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Association of Platelet Apheresis with Hematological and Electrolyte Abnormalities in Donors: A Pre- and Post-Donation Study

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ABSTRACT

Objectives: To assess the association of platelet pheresis with occurrence of abnormalities in hematological parameters and serum electrolyte homeostasis before and after donation.

Study Design and Setting: Prospective cohort study. Department of Pathology, PNS Shifa, Karachi (Jan-Dec 2024).

METHODOLOGY: A total of 126 platelet donors were studied. Patients aged 18–60 years who had a normal CBC, a platelet count of =200,000/µL and a body weight of at least 50kg were included. Individuals with chronic illness history, medication affecting hematological parameters, recent infection, prior platelet donations or surgery within the last 6 months were excluded. Pre-donation CBC and serum electrolytes were measured and then repeated immediate post-donation and then at one-week and one-month. The sample was calculated by WHO calculator with 5% significance (α) and 95% power of the test (1-β) with standard deviation (σ) of 0.385, variance (σ^2) of 0.148225, a mean serum calcium level prior to platelet pheresis of 9.91 mg/dL and a post-plateletpheresis of 9.75 mg/dL.

Results: The median-age at donation was 32.0 (IQR: 10.0) years with 122 (98.6%) patients being male and 19 (15.1%) had a history of previous donations. Haemoglobin (p=0.023), hematocrit (p<0.001), platelet count (p<0.001), serum calcium (p<0.001) and magnesium (p=0.003) were significantly lower in patients immediately after plateletpheresis. At 1-week post-donation, only platelet count (p<0.001) was below baseline levels. One month from the plateletpheresis procedure, all the haematological and electrolyte levels returned to baseline.

Conclusion: Plateletpheresis is a safe procedure with any haematological or electrolyte disturbance post-procedure returning to normal within one week.

Keywords: electrolyte balance, hemostasis, platelet aphersis

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INTRODUCTION:

Platelet apheresis is a critical and highly specialized procedure in the realm of modern medicine, playing an indispensable role in the treatment and management of patients suffering from thrombocytopaenia, malignancies, and other medical conditions that necessitate platelet transfusion. Among these conditions, immune thrombocytopaenic purpura stands out as a significant indication for platelet transfusion therapy.[1] This advanced medical process has gained increasing prominence in the field of transfusion medicine, primarily because of its unique ability to address the specific and individualized needs of patients requiring targeted platelet replacement therapy. Unlike traditional methods of whole blood donation, platelet apheresis is a procedure that involves the selective extraction of platelets from a donor's blood while simultaneously returning the remaining blood components, including red blood cells and plasma, back into the donor's circulation system.[1,2] This sophisticated technique not only yields a significantly higher quantity of platelets suitable for transfusion compared to conventional blood donation methods but also allows donors to participate in the process more frequently, given its minimal theoretical impact on the overall homeostasis and balance of the donor's

blood components.[3,4] Despite these numerous advantages, the exact impact of platelet apheresis on the donor's haematological parameters and overall health remains an area of ongoing research and clinical scrutiny. Researchers and medical practitioners continue to explore the various physiological and biochemical changes that occur during and after the apheresis procedure to better understand its implications for donor health, safety, and long-term well-being.

To safeguard donor health and ensure their well-being, the US Food and Drug Administration (FDA) established comprehensive guidelines in 2005. These guidelines permit up to 24 component donations per year and restrict each individual procedure to a maximum of three components. Additionally, the guidelines impose a limit of no more than two donations per week and require a mandatory minimum interval of 48 hours between consecutive donation sessions.5 These regulatory measures are designed to minimize any potential risks to donors, ensuring that the frequency and intensity of donations do not adversely affect their overall health or long-term physiological stability. While platelet apheresis is widely regarded as a safe and well-tolerated procedure, it is known to induce measurable changes in the donor's blood composition. These changes can persist for varying durations following the donation process.6 The most commonly observed change is a reduction in platelet count, which is an expected and inevitable outcome of the procedure. However, other haematological parameters, including white blood cell counts, hemoglobin levels, plasma protein concentrations, and electrolyte balances, may also be affected to varying extents.[7,8] Understanding the scope, extent, and duration of these changes is crucial for ensuring donor safety, optimizing the frequency of donations, and improving the overall efficacy and outcomes of the apheresis process. Previous research efforts have largely focused on examining the immediate and short-term impacts of platelet apheresis on donors. These studies have documented fluctuations in platelet counts, minor decreases in hemoglobin levels, and occasional alterations in white blood cell counts.?[,10] These findings have provided valuable insights into the acute physiological effects of the procedure, which are generally well-tolerated by the majority of donors. However, the long-term effects of platelet apheresis, as well as the timeline for the complete recovery of haematological parameters following repeated donations, remain less thoroughly explored. This gap in the available data creates a significant knowledge void, particularly with respect to understanding how repeated platelet apheresis sessions may influence donor health over extended periods of time.

