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ORIGINAL ARTICLE

The influence of haematocrit on quality control parameters in plateletpheresis procedure

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ABSTRACT

Aim Plateletpheresis is a specialized procedure that collects platelets from peripheral blood using a cell separator. Platelet concentrates obtained by apheresis have better content in terms of better functionality and viability of platelets, reduced risk of infection with blood transmissive viruses and HLA-sensitization. The aim of the study was to examine the influence of donors' predonation haematocrit on the value of quality control parameters in the plateletpheresis product, to determine the frequency of adverse events and its relation to the predonation haematocrit value of donors.

Methods A retrospective analysis included the total number of performed plateletpheresis in the period between 1 January 2022 and 31 December 2023 at the Polyclinic for Transfusion Medicine in University Clinical Centre of Tuzla. Two groups of platelet donors with haematocrit <45% and haematocrit ≥45% and quality control parameters in both groups were compared.

Results A total of 73 donors with Hct<45%, and a total of 43 donors with Hct≥45% was found. The total volume of processed blood was significantly higher in the group of donors with Hct ≥45% ($p<0.0001$). The duration of the plateletpheresis was significantly longer in donors with higher haematocrit ($p=0.003$).

Conclusion The level of haematocrit in the donor significantly affected the duration of the procedure and the consumption of resources, but the quality of the final product did not deviate much from the values recommended by the International Society for Blood Transfusion (ISBT) and the American Association of Blood Banks (AABB).

Keywords: donor, cell separator, transfusion

INTRODUCTION

Plateletpheresis is a specialized procedure that collects platelets from peripheral blood using a cell separator (1,2). The conditions for collecting platelets are the same as for classic blood donation with special conditions, which include the number of platelets in the peripheral blood higher than 150 $x10^9$/L and adequate haemoglobin (Hb) and haematocrit (Hct) values (3). The number of plateletpheresis depends on the institution's needs for platelet concentrates, the condition of the equipment and the availability of professional staff.

The quality of the apheresis product depends to a large extent on the initial number of platelets in donor's blood, the presence of lipids and other substances in the serum, the duration of the procedure and the degree of disaggregation of platelets in the control sample (4–6). The working principle is based on taking whole blood from the donor's vein, centrifugation, separating platelets and plasma from the circulation and returning the remaining blood components (erythrocyte suspension) back to the donor's circulation (6).

Platelet concentrates obtained by apheresis have better content in terms of better functionality and viability of platelets, reduced risk of infection with blood transmissive viruses and HLA-sensitization, and are indicated for all immunocompromised patients (haematological and oncological patients, transplant patients and children) (7). The American Association of Blood Banks (AABB) and the International Society of Blood Transfusion (ISBT) have defined that in each apheresis product of platelets the allowed number of residual leukocytes must be less than 0.3x 10^9/dose, and the number of platelets must be greater than $2x10^{11}$/doses (8–10). Many studies have shown absolute efficiency of platelet separators regardless of initial haematocrit values. The greater efficiency of the plateletpheresis process has been demonstrated in donors with a higher initial platelet count from 200 $x10^9$/L (11,12).

Due to their numerous advantages over classic blood collection and preparation of platelet products, apheresis procedures are in continuous development both in the European Union (1) and the region of Southeast Europe (5), including

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Bosnia and Herzegovina (B&H). Studies conducted so far in Europe and the world have shown that in addition to the qualitative benefit for the transfused patient, there is also a financial benefit for transfusion institutions, which is reflected in the saving of laboratory material for the collection and preparation of platelets, and the saving of time, space and laboratory staff that are employed in the process of production of platelet concentrates (6,7). In B&H, unfortunately, there are not many studies that have dealt with the quality control of apheresis platelet preparations to a large extent due to the fact that the plateletpheresis procedure is not a standardized procedure in all transfusion institutions, but only in larger transfusion centres.

A limited number of studies dealt with the influence of initial haematocrit and donor platelet count on the efficiency of the plateletpheresis procedure (5,9), but none dealt with the issue of the influence of predonation haematocrit and donor platelet count on the values of quality control parameters in the final product of plateletpheresis.

The analysis of plateletapheresis quality control parameters will educate all health professionals in the field of donor apheresis procedures, it can show which predonation values of blood counts are crucial to obtaining a high-quality apheresis platelet product, and thus will provide safe arguments for introduction of plateletpheresis procedures as a standard method in most transfusion centres in BiH.

