July 2021 to July 2022. Two groups of individuals, the Phosphophorylcholine group and the balanced coating group (Affinity Medtronic), were included in this study, with 25 individuals in each group.

The ethical committee of the hospital approved the study. Non-probability sampling was used, and written consent was obtained from all participants. Patients with average pre-operative platelet count and liver function tests undergoing cardiopulmonary bypass were included, while those with pre-operative thrombocytopenia, liver disorder, or bone marrow disorder were excluded. A questionnaire was used to collect data. Pre-operative and post-operative platelet counts were recorded to assess the platelet drop among the two groups.

Additionally, pre-operative and post-operative values of white blood cell count and coagulation profile were noted to determine if the platelet drop was truly coating-based and to avoid contamination of extrinsic variables. Demographic parameters and other risk factors were also considered. All data was analyzed using the SPSS 21 program. Categorical data was presented as percentages, while frequency distribution was used for quantitative analysis. A paired t-test was used to compare the two groups' pre and post-operative platelet drop, with a p-value of less than 0.05 considered significant. Results were concluded based on the p-value.

Results

In this study, we divided 50 patients into Group 1 (Phosphoryl Coating) and Group 2 (Balanced Coating). There was a male predominance, with 76% males and 24% females, as shown in Table 2. The mean age of the patients was 56.18 years, with a mean weight of 71.7 kg and a mean height of 167.24 cm. Other demographic details are shown in Table 1. 68% of the patients were undergoing CABG surgery, 20% valvular surgery, and 12% were CABG with valvular surgery, as shown in the table 2.

Table 1: Demographics of the study group

Variable	N =50	Minimum	Maximum	Mean
Age (yrs)	50	40	72	56.18
Weight (kg)	50	46	102	71.700
Height (cm)	50	150	184	167.24

Table 2: Gender and type of surgery Distribution

Gender	Frequency	Percent
Male	38	76
Female	12	24
Total	50	100
Type of surgery performed.		
CABG	34	68
Valvular	10	20
CABG+valvular	6	12
Total	50	100

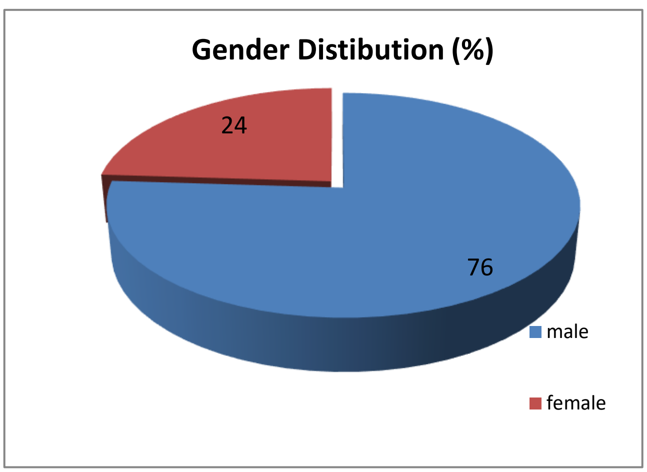

fig 1 Gender distribution of study population

The average hemoglobin level of patients in group 1 before the operation was 13.06g/dl with a 95% confidence interval. After the procedure, the intermediate hemoglobin level of these patients remained the same at 13.06g/dl with a 95% confidence interval. The average platelet count before the operation was 275.68 thousand/microliter; after the procedure, it decreased to 227.40 thousand/microliter. Additionally, the average White blood cell count before the process was 8.63*10*9/l; after the operation, it increased to 16.30X10^9/L. The average pre-operative prothrombin time was 11.36. You can find further details about Group 1 in Table 3.

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Table 3: Group 1(phosphoryl coating) preoperative and post-operative variables

Variable	N=25	Minimum	Maximum	Mean
Pre-operative hemoglobin	25	9.10	16.30	13.06
Post-operative hemoglobin	25	8.30	14.90	11.77
Pre-operative platelets	25	185	508	275.68
Post-operative platelets	25	80	409	227.40
Pre-operative white blood cells	25	4	15.10	8.63
Post-operative white blood cells	25	7.50	23.00	16.30
Pre-operative prothrombin time	25	11	15	11.36

In group 2 patients, the average hemoglobin level before surgery was 12.92g/dl (95% confidence interval), while after surgery, it dropped to 11.09g/dl (95% confidence interval). The mean pre-operative and post-operative platelet count was 297.68 thousand/microliter and 216.08 thousand/microliter, respectively. The mean pre-operative white blood cell count was 8.1×10^9/l, while the mean post-operative white blood cell count was 15.36×10^9/l. The mean pre-operative prothrombin time was 11.36. You can find more details about Group 2 in Table 4.

