Quality Validation of Platelets Obtained From the Haemonetics and Trima Accelautomated Blood-collection Systems

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Research

Keywords: platelet apheresis (PPH), leucocyte-reduced platelets apheresis(LRPH), plateletqualities, bacterium-screening test

DOI: https://doi.org/10.21203/rs.3.rs-38756/v1

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Abstract

**Background:** Platelet transfusion is required to treat haemo-oncology or trauma patients. Platelet apheresis (PPH) performed with apheresis equipment has increased rapidly in recent years. Leucocyte-reduced platelet apheresis (LRPH) can reduce the risk of platelet refractoriness and febrile nonhemolytic transfusion reactions (FNHTRs) for transfusion. Accordingly, this study aimed to investigate and compare the platelet metabolic and functional responses between PPH performed with Haemonetics and LRPH performed with Trima Accel cell separator.

**Methods:** The qualities of platelets collected through PPH and LRPH were evaluated in terms of visual appearance, morphology, platelet-aggregation changes, metabolic activities, and bacterium-screening test during 5-day storage. Statistical analyses included two-sample t-test and generalised estimating equation (GEE) method.

**Results:** During 5-day storage in LRPH, residual leucocytes were all <1.0\times10^6, and the parameters of platelet function were as follows: platelet aggregated to agonists such as adenosine 5′-diphosphate (ADP) and collagen, and the extent of shape change and pO_2 showed no statistically significant difference between PPH and LRPH. The hypotonic shock reaction (HSR) on days 0, 1, and 3 were significantly higher in LRPH than in PPH (71.78±6.92 vs. 64.10±7.42; p=0.002; 71.53±8.98 vs. 62.96±9.84; p=0.007; 68.05±7.28 vs. 57.76±6.80; p=0.0001, respectively). Values of mean platelet volume (MPV) were statistically significant larger in PPH than in LRPH on days 0, 1, and 3. On day 5, the swirling score was higher in LRPH than in PPH. The mean lactate levels had no statistically significant difference between PPH and LRPH. Moreover, no growth was observed through bacterium-screening test conducted on 40 samples.

**Conclusion:** Comparison of LRPH and PPH products collected from the Trima Accel and Haemonetics automated blood-collection systems, respectively, revealed that both products possessed good platelet qualities even though additional processes are needed to reduce leucocytes. Furthermore, investigating the outcomes of other apheresis instruments with focus on the safety of donors, products, and recipients is necessary.

1. Background

Platelets (PLTs) play a necessary role in preventing blood loss after traumatic injury and major haemorrhage. For thrombocytopenia and bleeding, transfusing PLT components (PCs) are an important treatment. A pool of four to six concentrates of whole-blood donations is a usual dose of PLT transfusion. To reduce donor exposure, transfusing single-donor apheresis components for patients is preferred. PLT transfusion plays a vital role in patients with haemo-oncological disorders.

The recommended storage temperature of PCs is 20–24 °C under continuous gentle agitation. Bacterial contamination of PCs is attributed to storage conditions because the condition facilitates the proliferation of bacterial contaminants. The storage temperature permits human and environmental microflora growth. The storage time is often limited to 5 days for PCs owing to the risk of bacterial contamination [1]. Haemovigilance reports confirm that clinical transfusion incidents occur through PC bacterial contamination [2]. Minimizing the risk of bacterial transfusion transmitted infectious diseases is an important issue. The contamination of PCs by bacteria lead to the development of a pause of PLT swirling [3].

The demand for PLT apheresis (PPH) by patients has increased over the past years. Accordingly, the collection of blood components by using apheresis instruments has rapidly increased. The advantages of PPH collection include the control of component volumes and high-quality products. The use of apheresis equipment is rapidly growing to provide the optimum blood components to patients.

The leucocytes of blood components may induce adverse events in patients during or after transfusion. The most important ones are transfusion-associated nonhaemolytic febrile transfusion reactions, graft-versus-host disease, alloimmunisation to human-leucocyte antigen, and human T-lymphotropic virus (HTLV) or CMV infections [4]. Leucocyte-reduced components may also prevent prion infections [5].

Using leucocyte-reduced blood components can decrease the incidence rate of PLT refractoriness. A study has shown that alloimmunisation rates an be significant decreased by transfused leucocyte-reduced PLT apheresis (LRPH) compared with nonleucocyte-reduced PCs [6]. To reduce side effects, almost all PCs are leucocyte reduced in Europe [7].