The aim of this study is to examine the influence of predonation haematocrit values in donors on the values of quality control parameters in the plateletpheresis product, to determine the frequency of adverse effects and to determine whether there is a correlation of the frequency of the adverse effects and the predonation value of the haematocrit.

PATIENTS AND METHODS

Patients and study design

A retrospective analysis was done including the total number of performed plateletpheresis in the period between 1 January 2022 and 31 December 2023 at the Department for the Collection of Blood and Blood Products, Polyclinic for Transfusion Medicine, University Clinical Centre of Tuzla, B&H.

Two groups of patients were analysed: the first group were platelet donors with the initial haematocrit of <45%, and the second group were donors with haematocrit ≥45%. A platelet concentrate sample was collected from the apheresis product of each donor for analysing the complete blood count in the Polyclinic for Laboratory Medicine, University Clinical Centre of Tuzla.

Quality control parameters of the plateletpheresis product were compared: complete blood count, whole blood processed, anticoagulant-ACD, saline, platelet yield, duration of the procedure. It was determined whether and to what extent there were deviations of the allowed values defined by the criteria of ISBT and AABB. The two observed groups (with Hct < 45% and with Hct ≥45%) were further compared in order to determine a correlation between the initial haematocrit and the value of quality control parameters in the apheresis product sample and the frequency of adverse effects in plateletpheresis donors.

Collected data were stored in the database of the Polyclinic for Transfusion Medicine (Renovatio RGB), a system created strictly for transfusion blood management.

Methods

All procedures were performed using a continuous flow cell separator (Amicus Separator, Fresenius Kabi AG, Bad Homburg, Germany; software version 4.6), following precise work procedures of the Institution. Platelet collection was carried out by using single-needle procedure and anticoagulant ACD-A (acidum citricum dextrose-A). During the extracorporeal procedure the anticoagulated whole blood enters the separator, then using centrifugal separation a certain amount of platelets; autologous plasma was separated into the collection bag and the rest of blood components were returned to the donor. The end point of each procedure was based on the target yield of 3.0 x 10^{11} platelets per unit of the final product.

The final platelet yield was calculated using the formula:

Platelet yield = Product volume (mL) x Product platelet count/μL x conversion factor (1000 μL).

Platelet units were stored at 22-24 °C under continuous agitation in a platelet incubator. Side effects were observed during and after the procedure and included slight tingling/paraesthesia around the mouth, chest vibrations and feelings of cold and chill. Calcium in the form of effervescent tablets of 500 mg was given during or after the plateletpheresis procedures if any of the symptoms occurred.

Statistical analysis

Standard methods of descriptive statistics were used in statistical processing (arithmetic mean and standard deviation) and independent samples t-test. The significance level was set at $p<0.05$.

RESULTS

A total of 116 plateletpheresis procedures were performed, 86 procedures in 2022 and 52 in 2023. The donor population consisted mainly of males, 111 (95.7%), and 5 (4.3%). women. Mean age of male donors was 42 (20-64), and females were 33 (30-36) years old. Mean weight (range) of males was 82.5 kg (60-105 kg) and 72.5 kg for females (70-75 kg). The most represented platelet donors were males 40-50 years old (37, 32.0 %); the lowest number of donors were in the age group of 18-30 (22, 19.0 %) years (Table 1).

Table 1. Distribution of platelet donors by age groups

Age groups (years)	No (%) of donors in the group		
	Total	**Hct < 45%**	**Hct ≥ 45%**
18-30	22 (19.0)	16 (21.9)	1 (2.3)
30-40	32 (27.6)	22 (30.1)	9 (21.0)
40-50	37 (32.0)	27 (37.0)	16 (37.2)
50-65	25 (21.4)	8 (11.0)	17 (39.5)
Total	**116**	**73**	**43**

The degree of efficiency of the platelet separation process and the purity of the plateletpheresis product itself was determined by the number of leukocytes, platelets, erythrocytes, haemoglobin and haematocrit in the platelet concentrate sample from the apheresis product. The values of the quality control parameters were consistently within the limits of the recommended values by the ISBT (9) and AABB (10).