This article aimed to address these critical knowledge gaps by conducting a detailed analysis of the effects of platelet apheresis on donors' haematological parameters. The analysis covered both short-term and long-term changes, providing a comprehensive overview of the physiological adjustments experienced by donors. By comparing haematological parameters before the procedure and at various intervals following the donation, this study sought to elucidate the extent and duration of any observed changes. Such an approach allows for a more nuanced and detailed understanding of the physiological processes involved, offering valuable insights that could enhance donor management and safety protocols. For example, identifying trends in recovery times or persistent alterations in specific haematological parameters could lead to recommendations for adjusting donation frequencies or developing personalized donor care strategies. Furthermore, this research not only contributes to the broader scientific knowledge surrounding apheresis but also holds practical significance for clinical practices in transfusion medicine. By shedding light on the physiological effects of platelet apheresis, the findings aim to support the development of evidence-based guidelines that prioritize donor safety while maximizing the availability of life-saving platelets for patients in need. Ultimately, this study highlights the importance of balancing the significant benefits of platelet apheresis with the critical need to protect and preserve the health and well-being of the donors who make this vital medical procedure possible.

METHODOLOGY

This prospective cohort study was carried out in the Department of Pathology at PNS Shifa, Karachi, over a duration of eight months, spanning from January 2024 to August 2024. The ethical review for this study was approved under the reference number ERC No. ERC/2024/PATH-125. The research sample consisted of 126 voluntary donors who underwent plateletpheresis during the study period. Written informed consent was obtained from all participants prior to their inclusion in the study, ensuring that they were fully aware of the procedure and its potential implications. The study was carefully designed and executed in strict adherence to the principles outlined in the Declaration of Helsinki, as well as the ethical standards and institutional guidelines established by our organization. The participants included in the study were selected through consecutive, non-random sampling, a method that allowed for the inclusion of eligible donors as they became available. To determine the appropriate sample size, the World Health Organization (WHO) sample size calculator was employed. The calculations were based on a level of significance (α) of 5%, a test power (1-β) of 95%, a population standard deviation (σ) of 0.385, and a population variance (σ^2) of 0.148225. The mean serum calcium level prior to plateletpheresis was estimated at 9.91 mg/dL, with a post-plateletpheresis mean level of 9.75 mg/dL, as reported in the study by Syal et al.[8]

Inclusion Criteria: The study included donors aged 18 to 60 years who met specific health requirements. All participants were required to have a normal complete blood count, a platelet count of at least 200,000/µL, and a minimum body weight of 50 kg to qualify for participation.

Exclusion Criteria: Individuals were excluded from the study if they had a history of chronic illnesses, were taking medications known to affect haematological parameters, or had experienced recent fever or infection. Additionally, donors who had undergone prior platelet donations or surgeries within the past six months were also excluded to minimize confounding factors.

For each participant, a comprehensive medical history was meticulously recorded at the time of enrollment. Baseline haematological parameters were measured before the donation, including haemoglobin (Hb), haematocrit (Hct), white blood cell count (WBC), platelet count, mean platelet volume (MPV), and serum levels of calcium, magnesium, and potassium. Immediately after the plateletpheresis session, these parameters were reassessed to evaluate any short-term effects of the procedure. To monitor potential long-term changes, additional blood samples were collected at one week and one month post-donation, with the same parameters being tested at each time point.

Plateletpheresis procedures were conducted using a standard apheresis system (Cell Separator Haemonetics; MCS+ USA) following the manufacturer's protocols and guidelines. Each donor participated in a single apheresis session, which lasted for an average duration of 60 to 90 minutes. The volume of platelets collected during each session ranged between 200 and 300 mL, with a minimum target yield of 3×10^{11} platelets per unit to ensure optimal collection efficiency.

The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 27.0. Quantitative variables were summarized using mean and standard deviation or median and interquartile range (IQR), depending on the distribution of the data. Qualitative variables were expressed in terms of frequency and percentage. To compare the parameters measured at different time points, paired samples t-tests were utilized. A *p*-value of =0.05 was considered statistically significant, ensuring robust interpretation of the findings.