Another study that used four agonists for the pre-storage leukodepletion of PCs on day 5 has shown that improving the quality and PLT-aggregation activity has no advantage and may even be detrimental [8]. Technical advances have improved the productivity and quality of apheresis-PLT-collection methods, particularly those involving automated cell separators, to enable PC production without filtration.

The present study aimed to examine the effects of the Trima Accel device on leucocyte-reduced cell separation and compare the metabolic and functional responses between the PPH and LRPH products of Haemonetics and Trima Accel automated blood-collection systems.

2. Methods

2.1. Study design and participants

All of the participants in this study met the criteria for blood donors in accordance with Taiwan's Ministry of Health and Welfare guidelines and were recruited in the Taichung Blood Center, located in central Taiwan.
The eligibility criteria for double units (≥ 3 x 10^{11} PLTs/unit) were as follows: (1) age 17–65 years; (2) preapheresis PLT count ≥ 300 x 10^3 /µL and ≥ 250 x 10^9 /µL for Haemonetics MCS + ED and Trima Accel, respectively; (3) haemoglobin (Hb) level from 13.5–18.5 g/dL for male; (4) donor body weight ≥ 60 kg; (5) negative tests for hepatitis B surface antigen, hepatitis C, human immunodeficiency virus, HTLV, and syphilis, and normal level of alanine aminotransferase; (6) in good health; and (7) no drugs taken in the last 7 days (those taking aspirin or anti-inflammatory drugs were not allowed to donate blood).

If donors have been fasting, we asked them to eat a meal or offered them snacks, water, drink, or milk before donation. Almost all PPH and LRPH donors in Taiwan were male. From June to September 2013, 40 eligible male donors were recruited to participate in this study.

2.2. Data collection

Donors were individually subjected to the blood collection with Haemonetics or Trima Accel device. Vital signs included systolic and diastolic blood pressure, and pulse was monitored and recorded at the beginning and end of the procedure. The donors were also monitored for adverse events during the procedures. The following data were entered into the cell-separator program for both devices: donor height, weight, gender, hematocrit, and pre-count of PLT values. Well-trained apheresis staff performed all the procedures. The body mass index (BMI), defined as the body mass divided by the square of body height, was also recorded.

2.3. Instruments and quality control

A Haemonetics MCS + ED cell separator (Braintree, MA, USA) was used with a targeted yield of 6 x 10^{11} PLTs for double units. The whole-blood flow was set to 85 mL/min, which can be modified by the collection staff depending on the donors’ venous condition. The acid citrate dextrose-A (ACD-A) anticoagulant (AC)/whole-blood ratio was 1:10 (n = 20). The second device used for PLT collection was Trima Accel software version 5.0 (Caridian BCT, Lakewood, CO, USA) with a targeted yield of 6 x 10^{11} PLTs for double units. The whole-blood flow was 75–100 mL/min the, and the ACD-A AC/whole-blood ratio was 1:11 (n = 20). Quality control tests for the residual leucocytes of LRPH collected with Trima Accel version 5.0 were performed by manually counting the cells in the Nageotte chamber as described elsewhere [9]. A previous study has shown that resident skin flora are the major bacterial contamination in PCs [10]. One strategy to reduce such contamination is to use a diversion bag for the first aliquot of the donation. The volume of this diversion bag is then used for routine laboratory-screening tests, such as blood-type and infection-disease testing. The collected apheresis sets from the two instruments in this work included the diversion pouch. The quality-control criteria for the product were determined through standard operation procedure (SOP). At least 90% of units sampled contained ≥ 3.0 x 10^{11} PLTs, and at least 90% of units had a pH ≥ 6.2 during 5-day storage. Moreover, the residual leucocytes of LRPH were < 5 x 10^7 per final product for 95% of units sampled.

2.4. Visual appearance

When discoid PLTs are exposed to a light source, swirling is caused by the reflection of light. This swirling can be used to evaluate PLT function. Herein, swirling was assessed by visual inspection, and we defined the scores as follows: 0, no swirling; 1, limited swirling; and 2, maximum swirling.

