RESEARCH PAPER

Determinants of Platelet Yield in Single Donor Plateletpheresis: Influence of Donor Characteristics and Haematological Parameters

[1]Dr.Farhanaaz Ghani, [2]Dr.Tanya Tripathi, [3]Dr. Mandira Sharma

[1*]Junior Resident 2 PATHOLOGY DEPARTMENT, CAREER INSTITUTE OF MEDICAL SCIENCES AND HOSPITAL, LUCKNOW, farhaghani14@gmail.com

[2]ASSISTANT PROFESSOR MD (PATHOLOGY), PATHOLOGY DEPARTMENT, CAREER INSTITUTE OF MEDICAL SCIENCES AND HOSPITAL, LUCKNOW, tanyatripathi@rediffmail.com

[3]Head of department MD (PATHOLOGY) PATHOLOGY DEPARTMENT, CAREER INSTITUTE OF MEDICAL SCIENCES AND HOSPITAL, LUCKNOW, mandirasharmalko@gmail.com

Abstract

Introduction: Plateletpheresis is increasingly used for the collection of single donor platelets due to its advantages over conventional methods. Platelet yield, an important quality parameter, is influenced by various donor-related factors such as haematological indices and demographic characteristics. This study aims to evaluate the impact of donor variables on platelet yield.

Materials and Methods: This observational study included healthy donors undergoing plateletpheresis. Baseline demographic data (age and weight) and haematological parameters, also documented. Pre and post-apheresis platelet count and haemoglobin levels were compared. Donors were stratified by gender and pre-apheresis platelet count groups. Statistical analysis was performed using the Mann–Whitney U test, with $p<0.05$ considered significant.

Results: A significant reduction in platelet count (264.34±60.32/µL to 176.27±44.51/µL) and haemoglobin (14.84±1.19 g/dL to 14.03±1.20 g/dL) was observed post-procedure ($p<0.001$). Platelet yield did not differ significantly between males and females ($p=0.845$). A strong positive association was found between pre-apheresis platelet count and platelet yield, with higher yields observed in donors with counts >250/µL ($p<0.001$).

Conclusion: Pre-apheresis platelet count is the most significant predictor of platelet yield, whereas gender has no substantial impact. Other donor and procedural variables showed no significant independent effect on platelet yield. Optimizing donor selection based on platelet count can improve collection efficiency and resource utilization.

Keywords: Cell separator, donor variables, demographic parameters, haematological parameters, platelet yield.

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1. Introduction

Platelet transfusion is an effective therapeutic measure in cases of bleeding with thrombocytopenia or platelet dysfunction. It is also used prophylactically in cases of thrombocytopenia in which invasive procedures are to be performed to prevent bleeding (Solves, 2020). Platelet concentrates used for transfusion can be prepared by two main techniques. In the first technique, whole blood is centrifuged, and then platelets are pooled from various donors, referred to as random donor platelets (RDP). In another technique, platelets are collected from a single donor, referred to as single donor platelets (SDP), by apheresis (Capraru et.al. 1990). Apheresis is a procedure in which one or more components of blood are separated and removed from the circulating blood of the donor, and the rest of the components are reintroduced into circulation using automated cell separator devices. The scientific principle of apheresis is based on centrifugation and filtration technologies, which work in either continuous or intermittent flow modes. Plateletpheresis is a safe procedure that is completed in approximately 90 minutes. During the procedure, the blood of the donor is passed through a cell separator and a platelet concentrate is collected, which contains $3*10^{11}$ platelets (Transfusion Medicine 2024). The transfusion of one unit of SDP usually achieves an increment of 30,000-60,000/µL in the platelet count of the recipient and is therapeutically equivalent to 4-6 units of RDP. Plateletpheresis is becoming the popular choice because it is believed that single donor platelets are better than random donor platelets because the post-transfusion platelet recovery in the recipient is better, and the risk of alloimmunization and infectious disease transmission is reduced (Karim et.al. 2019). The quality of SDP is largely measured by the platelet yield. Several donor-related and procedural factors are believed to affect the platelet yield. Donor-related factors include age, gender, body weight, blood group, pre-donation hemoglobin levels, baseline platelet counts, and hematocrit levels. The quality of Single Donor Platelet (SDP) concentrates is generally related to the platelet yield (Geetha et.al. 2017). Several investigations were designed to assess the impact of donor-related variables on platelet yield, which include age, body mass index (BMI), hemoglobin (Hb), hematocrit (Hct), baseline platelet counts, mean platelet volume (MPV), platelet distribution width (PDW), and total leukocyte counts (TLC) (Fateen et.al.