RESULTS

Our research study was conducted on a total of 126 individuals who voluntarily participated in plateletpheresis procedures during the study period. The median age of the donors at the time of their platelet donation was 32.0 years, with an interquartile range (IQR) of 10.0 years, reflecting a relatively young and uniform donor population. Notably, the overwhelming majority of participants, amounting to 122 individuals (98.6%), were male, highlighting a significant gender disparity within the donor pool. Additionally, it is important to note that only a small proportion of the participants, specifically 19 individuals (15.1%), reported having a prior history of platelet or blood donations. This suggests that the majority of the donors in our study were first-time donors, which may have implications for the interpretation of their physiological responses to the plateletpheresis procedure. Table-1 provides a detailed summary of the baseline haematological and serum electrolyte parameters for all participants before proceeding with the platelet donation.

Table-2 provides a comprehensive overview of the haematological parameters that were measured at three distinct time points: immediately following the plateletpheresis procedure, one week after the donation, and finally, one month post-donation. The data reveal that haemoglobin levels, haematocrit values, platelet counts, as well as serum calcium and magnesium concentrations, showed a statistically significant decrease immediately after the plateletpheresis session. However, it was observed that these values generally returned to their normal, pre-donation levels within one week of the procedure, with one notable exception—platelet counts.

The recovery of platelet counts was comparatively slower, as they did not return to baseline levels within the one-week timeframe. By one month following the plateletpheresis procedure, however, all haematological parameters, including platelet counts, and all electrolyte levels had fully returned to their baseline values, indicating complete recovery from the physiological changes induced by the procedure. Notably, a mean reduction in platelet count of 23.59 ± 3.97% was observed immediately after the plateletpheresis session. This decline is an expected outcome of the procedure, given the nature of platelet collection during apheresis.

DISCUSSION:

This study was designed to evaluate the effects of plateletpheresis on various haematological parameters and serum electrolyte levels among healthy, voluntary donors. The primary objective was to determine whether this commonly performed procedure induces significant changes in these parameters and, if so, to assess the timeline for their recovery to baseline levels. Our findings suggest that while plateletpheresis is generally well tolerated by donors, it does lead to measurable changes in certain haematological parameters and serum electrolyte levels immediately following the procedure. However, most of these alterations appear to resolve within a recovery period of one week to one month post-donation. These results align with those

Table-1. Patient haematological and electrolyte characteristics prior to plateletpheresis (n=126)

Variable	Value
Haemoglobin (g/dL)	15.0 (IQR: 1.3)
Haematocrit (%)	47.0 (IQR: 5.0)
White Blood Cell Count (/µL)	7.55 (IQR: 3.4)
Platelet Count (/µL)	328.0 (IQR: 112.0)
Mean Platelet Volume (fL)	9.0 (IQR: 5.0)
Calcium Level (mg/dL)	9.2 (IQR: 0.8)
Magnesium Level (mg/dL)	2.0 (IQR: 0.4)
Potassium Level (mg/dL)	4.25 (IQR: 0.8)

Table-2. Patient haematological and electrolyte characteristics after plateletpheresis (n=126)

Variable	Immediately After Plateletpheresis (p-value)	At One Week Post-Plateletpheresis (p-value)	At One Month Post-Plateletpheresis (p-value)
Haemoglobin (g/dL)	15.0 (IQR: 1.30) 0.023	15.0 (IQR: 1.5) 0.195	14.9 (IQR: 1.5) 0.248
Haematocrit (%)	44.0 (IQR: 4.0) <0.001	47.0 (IQR: 5.0) 0.291	47.0 (IQR: 5.0)0.144
White Blood Cell Count (/µL)	7.60 (IQR: 3.4) 0.465	7.7 (IQR: 3.5) 0.744	7.6 (IQR: 3.6) 0.384
Platelet Count (/µL)	247.5 (IQR: 78.0) <0.001	304.0 (IQR: 104.0) <0.001	326.0 (IQR: 115.0) 0.241
Mean Platelet Volume (fL)	9.0 (IQR: 5.0) 1.000	9.0 (IQR: 5.0) 1.000	9.0 (IQR: 5.0) 0.425
Calcium Level (mg/dL)	9.0 (IQR: 1.0) <0.001	9.2 (IQR: 0.8) 0.867	9.2 (IQR: 0.8) 0.904
Magnesium Level (mg/dL)	1.9 (IQR: 0.3) 0.003	1.95 (IQR: 0.4) 0.711	1.9 (IQR: 0.5) 0.251
Potassium Level (mg/dL)	4.2 (IQR: 0.7) 0.264	4.2 (IQR: 0.8) 0.931	4.2 (IQR: 0.8) 0.183

reported in previous studies, which have consistently demonstrated that the effects of plateletpheresis on haematological and electrolyte parameters are transient in nature.[11]