2.5. Laboratory testing

Pre- and post-apheresis samples were subjected to complete blood counts (CBCs) by using an automated blood-cell counter (Sysmex KX-21N, Sysmex Corp., Kobe, Japan). PLT quality was examined through morphological, biochemical, and functional changes on days 0, 1, 3, and 5. The PLT count and mean PLT volume (MPV) were tested. The potential marker of PLT reactivity was used to measure MPV. PLT shapes ranged from discoid to spheroid, and the MPV increased (swelling) in correlation with reduced PLT survival. Loss of swirling was associated with loss of PLT function.

PLT-aggregation changes were examined by light transmission aggregometry (Chrono-log 490-4D) in response to adenosine 5’-diphosphate (ADP) and collagen (CHRONO-LOG, Leiden, the Netherlands)-induced aggregation. For ADP-induced aggregation, the final concentration of PLT rich plasma (PRP) was 300 x 10^3 µL, and the corresponding PLT poor plasma served as the control. About 450 µL of PRP was placed in a reaction cup under continuous stirring at 37 °C, and then 50 µL of ADP (final concentration = 30 µM) was added to the PRP sample. PLT-aggregation activity was then tested. About 490 µL of PRP was placed in a reaction cup under continuous stirring at 37 °C, and then 10 µL of collagen (final concentration, 20 µg/µL) was added to the PRP sample. Collagen-induced aggregation activity was then tested.

Hypotonic shock response (HSR) and extent of shape change (ESC) were explored to evaluate PLT survival. pO_2, pCO_2, glucose, and lactate tests were conducted to examine PLT storage.

HSR was measured according to dynamic light transmittance through light transmission aggregometry and calculated as follows: HSR=[(Y–a)/(Y–X)] × 100%, where X is the transmittance of normal-saline-diluted PRP, Y is the maximum transmittance of deionized-water-diluted PRP, and “a” is the minimum transmittance of deionized-water-diluted PRP.

PLT shape change, as one of the earliest morphological indicators of PLT activation, was subsequently examined. ESC was tested by adding 10 µL of 0.1 M ethylenediaminetetraacetate to PRP. Subsequent aggregation was blocked by adding 10 µL of 0.1 mM ADP. The change in shape was measured by light transmission aggregometry.

The pH, pO_2, pCO_2, lactate, and glucose values were measured using an automatic blood gas analyser (GEM Premier 3000, Werfen) at 22 °C.

The bacterium-screening tests for all PPH and LRPH were conducted in 2007 in Taichung Blood Center. About 8 mL of sample was collected from each PLT unit ≥ 24 h after blood donation and inoculated in an automated blood-culture system (BacT/ALERT®, bioMérieux, Marcy l’Etoile, France). CO_2 production was monitored to determine bacterial growth, which changed the color from grey to yellow at the bottom of the culture bottle as detected with a gas-
permeable sensor [11]. Each sample was placed in an aerobic culture bottle inoculated in the automated culture system for up to 24 h at 35–37 °C. APs were released to the hospital if no growth was observed.

2.6. Statistical analysis

Continuous variables were reported as the mean ± standard deviation. The two-sample t-test was used for continuous variables in bivariate analysis.

To further assess PLT function on different days, i.e., to compare the results of days 0 with those of day 1,3 and 5, the method of generalised estimating equations was used by considering the dependence. A p value less than 0.05 was considered as statistically significant. All analyses were performed with SAS version 9.4 (SAS Institute Inc, Cary, NC, USA).

3. Results

3.1 Sample characteristics

The demographic characteristics and CBC data of a total 40 male donors (N = 20 per group) are shown in Table 1. No statistically significant difference was observed between the two groups in terms of age, weight, height, donation times, and BMI of the participants. Moreover, no significant difference in CBC values before and after blood donations was observed.

Table 1. The demographic characteristics and pre-apheresis laboratory data of the participants

| Variable       | PPH (n=20)       | LRPH (n=20)      | p-value |
|----------------|------------------|------------------|---------|
| Age (years)    | 41.15±7.87       | 42.85±7.66       | 0.493   |
| Donated_times  | 478.00±325.20    | 387.90±269.20    | 0.346   |
| Weight (kg)    | 78.60±10.59      | 73.73±9.07       | 0.126   |
| Heigth (m)     | 1.72±0.05        | 1.71±0.07        | 0.379   |
| BMI (kg/m²)    | 26.47±3.18       | 25.37±2.85       | 0.255   |
| Pre-WBC (×10^3/ul) | 5.96±1.30 | 5.96±1.23       | 1.000   |
| Hb (g/dl)      | 14.97±0.85       | 14.9±0.89        | 0.787   |
| Hct (%)        | 43.26±2.13       | 43.03±2.10       | 0.738   |