The number of residual leukocytes in the product was, in average, lower than the permitted value of 0.3 x 10^9 /L and amounted to an average of 0.006 x 10^9, which meets the set reference limits of the analysed parameters. The concentration of platelets in the apheresis product was within the reference values, with an average value of 3.045 x 10^{11}/dose of the apheresis product. The presence of residual leukocytes, erythrocytes and haemoglobin was in negligible amounts, which represents the basic purpose of separation and leukofiltration of the platelet apheresis product.

A total of 73 donors with Hct<45% (the first group), and 43 donors with Hct≥45% (the second group) were included in the analysis. The largest number of donors belonged to the age group of 30-50 years (Table 1).

Comparing these two groups of donors, no significant difference was observed in the values of quality control parameters. The number of platelets in the plateletpheresis product was not significantly higher in the first group with Hct<45% (p=0.5).

The number of residual leukocytes, erythrocytes, haemoglobin concentration, haematocrit and mean platelet volume (MPV) did not show a significant difference in the two observed groups (p=1).

The total volume of processed blood was significantly higher in the first group with Hct ≥ 45% (p<0.0001). The duration of the plateletpheresis procedure was significantly longer in donors with higher haematocrit. The platelet yield did not show a statistically significant difference between the two observed groups (p=0.4). The average consumption of ACD anticoagulants and saline solution during the process of plateletpheresis showed statistically higher significance at higher haematocrit values (Table 2).

Table 2. Overview of average values of quality control parameters depending on the haematocrit value

Quality control parameters	Mean ±SD in the group		p
	Hct <45%	Hct ≥45%	
PLT (x109/L)	3.0 ± 1.4	2.8 ± 1.3	0.5
Le (x109/L)	0.006 ± 0.02	0.006 ± 0.02	1
Er (x106/L)	0.02 ± 0.007	0.01 ± 0.005	0.95
Hb† (g/L)	1 ± 0.45	1 ± 0.37	1
Hct (L/L)	undetectable	Undetectable	-
Total volume of processed blood (mL)	2115 ± 263	2434 ± 385	0.0001
Duration of procedure (min)	52 ± 16	70 ± 34	0.003
Platelet yield (x1011/unit)	3.0 ± 0.5	2.8 ± 0.5	0.4
Saline (mL)	400 ± 52	420 ± 46	0.75
ACD (mL)	254 ± 37	300 ± 42	0.03

PLT, platelet count; Le, leucocyte count; Er, erythrocyte count; Hb, haemoglobin concentration; Hct, haematocrit; ACD, acidum citricum dextrose

During the period 2022-2023, not many adverse events of plateletpheresis collection were observed. Mild citrate reactions were observed mostly in the age group from 30-40 and 40-50 years of age, while vazovagal reactions predominated in the younger age groups of donors, especially first time donors.

Mild citrate reactions in the form of tingling of the perioral muscles and muscles of the hands and feet dominated, which were more numerous in the group of donors with a higher haematocrit. Severe citrate reactions were not recorded. Hematomas at the site of venipuncture were recorded in smaller numbers and cannot be related to the level of the donor's haematocrit. Complications during the operation of the separator were recorded twice and were primarily related to the malfunction of separator centrifuge (Table 3).

Table 3. Overview of adverse events of the plateletpheresis procedure

Type of adverse reaction	No (%) of donors	
	Haematocrit <45%	Haematocrit ≥45%
Vasovagal reactions	2 (14.3)	4 (20)
Mild citrate reactions	8 (57.1)	15 (75)
Hematomas	2 (14.3)	1 (5)
Complications associated with separator disfunction	2 (14.3)	0 (0)
Total	**14**	**20**

DISCUSSION

By analysing the quality control data in our research, we determined that plateletpheresis products collected from the blood of voluntary donors do not deviate from the permitted values of quality control parameters in the plateletpheresis product determined by the ISBT and AABB. An initially higher haematocrit in platelet donors (Hct≥45%) resulted in longer duration of the apheresis platelet collection procedure, but quality control parameters remained the same which proves that the filter for separating cellular elements is highly efficient, so that the number of leukocytes and erythrocytes that pass from the bloodstream into the product is negligible.

Likewise, it has been proven that the existing filters successfully remove leukocytes from the platelet apheresis product both at lower and higher haematocrit values (7–10).