In the current study, there was a statistically significant reduction in haemoglobin (p=0.023) and haematocrit levels (p<0.001) immediately after plateletpheresis. Notably, both parameters returned to their pre-donation levels within one week, indicating a rapid recovery. Our findings are consistent with those reported in earlier research. For instance, Gil-Betacur et al observed a significant reduction in haemoglobin levels by approximately 0.80 g/dL (CI 95%: 0.75–0.86) and a corresponding drop in haematocrit by 2.26% (CI 95%: 2.11–2.41).? Similarly, Ashok et al documented a decrease in haemoglobin of -0.50 g/dL (CI 95%: -0.72–-0.27) and a reduction in haematocrit of -1.36% (CI 95%: -2.05–-0.66).[1°] Sharma et al also reported a modest mean haemoglobin drop of 0.4 g/dL in their study.[14] The reduction in haemoglobin and haematocrit observed during plateletpheresis may be attributed to several factors. These include blood loss associated with the lines and donation circuit, the type of apheresis procedure used, haemolysis during the process, fluid dilution effects, and blood lost at the time of line insertion.[12-15] Despite these potential contributing factors, the observed reductions in haemoglobin and haematocrit were mild, and the lost levels were quickly replenished by the donors' natural physiological mechanisms.

In addition to changes in haemoglobin and haematocrit, the present study found a significant reduction in platelet counts immediately after the procedure (p<0.001). This result is unsurprising given the nature of plateletpheresis, which involves the selective extraction of platelets from the donor's blood. The mean drop in platelet count was 23.59 ± 3.97%, consistent with findings from prior studies. For example, Rajput et al reported that plateletpheresis temporarily reduces circulating platelet levels, while Thokala et al observed a 20–25% drop in platelet counts post-procedure, with full recovery typically occurring beyond the first week.[16,17] Interestingly, studies such as Shima et al have suggested that donors with lower platelet counts prior to plateletpheresis may experience larger drops in platelet levels following the procedure.[18] The mechanism underlying this observation remains unclear, warranting further investigation. Importantly, extended follow-up studies have consistently demonstrated that plateletpheresis does not result in long-term alterations in haematological parameters, further affirming the safety of this procedure for regular donors.[1?]

Serum electrolyte levels were also assessed in this study, with significant decreases observed in calcium (p<0.001) and magnesium (p=0.003) levels immediately after donation. These findings are consistent with studies by Barrientos-Galeana et al and Navkudkar et al, which have similarly reported reductions in calcium and magnesium levels following plateletpheresis.[2°,21] These changes are primarily attributed to the use of citrate as an anticoagulant during the procedure, as citrate chelates calcium and magnesium, leading to transient hypocalcaemia and hypomagnesaemia.[2°–22] However, both calcium and magnesium levels normalized within one week in the present study, indicating that these disturbances are temporary and unlikely to pose any long-term risks to donors. In contrast, potassium levels remained stable throughout the study period, with no significant changes observed. Furthermore, the study found no significant alterations in white blood cell counts or mean platelet volume at any of the time points assessed. This stability suggests that plateletpheresis does not have a meaningful impact on these haematological parameters, further supporting its safety and tolerability. These findings align with those of Nayak et al, who also reported minimal haematological disruption in donors undergoing plateletpheresis.5

In summary, this study highlights that while plateletpheresis induces temporary changes in certain haematological parameters and serum electrolyte levels, these effects are short-lived and resolve within a predictable timeframe. These results reaffirm the safety of plateletpheresis as a viable and effective method for platelet donation, with minimal risk to donor health. Future research should focus on exploring

these effects in more diverse donor populations and over longer follow-up periods to provide even greater clarity and assurance regarding the safety of this critical procedure.

CONCLUSION

Our study provides clear evidence that plateletpheresis induces significant, though transient, changes in several haematological and serum electrolyte parameters, including haemoglobin, hematocrit, platelet count, calcium, and magnesium levels. These alterations, while measurable and statistically significant immediately following the procedure, tend to normalize within approximately one week post-donation. This rapid recovery suggests that plateletpheresis is a safe and well-tolerated procedure, with no apparent long-term adverse effects on the donor's haematological or electrolyte parameters. The findings of our research strongly support the continued and widespread use of plateletpheresis as an effective and reliable method for platelet donation. However, it is important to note that future studies should aim to address certain limitations, including the need to evaluate more diverse donor populations. Furthermore, extending the follow-up periods would provide additional insights into the longer-term recovery process and help identify any delayed effects that might not have been captured within the timeframe of our study. Such extended research would contribute to a more comprehensive understanding of the physiological impact of plateletpheresis and further reinforce its safety profile.

Authors Contribution:
Anum Shabir: Principal Investigator
Saeed Akhtar Khan Khattak: Supervisor
Kiran Jabbar: Topic Selection
Dawood Ahmed: Biostatistics
Shahzaib Shaikh: Strictly limitation
Muhammad Umar: Discussion

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