Table indicates standard deviation; p-value by t-test

PPH=plateletapheresis ;LRPH=leukocyte-reduced platelets apheresis ;
Hb=hemoglobin;Hct=hematocrit; WBC= white blood cell; BMI = body mass index

3.2 Haemonetics and Trima Accel systems

The universal PLT protocol (UPP) disposable set elements were efficiently installed as follows: 1, PLT storage bags and air removal/sample pouch; 2, air-management bag; 3, plasma bag; 4, centrifuge bowl and dual pump manifold; 5, anti-coagulant (AC), saline line, and donor lines; and 6, blood filter chamber. The bowl was centrifuged well, and the head of the bowl was firmly pressed down on to fully seat it in the centrifuge chuck. The dual pump tubing around the “Blood” and “Transfer” pumps was looped in preparation for the pump autoload sequence. The single pump manifold was snapped into place, and the AC tubing was looped around the AC pump.

The system collected the PLT layer in a small volume of plasma to obtain concentrated PLT products. If the PLT yield was 6 x 10^11 or above, Haemonetics recommends opening the clamps on both PLT storage bags. The MCS + UPP disposable set is shown in Fig. 1.

To separate whole blood into PCs by using Trima Accel system, a continuous-flow centrifuge was used. Whole blood was collected from the blood donor and mixed with an AC. The mixture was pumped into the channel that was a plastic pathway set in the centrifuge filter with a well-designed groove. Five pumps drew and returned the blood from the donor by using the Trima Accel system. A cassette that was part of the tubing set guided the flow of blood and products.

A leucoreduction system (LRS) was used in Trima Accel to minimize the leucocyte content of LRPH products. Following the principle of elutriation, the chamber enabled the separation of PLTs from leucocytes through the technology of saturated, fluidized particle-bed filtration. The LRS chamber trapped the
leucocytes, which can solve the problem of low-yield PLT collection for LRPH. The system can consistently collect LRPH products with residual leucocytes < 1.0 x 10^6.

### 3.3 PLT qualities

The results of comparing PLT qualities between PPH (MCS+) and LRPH (Trima Accel) products during storage days 0, 1, 3, and 5 are presented in Table 2. The MPV values were statistically larger in PPH than in LRPH on days 0, 1, and 3. PPH and LRPH units were scored as good swirling on days 0, 1, and 3. On day 5, the swirling score was better in LRPH than in PPH. The ability of PLT to aggregate to ADP and collagen showed no statistically significant difference between PPH and LRPH during days 0, 1, and 3. ESC showed no statistically significant difference between the two groups. The pH of LRPH products was significantly higher than that of PPH products on days 0, 1, and 3 (7.21 ± 0.03 vs. 7.17 ± 0.03; p < 0.001; 7.29 ± 0.04 vs. 7.26 ± 0.03; p = 0.015; and 7.30 ± 0.05 vs. 7.27 ± 0.04; p = 0.041, respectively). For pO2, no statistically significant difference was found between PPH and LRPH products during days 0, 1, 3, and 5. pCO2 was significantly higher in LRPH than in PPH on days 3 and 5 (31.20 ± 2.35 vs. 29.25 ± 1.92; p = 0.007; and 28.45 ± 1.79 vs. 26.55 ± 2.06; p = 0.004, respectively). The mean glucose levels were higher in PPH than in LRPH on days 0, 1, and 3 (361.90 ± 23.34 vs. 289.80 ± 19.79 vs. 7.26 ± 0.03; p = 0.023; 354.40 ± 26.32 vs. 37.85 ± 15.29; p = 0.010; and 322.70 ± 22.26 vs. 301.20 ± 25.12; p = 0.007, respectively). The mean lactate levels were higher in LRPH than in PPH on days 0, 1, and 3 (28.45 ± 1.79 vs. 26.55 ± 2.06; p = 0.004, respectively).