*Author for Correspondence: : farhaghani.14@gmail.com

2022). However, the most important donor-related factor affecting platelet yield is the platelet counts prior to donation. Although some investigations demonstrated inconsistent associations between donor-related variables and platelet yield, the majority of the investigations demonstrated a positive correlation between platelet counts prior to donation and platelet yield. In this context, the present study was designed to assess the effect of donor factors such as age, BMI, Hb, platelet count, MPV, PDW on the yield of platelets in single donor plateletpheresis.

2. Material and Methods

2.1. Study Design

A prospective observational study was done in a tertiary care hospital in north India. 104 single donor platelets were selected according to departmental standard operating procedures (SOPs) prepared as per directorate general health services transfusion medicine technical manual 2003. Study was approved by the Institutional Ethical Committee. All those donors who were willing to participate in the study and gave written consent for the same were included in the study. Unfit donors, procedures interrupted due to small veins, kit leakage during priming, incomplete procedures, and donors who did not give consent were excluded from the study.

2.2. Study Procedure

Preprocedural work-up such as donor screening, blood grouping, and screening for transfusion-transmitted infections was done as per departmental SOPs. The donor was counselled, and queries were answered. Continuous monitoring of the procedure was done to assure an uneventful procedure. 104 procedures each were performed on three different cell separators. The selection of donors on the cell separator was subject to the availability of a particular cell separator at the time of the procedure. Single-needle (SN) system was used in all the procedures. Apheresis machine used was by Trima accel Automated Blood Collection System.

Relevant data such as donor weight, age, gender, pre-procedural Hb, Hct, and platelet count were entered. Processed blood volume to attain the target platelet yield ($\geq 3\times10^{11}$) was calculated by all cell separators. Machine variables such as blood volume processed, product volume obtained, and duration of the procedure were recorded after the procedure. Donor's blood sample was collected in Ethylenediaminetetraacetic acid vial after 30 min of procedure and platelet count, Hb, and Hct were noted. Two ml sample from the diversion pouch of the product bag was obtained in a plain vial after one hour without being placed in platelet agitator and analyzed for platelet count. Blood counts were analyzed by a calibrated automated analyzer. Platelet yield was noted for each procedure and evaluated concerning donor and machine variables. Platelet yield was calculated as:

Platelet yield = Product volume (ml) × Product count (platelet/µl) × Conversion factor (1000) (Khan and Imran 2023)

2.3. Statistical Analysis

All data obtained were entered, segregated, and tabulated in micro excel software as per mentioned variables. Statistical analysis was done using the SPSS V.27. Qualitative data was demonstrated in the form of percentages and proportions. The normality of continuous variables was examined using the Shapiro-Wilk test. Continuous data were presented as mean±standard deviation (SD). Comparison between pre and post-treatment biochemical parameters were analyzed using the Wilcoxon signed-rank test and baseline parameters were compared using Man Whitney U-test since most of the variables were non-normal. Probability was considered significant if $p< 0.05$.

3. Observations and Results

3.1. Baseline Demographic and Hematological Characteristics of Participants

The majority of the study participants were young-middle-aged people, as evidenced by the donor's mean age of 30.69±6.47 years, with an age range of 19-50 years. Body weight ranged from 57 to 105 kg, with a mean of 71.74±8.96 kg. It demonstrated that comparatively healthy donors made up the majority of the sample. In terms of platelet indices, the range was 1.2-15.3 fL, and the mean MPV was 10.31±1.61 fL. There was a moderate variance in platelet size, as indicated by the mean PDW of 15.56±0.45 with a range of 13.6-16.6 (Table.1).

Furthermore, some variation in platelet mass and size was shown by the average values of Plateletcrit (PCT) and Platelet Large Cell Ratio (PLCR), which were 2.18±2.27 (Range: 0.200-5.00) and 32.03±7.26 (Range: 6.7-46.5), respectively. Regarding processing characteristics, however, the average volume of processed whole blood was 2856.55±428.10 mL (range: 1864-4220 mL). In the meantime, the average volume of processing-derived plasma and ACD used to produce platelets was 317.83±106.44 mL (range: 206-797 mL) and 273.20±44.59 mL (range: 181-394 mL), respectively (Table.1).