Landžo et al. (5) demonstrated that the initial haematocrit does not significantly affect the speed of the procedure, but significantly reduces the efficiency and prolongs the duration of the separation. For this reason, the only way to increase the efficiency of the procedure is to select donors with a haematocrit lower than 45% and a platelet count higher than 200 x 10^9/L. In this way, the procedure can be accelerated and the efficiency of platelet extraction can be increased, which is a very important item in the functioning of the transfusion system (6–9).

It was demonstrated that for the best possible plateletpheresis product, it is necessary to choose a healthy donor, with a higher body weight, a higher number of predonation platelets, a higher haematocrit in the blood, which all results in a higher availability of platelets and a better platelet yield (11).

However, despite the possibility of frequent platelet donation through a cell separator and the ability of platelets for quick recovery, frequent platelet donation reduces the number of platelets in the donor's blood and thus the efficiency of the next procedure (12–15). That is the reason why plateletpheresis procedures are not recommended to be performed too often and a reasonable recuperation period is needed (16,17).

Adopting new knowledge from theory and practice, and monitoring the influence of a combination of various prognostic factors can globally increase the efficiency of plateletpheresis

collection (18). The results of our study have shown that the predonation value of haematocrit does not significantly affect the valuable parameters of quality control of apheresis platelet preparation, but haematocrit values ≥45% increase the value of total volume of circulating blood, prolong the time of the procedure and increase the consumption of anticoagulant and saline solution. This can be explained by the longer time of platelet separation due to the higher viscosity of circulated blood in the system (14,15).

A relation between the predonation platelet count and the final platelet yield in the product was reported (18). The average predonation platelet count was higher than $300x10^3$/μl and the platelet yield was higher than $3x10^{11}$ platelets/unit in 80% of the products (18). In comparison with other methods of platelet preparation, the apheresis collection method convincingly showed the best quality control parameters (19,20).

Adverse reactions in plateletpheresis are mostly a result of individual response to the procedure and the quality of the venipuncture method. Most of the adverse reactions were of a mild type which proves that the plateletpheresis is a safe and well tolerated procedure by the donors (21,22).

There was no evidence that the value of haematocrit of the donor affect more significantly the frequency of adverse reactions. Adverse reactions during and after the plateletpheresis procedure appear in approximately 1,2% voluntary platelet donors (22). A study from Serbia demonstrated that mild citrate reactions were most frequent among platelet donors (23). Our results also show that mild citrate reactions (perioral or acral paraesthesia, shivering, headaches and flushing were predominant and more frequent in the group of donors with Hct ≥45% and in the group of younger first time platelet donors. That can be explained by the prolonged duration of the apheresis procedure and the mild hypocalcaemia present in the donors' blood.

Our research included a very limited number of female donors. The reason for such a low level of interest among women is the weak promotion of platelet donation among female population, the poor preliminary findings of platelet count, haemoglobin, haematocrit in the blood, and inadequate quality of the veins for venipuncture.

However, despite the modern principle of operation and numerous advantages of plateletpheresis procedures, the financial moment is a limiting factor, because the costs for the purchase of separators, depreciation of equipment, adequate space for work and staff education are nevertheless of decisive importance (23).

In conclusion, apheresis platelet collection is a procedure that is slowly becoming a standardized method in all major transfusion centres in B&H, and therefore requires systematized measurement of quality control parameters. The results of our research are very much in line with the results of the few studies conducted worldwide. The adequate selection of plateletpheresis donors proved to be a key factor for the success of the procedure. The predonation haematocrit of a donor significantly affects the duration of the procedure and the consumption of resources, but the final plateletpheresis product shows extremely high quality.

The significance of the research is primarily reflected in the ability to plan and organize donor plateletpheresis by assessing the predonation factors of the blood count, which can contribute to a higher platelet yield and better quality of the plateletpheresis product. At the time of high demand for transfusion support and limited human resources in blood transfusion centres, donors safety and platelet availability are of crucial significance and the adequate selection of plateletpheresis donors proved to be a key factor for the success of the procedure.

AUTHOR CONTRIBUTIONS

Conceptualization, S.J.L.; Methodology, S.J.L. and A.Ž.; Supervision, S.J.L. and S.D.Ć.; Validation, S.J.L. and A.S.M.; Resources, S.D.Ć.; Investigation, A.Ž.; Formal Analysis, A.S.M.; Visualization, S.Č.S. and A.O.H. All authors have read and agreed to the published version of the manuscript.

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TRANSPARENCY DECLARATION

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