| Variables   | Day 0       | Day 1       | Day 3       | Day 5       |
|-------------|-------------|-------------|-------------|-------------|
| MPV (fl)    | 7.99 ± 0.49 | 7.68 ± 0.47 | 7.51 ± 0.43 | 7.53 ± 0.46 |
| Swirling score | 2.00 ± 0.00 | 2.00 ± 0.00 | 2.00 ± 0.00 | 1.50 ± 0.51 |
| ADP (µM)    | 86.75 ± 25.97 | 86.15 ± 20.08 | 93.97 ± 24.06 | 19.79 ± 16.10 |
| Collagen(µg/ml) | 106.60 ± 15.29 | 108.10 ± 7.63 | 85.85 ± 15.80 | 70.23 ± 22.14 |
| HSR (%)     | 64.10 ± 7.42 | 71.78 ± 6.92 | 71.53 ± 8.98 | 50.20 ± 11.46 |
| ESC (%)     | 20.98 ± 2.50 | 21.29 ± 3.53 | 18.57 ± 2.63 | 16.77 ± 3.82 |
| pH          | 7.17 ± 0.03 | 7.21 ± 0.03 | 7.29 ± 0.04 | 7.24 ± 0.06 |
| pCO2 (mmHg) | 50.20 ± 4.10 | 49.60 ± 3.44 | 37.85 ± 2.28 | 31.20 ± 2.35 |
| pO2 (mmHg)  | 96.70 ± 12.15 | 95.50 ± 11.66 | 92.70 ± 9.85 | 102.40 ± 11.51 |
| Glucose (mg/dl) | 361.90 ± 23.34 | 342.90 ± 27.16 | 334.40 ± 19.71 | 322.70 ± 22.26 |
| Lactate (mM) | 2.33 ± 0.51  | 2.33 ± 0.50  | 3.48 ± 0.54  | 7.00 ± 0.79  |
| WBC residual (10^6/unit) | 6.40 ± 0.26  | 6.04 ± 0.25  | 5.73 ± 2.23  | 5.65 ± 2.15  |

p-value by t-test

*: the variable compared with day 0 for PPH, and statistically significant (p < 0.05) by using GEE analysis

#: the variable compared with day 0 for LRPH, and statistically significant (p < 0.05) by using GEE analysis

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The results of bacterium-screening test showed no bacterial growth using the two different devices in this work. Blood components can reduce the rates of
and non-leucocyte-reduced blood products than for leucocyte-reduced ones. Transfusion reactions (FNHTRs) are the most frequent adverse reactions for blood transfusion during storage, indicating that prestorage leukoreduction blood components reduced the transfusion-associated adverse reactions. Furthermore, LRPH have better PLT survival, pH value as PLT components quality indicator and smaller MPV than PPH during days 0, 1 and 3.

4.2. Comparison with literature data and possible explanations

This study aimed to compare the metabolic and functional responses between the PPH and LRPH products of the Haemonetics and Trima Accel automated blood-collection systems, respectively. We assessed the quality of the products and subsequently stored condition in terms of PLT aggregation activity and PLT survival and performance during storage in PH and LRPH from different instrument in both groups during the 5-day storage. Data showed the ability of PLT to aggregate to ADP and collagen, with no difference between PPH and LRPH from different instruments during days 0, 1, 3, and 5. Moreover, the leucocyte-depletion process for LRPH collection (Trima Accel) did not affect the functional capacity and metabolic responses of the PCs. Furthermore, LRPH have better PLT survival, pH value as PLT components quality indicator and smaller MPV than PPH during days 0, 1 and 3.

4.3. Strengths And Limitations

This study compared the metabolic and functional responses (e.g., visual appearance and bacterium-screening test responses) between the PPH and LRPH products of the Haemonetics and Trima Accel automated blood-collection systems and found that additional processes are needed to reduce leucocytes and obtain high-quality PLTs.

The transfusion of PLTs significantly increased in 2013 [20]. Since then, significant improvements have been made in terms of the efficiency and quality of PLT phepheresis to offer high donor comfort. The use of apheresis PLT concentrates was intended to reduce the risk of antibody-positive TRALI [21].