Table.1. Baseline Demographic and Hematological Data of Participants

Parameters	Range	Mean±SD
Age	19-50	30.69±6.47
Weight (kg)	57-105	71.74±8.96
MPV (fL)	1.2-15.3	10.31±1.61
PDW	13.6-16.6	15.56±0.45
PCT	0.200-5.00	2.18±2.27
PLCR	6.7-46.5	32.03±7.26

WB Processed (mL)	1864-4220	2856.55±428.10
Plasma (mL)	206-797	317.83±106.44
ACD (mL)	181-394	273.20±44.59
Yield ($\times 10^{11}$)	1.9-4.9	3.94±0.55
Pulse Rate	70-74	72.32±1.12

Note: Values are expressed as range and mean ± SD. MPV: Mean Platelet Volume; PDW: Platelet Distribution Width; PCT: Plateletcrit; PLCR: Platelet Large Cell Ratio; ACD: Acid Citrate Dextrose. Yield in $\times 10^{11}$. Statistical test: Mann-Whitney U test, ($p<0.05$), significant association

3.2. Pre- and Post-Apheresis Hematological Parameters of Donors

There was a significant decline in the values of haematology markers after the apheresis procedure. In particular, the value of platelets reduced from 163-455/µL prior to the procedure to 119-373/µL after the procedure ($p<0.001$). Similarly, haemoglobin (Hb) levels dropped from 12.5 to 18.3 g/dL prior to the apheresis procedure to 11.0 to 16.4 g/dL following the procedure (Fig.1). Overall, the post-procedural decline in platelet count and Hb indicates a significant haematological impact of the apheresis procedure (Table.2).

Table.2. Pre- and Post-Apheresis Hematological Values of Donors

Parameters	Range	Preapheresis Mean±SD	Range	Postapheresis Mean±SD	p-value
Platelet Count (/µL)	163-455	264.34±60.327	119-373	176.27±44.517	**<0.001**
Hb (g/dL)	12.5-18.3	14.841±1.1927	11.0-16.4	14.026±1.2016	**<0.001**

Note: Hb: Haemoglobin, Platelet yield ($\times 10^{11}$) is expressed as mean ± SD. Statistical test: Mann-Whitney U test, ($p<0.05$), significant association

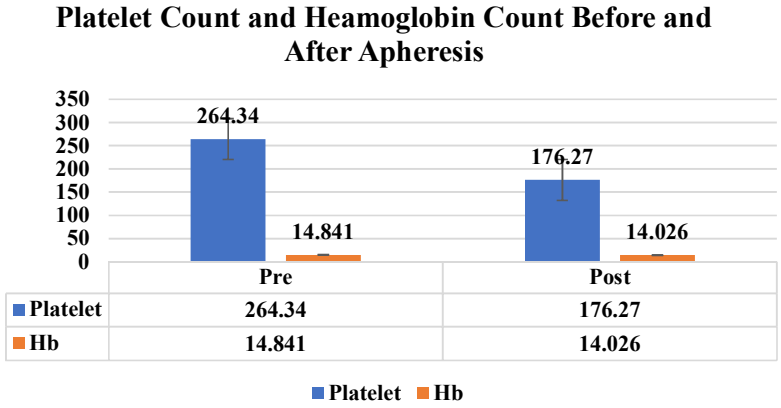

Fig.1. Bar diagram showing mean platelet count and haemoglobin levels before and after apheresis (mean ± SD), demonstrating a significant reduction in both parameters post-Procedure.

3.3. Gender Wise Analysis of Difference In Yield And Pre And Post Clinical Parameters

To determine the effect of gender on the platelet yield and haematological parameters, the donors were grouped as males and females. There was no significant difference noted regarding platelet yield in the two genders (males: 3.936±0.5591; females: 3.963±0.5708; $p=0.845$) (Table.3). Upon further analysis of the different haematological parameters, there was found a marked decrease in the number of platelets after the procedure among the two genders. Among male patients, the mean platelet count dropped from 269.12±63.213/µL before apheresis to 179.42±47.117/µL after apheresis ($p<0.001$). In female subjects, the mean platelet count went down from 242.95±39.829/µL to 162.16±26.881/µL ($p<0.001$). There was also an observable drop in the mean Hb in the two groups after the process. Males had a lower level of Hb after the procedure, dropping from 14.956±1.1632 g/dL before apheresis to 14.082±1.1553 g/dL after apheresis (Table.3).