Table 4: Group 2 (Balanced coating) pre-operative and post-operative variables

Variable	N=25	Minimum	Maximum	Mean
Pre-operative hemoglobin	25	10	15.50	12.92
Post-operative hemoglobin	25	7.50	14.30	11.09
Pre-operative platelets	25	157	504	297.68
Post-operative platelets	25	102	371	216.08
Pre-operative white blood cells	25	4.50	15.10	8.1
Post-operative white blood cells	25	7.90	30.90	15.36
Pre-operative prothrombin time	25	11	13	11.36

The study shows that both groups have P-values less than 0.05 at a 95% confidence interval, indicating a significant impact of biocompatible coated CPB circuits on circulating platelet drop. The Cohens test suggests that group 1 (Phosphoryl choline coating) has a more significant effect on platelet drop than group 2 (Balanced coating), as shown in Table 5.

Table 5: Comparison of p-value among both groups

Variable	P value	Effect size
Group 1(pre-operative and post-operative platelet count)	0.036	108.4
Group 2(pre-operative and post-operative platelet count)	< 0.01	68.5

Discussion

Cardiopulmonary bypass (CPB) is a crucial component of cardiac surgery, providing circulatory support to oxygenate and pump blood during procedures such as coronary artery bypass grafting (CABG) and valve replacement. Despite its life-saving capabilities, CPB is associated with various complications, including hemostasis and platelet function alterations. To mitigate these issues, bio-compatible coatings have been developed for CPB circuits to enhance their interaction with blood components.

P value for the platelet drop due to bio-compatible balanced coating CPB circuit came to be less than 0.01, suggesting that balanced coating significantly impacts platelet drop. Effect size calculated by Cohen's d came to be 68.5, showing less impact of balanced coating on platelet drop than phosphoryl coated CPB in which the effect size estimated by Cohen's d formula is 108.5.

The effect size of both groups suggests that phosphorylcholine-coated CPB circuits have more impact on platelet drop than balanced coating affinity Medtronic. Our research found that using a balanced-coating on the CPB circuit considerably affected During the initial 24 post-operative hours, blood loss remained minimal. The advantage was more significant following CABG surgery compared to mitral valve repair. These findings back up the results reported by De Somer et al., who discovered a substantial reduction in blood loss in the PC group within the first four post-operative hours. (De Somer et al., 2002a) Although the PC-coated CBP circuit reduced early post-operative blood loss, transfusion needs did not differ across groups, probably because of a patient selection restriction. Our research exclusion criteria indicated that our included patients were at minimal risk of perioperative hemorrhage. Only individuals at high risk of bleeding may benefit clinically in terms of transfusion needs and post-operative morbidity. Platelet alpha-granule contents are generally replenished after 4 hours of CPB, and platelet surface GpIIb/IIIa and GPIb receptor expression recovers to baseline within 6 hours following decannulation.(Nouette et al., 2004) Most second surgeries for early post-operative bleeding occur during this time when platelet function recovers to baseline.

A comparable decline in platelet count was detected in both groups during the first minutes of commencing CPB, as stated in prior publications (Nouette et al., 2004; Palanzo et al., 1999; Ray et al., 1994), but this drop was more in phosphorylcholine group than in balanced coating group.

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Interaction between the cells in the blood and the CBP circuit surface impairs coagulation. Thrombin levels rise 20-fold in the initial 5 minutes of CBP. It also increases after decannulation, reperfusion of the ischemic myocardium, and protamine delivery before returning to baseline within 2 hours of CBP.(De Somer et al., 2002b; Knudsen et al., 1996)

High thrombin production consumes platelets, fibrinogen, and clotting factors, increasing the risk of bleeding. (Chandler and Velan, 2003)

Balanced coating AFFINITY allows a smoother hydrophilic surface for blood components preservation, such as blood cells and proteins. Balance biosurface is a hydrophilic polymer coating without heparin for cardiopulmonary bypass circuit devices. This coating reduces platelet adhesion and activation, preserving platelet function and preventing platelet drop, as shown in the result of our study. Balanced biosurface provides reduced platelet activation and adhesion and preserves platelet function with a non-heparin coating.

Conclusion

Blood components, including platelet conservation, depend on the type of non-endothelial biocompatible surface. The more compatible the surface, the more they allow the preservation of blood cells. In our study, we considered two coating phosphoryl coating and balanced coating to check whether there is any significant impact on the platelet drop of these coatings. According to the results obtained in our study, we concluded that the phosphoryl-coated CPB had more impact on platelet drop as compared to balanced coating (the decision was made according to the p-value and effect size).

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.
Ethics approval and consent to participate.
Approved by the department Concerned.
Consent for publication
Approved
Funding
Not applicable

Conflict of interest

Writers have affirmed they have no pending conflicts of interests

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