A previous study has shown that IL-1β, IL-6, and IL-8 levels were significantly higher in post-leucocyte-reduced PPHs than in pre-leucocyte-reduced ones during storage, indicating that prestorage leukoreduction blood components reduced the transfusion-associated adverse reactions [22]. Febrile non-haemolytic transfusion reactions (FNHTRs) are the most frequent adverse reactions for blood transfusion [23]. The risk rates of FNHTRs are higher for transfusion PLT and non-leucocyte-reduced blood products than for leucocyte-reduced ones [24, 25]. Many studies have also reported that using universal leucocyte-reduced blood components can reduce the rates of [26], which is a considerable problem for patients and hospitals [27]. Different PPH technologies can affect bacterial contamination. A higher rate of positive bacterial culture results is associated with a higher rate of apheresis PLT septic transfusion reactions [28]. The results of bacterium-screening test showed no bacterial growth using the two different devices in this work.
Our study has several limitations. First, we did not monitor the bacterium-screening tests for PPH and LRPH to expired days (5-days). The availability of PCs was delayed for up to 48 h after blood collection for bacteria testing. We followed the SOP to incubate 24 h (only to day 2) by using routine test conditions for PPH and LRPH distribution to the hospital. Second limitation was the relatively small number of analyzed PPH and LRPH samples. Third limitation was that based on the criteria for donating PPH and LRPH products, the mean BMI of our participants was > 24 kg/m$^2$. BMI > 24 kg/m$^2$ is defined as overweight according to the Health Promotion Administration of the Ministry of Health and Welfare of Taiwan. The mean age of our participants was ≥ 40 years old (middle-age was defined as 40–65 years). We also cannot analyze the association of PLT activity with different subgroups of BMI and age, respectively.

The hameovigilance system is very important for public health practitioners to understand the adverse reactions of transfusion and prevent bacterial contamination in PLTs [29]. Bacterial transmission remains a major challenge in PLT transfusion. A previous study has shown that additive solution substitutes for plasma in PLTs at 4 °C storage are necessary [30].

5. Conclusions

Our findings showed that LRPH collected form the Trima Accel automated blood-collection system required additional processes to reduce leucocyte and had no disadvantageous for PLT qualities compared with PPH products collected form Haemonetics device. The MPV and swirling score were better in LRPH than in PPH collected by Haemonetics machine. All products met the criteria of quality control, and no bacterial growth was observed through bacterium-screening tests.

Patients with clinical indications such as dyserythropoiesis, chemotherapy, thalassemia, bone-marrow transplantation, organ transplantation, and immunodeficiency, as well as those who had experienced two times of fever or chills and adverse reactions caused by leucocytes, should be transfused with LRPH products according to the National Health Insurance regulations in Taiwan. Further study should be conducted to investigate additional methods for reducing the adverse events caused by leucocytes and to compare the outcomes of more apheresis instruments with consideration of the safety of donors, products and recipients.

Abbreviations

PPH:Platelet apheresis; LRPH: Leukocyte-reduced platelets apheresis;
Hb: Hemoglobin; Hct: Hematocrit; WBC:White blood cell; BMI:Body mass index; FNHTRs:Febrile nonhemolytic transfusion reactions; MPV: Mean PLT volume; ADP: Adenosine 5’-diphosphate; HSR: Hypotonic shock response; ESC: Extent of shape change; GEE: Generalised estimating equation;HTLV : Human T-lymphotropic virus;ACD-A:Acid citrate dextrose-A;PRP: PLT rich plasma;LRS: Leucoreduction system; TRAP-6: Thrombin receptor activator for peptide 6

Declarations

Acknowledgement

We thank all participants who donated blood for this study. We are also grateful to the blood-collection staff and to Mr. Kuo-Chou Chen for the data gathering.

Authors’ contributions

Hsuan-Hui Wang wrote a first draft of this paper and performed the analysis with Li-Na Liao. Chi-Ling Lin provided medical information and Ling-Ling Yen collected the data. Jiunn-Liang Ko and Yi-Min Hsia reviewed and editing the draft.

All authors have reviewed and accepted the final version of the manuscript.

Funding

This research was supported by the Taiwan Blood Services Foundation (PM-102-TC-118).

Availability of data and material

Taitung Blood Center of Taiwan Blood Services Foundation managed the data collection.

Ethics approval and consent to participate

The participants were provided with information on this study, and all signed an informed consent form. Ethical approval was obtained from the Ethical Review Board of the Taiwan Blood Services Foundation (PM-102-TC-118).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.
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Figures
1. Donor line sample pouch
2. Donor/needle line
3. Single pump manifold
4. AC solution line
5. Blood filter chamber
6. Donor pressure monitor (DPM)
7. Dual pump manifold
8. Latham bowl
9. Plasma bag
10. System pressure monitor (SPM)
11. Air bag
12. Air removal pouch
13. Platelet storage bags
14. Saline solution line

Figure 1
Scheme of an MCS+ UPP disposable set in the Haemonetics system

AC=anti-coagulant

Figure 2
Scheme of tubing set, cassette overview, and LRS in the Trima Accel system