Table.3. Gender-wise Platelet Yield and Haematological Parameters

Gender	Platelet Yield (Mean±SD)		p value
Male	3.936±0.5591		1.0
Female	3.963±0.5708		0.845

	Preapheresis Mean±SD	Postapheresis Mean±SD	
Male			
Platelet Count (/µL)	269.12±63.213	179.42±47.117	**<0.001**
Hb (g/dL)	14.956±1.1632	14.082±1.1553	**<0.001**
Female			
Platelet Count (/µL)	242.95±39.829	162.16±26.881	**<0.001**
Hb (g/dL)	14.326±1.2183	13.774±1.3968	**<0.001**

Note: Hb: Haemoglobin, Platelet yield ($\times 10^{11}$) is expressed as mean±SD. Statistical test: Mann-Whitney U test, ($p<0.05$), significant association

3.4. Comparison of Platelet Yield Across Different Pre-Apheresis Platelet Count Group

For assessing the impact of platelet count on platelet yield, donors were classified into four categories depending upon their platelet count before apheresis. With increasing platelet count, there was a continuous rise in the average platelet yield. In the category of 150-200/µL, donors exhibited the minimum mean yield ($3.308\pm0.6576\times10^{11}$), and this category was used as a control group. There was a marked rise in the mean yield in the second category (201-250/µL), i.e., ($3.874\pm0.4778\times10^{11}$, $p=0.005$). In the same way, the third category (251-300/µL) yielded an even higher result ($4.195\pm0.4509\times10^{11}$, $p<0.001$). The >300/µL group also showed significantly increased yield ($4.117\pm0.4647\times10^{11}$, $p<0.001$) compared to the reference group (Table.4).

Table.4. Platelet Yield Across Platelet Count Groups

Platelet Count Group (/µL)	Yield ($\times10^{11}$) (Mean ± SD)	p value
150–200	3.308±0.6576	1.0
201–250	3.874±0.4778	**0.005**
251–300	4.195±0.4509	**<0.001**
>300	4.117±0.4647	**<0.001**

Note: Platelet yield ($\times10^{11}$) is expressed as mean±SD. Statistical test: Mann-Whitney U test, ($p<0.05$), significant association

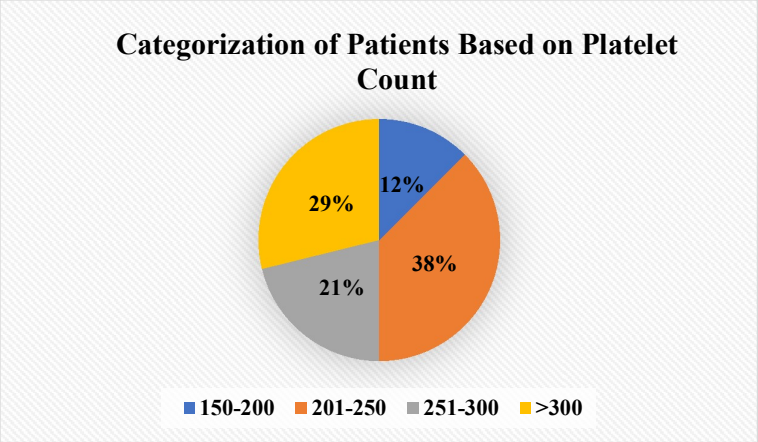

Fig.2. Distribution of Patients Across Different Platelet Count Groups

4. Discussion

In the present study, the baseline features of donors and the effect of plateletpheresis on haematological parameters were studied. The donors involved in our study were primarily male subjects, like most other studies that found that females had problems regarding venipuncture procedures and were more likely to suffer from vasovagal reactions than males (Winters 2006) (Philip et.al. 2013). The incidence of vasovagal reactions in female apheresis donors was reported to be 1.25%, whereas the incidence among male donors was 0.83% (Tomita et.al. 2002). Nevertheless, no such relationship was found between the weight and height of the donors and platelet yield in our study.

There was a wide variation in the platelet parameters (MPV, PDW, PCT, and PLCR), which is indicative of differences in the shape and weight of the platelets across different individuals and can affect the yield of

platelets during the procedure. All the parameters related to the process of platelet collection were well within the acceptable limits and produced a satisfactory yield of platelets. This suggests that the apheresis procedures were performed efficiently and in accordance with standard protocols.

4.1. Baseline Donor Characteristics and Platelet Indices

Our cohort's donor attributes, such as age and health, were well within the recognized donor parameters and helped create the perfect environment for platelet harvesting. Variability in platelet structure was suggested by the comparatively large ranges of platelet properties including MPV, PDW, PCT, and PLCR. However, in our study, these variables do not appear to have an impact on platelet formation. Recent research indicates that although several total blood count indicators may have some link with yield, platelet count frequently has a greater impact (Gulia et.al. 2024). However, other parameters including donor weight, age, and haemoglobin were not associated with platelet yield in our study supported by Chaudhary et.al. 2006.

4.2. Haematological Changes Following Plateletpheresis

There has been a notable drop in both the platelet and haemoglobin levels after the procedure ($p<0.001$), a trend expected from the physiological effect of platelets depletion. The data is well supported by past researches, which has shown that the haemoglobin level drops after plateletpheresis (Sharma et.al. 2024). Though statistically significant, post-apheresis figures did not go beyond safe clinical parameters, thus emphasizing the safety of the procedure. This finding has been replicated in other high-quality studies wherein haematological reduction following donation was temporary and not linked to any adverse effects (Sharma et.al. 2024).

4.3. Gender-Based Analysis of Platelet Yield and Haematological Parameters

No significant variation was found in terms of platelet yield in relation to donor's gender ($p=0.845$) in our study, even though both genders were found to have significant depletion of platelet counts and haemoglobin after procedure. The above finding is consistent with previous research studies which showed lack of significant relationship between donor's gender and platelet yield (Chaudhary et.al. 2006) (Sudev et.al. 2026).

4.4. Impact of Pre-Apheresis Platelet Count on Platelet Yield

One of the most important results obtained through our study is the statistically significant relationship between the pre-apheresis platelet count and platelet yield. There was a gradual increase in the yield for each higher category of platelets, with the largest yield observed among the 251-300/µL category. This finding supports the well-established role of baseline platelet count as a key determinant of yield, as also reported by Sudev et.al. 2024.

Notably, our finding that there is a small plateau for yield after reaching a certain level of platelet count (>300/µL) fits the idea of a threshold effect, which is seen in a study by Chopra et.al. 2021.

5. Clinical Implications and Future Perspectives

This study's results carry substantial clinical significance in maximizing plateletpheresis efficiency. The selection of donors with higher platelet counts will maximize yield and minimize procedure duration, supported by previous research that prioritized platelet count as the basis for donor selection. However, the observed physiological changes underscore the need for rigorous donor screening and post-procedure monitoring, despite the safety profile being relatively favourable. Since there was no gender-based effect, the process of selecting donors becomes simplified, as the main consideration is limited to physiological factors. Future research needs to be conducted on the effect of these variables in tandem along with other emerging predictors like genetic/biochemical indicators to improve the model predicting the yield of platelets from the machine.

6. Conclusion

In summary, our findings support that plateletpheresis is a safe and reliable procedure that results in reproducible changes in blood parameters. The pre-procedure platelet count is found to be the most critical parameter in determining platelet production, and there is robust scientific evidence from many different studies. Other parameters, such as sex and platelet indices, play a minor role individually in platelet production.

7. Acknowledgements

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8. Statement and Declarations

Ethical Considerations

This study was conducted in accordance with institutional ethical guidelines for human subject research.

Consent To Participate

Written informed consent was obtained formal study participants following a comprehensive explanation of the study's objectives and potential benefits. Consent to publish the authors affirmed that the human research participants provided informed consent for publication.

Consent for Publication

All authors have agreed to the publication of this manuscript.

Conflict of Interest

Authors declares no conflict of interests.

Funding Statement
Not Applicable

Data availability
The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

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