Red Cell Apheresis with Automated In-Line Filtration

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Summary

Background: The aim of this study was to provide data on concurrent red blood cell (RBC) and platelet (PLT) apheresis with RBC in-line leukoreduction and automated addition of saline-adenine-glucose-mannitol (SAGM) using the new version (V6.0) of Trima Accel[®].

Methods: In this two-center paired study, each subject completed a test and a control procedure with an interval of 9 weeks between procedures. In the test arm, single RBC and PLT units were collected on the Trima Accel V6.0 (in-line leukofiltration and automated addition of SAGM). In the control arm, they were collected on Trima Accel V5.1/V5.2 (post-collection leukoreduction, manual SAGM addition). RBC percent hemolysis, potassium concentration and adenosine triphosphate over storage, hemoglobin (Hb) yield, and residual white blood cells (WBC) were determined. **Results:** 34 subjects successfully completed both test and control procedures. Post-storage hemolysis was similar in both groups, and all values were less than 0.8% for both arms. Residual WBC counts in all RBC units were less than 1×10^6 /unit. In-line processed RBC units (V6.0) have a significantly higher volume and more Hb/unit due to filtration recovery improvements. All procedures were well tolerated by the subjects. **Conclusion:** In-line filtration and automated addition of storage solution on Trima Accel V6.0 allows collection of ready-to-use RBC units that meet EU requirements.

Introduction

Multicomponent blood collection (MCC) by apheresis allows the collection of different blood components from the same donor during a single apheresis session [1–9]. Red blood cell (RBC) units can be concurrently collected with plasma and/or platelet (PLT) units. Donor blood volume and blood counts define the range of products that can be collected. Collection efficiency data of RBC apheresis and quality control data (hemolysis and biochemical parameters) show that MCC products meet national guidelines [3, 4]. MCC provides standardized blood products tailored to patients' needs, and has the potential to improve the logistics of blood collection and banking. Apheresis RBC units from current multicomponent systems usually need post-collection manual leukocyte filtration and manual addition of storage solutions.

The objective of this study was to provide data on a new software and disposable tubing set upgrade of the Trima Accel[®] system version (V) 6.0 (Terumo BCT Inc., Lakewood, USA) with 2 new features: automated in-line RBC leukoreduction in a continuous process using an in-line filter, and automated addition of saline-adenine-glucose-mannitol (SAGM) additive solution to the leukoreduced RBC product. Procedures were done and data was collected by 2 independent blood banks. RBC quality data for products collected by Trima Accel V6.0 was compared with that for RBC units produced using Trima Accel V5.1 in one site and V5.2 in a second site. The results of evaluation procedures with the new Trima Accel V6.0 showed that the system satisfies in vitro acceptance criteria for 42-day RBC storage [10–12]. The primary outcome parameter was percent hemolysis in the RBC units after 42 days of storage. The EU requirement is that free hemoglobin (Hb) in plasma after storage does not exceed 0.8% of initial red cell Hb per unit [13]. Secondary outcome parameters were apheresis and storage characteristics, especially for

RBC products. Because the changes to the Trima Accel apheresis system in V6.0 do not affect PLT collection outcomes, the storage data for the PLT products are not shown in this paper.

Material and Methods

Study Design

This was a two-center, paired, randomized study comparing apheresis procedures of combined RBC and PLT product collections from control and test systems to evaluate in vitro laboratory measures from 1 to 42 days for stored RBC units collected on the systems. Paired multicomponent apheresis procedures were performed at 2 sites: i) Institute of Transfusion Medicine, University Hospital and Clinics, Leipzig (Germany) – Trima Accel V5.1 vs. V6.0; and ii) Blood Transfusion and Transplantation Center, IPST, IP, Porto (Portugal) – Trima Accel V5.2 vs. V6.0. All donors at the 2 sites underwent 2 apheresis procedures, each including collection of a single RBC unit and a single PLT unit. One procedure was done using the Trima Accel V6.0 system (test) and the other using the Trima Accel V5.1 (control) in Leipzig and the Trima Accel V5.2 (control) in Porto, with a minimal deferral period of 9 weeks between procedures. Both Trima Accel V6.0 and Trima Accel V5.1/5.2 and the corresponding disposable tubing sets were CE-marked for collection of blood products from donors and transfusion of the collected products at the time of the study. At the Leipzig site, the paired study for comparison of Trima Accel V5.1 vs. V6.0 was approved by the Ethical Committee of the University of Leipzig, as performance data was being collected for submission to the German blood products regulatory agency, the Paul Ehrlich Institute.

Collection Procedures on Trima Accel V5.1 and V5.2

The control procedures at the Leipzig site were apheresis donations targeting 245 ml of 80% hematocrit (Hct) RBCs and 250 ml of PLT concentrate containing 3.5×10^{11} PLTs using the Trima Accel V5.1. 80 ml SAGM were manually added to the RBCs post-donation followed by manual leukoreduction by gravity flow through the filter supplied with the set. The control procedures at the Porto site were apheresis donations targeting 225 ml of 80% Hct RBCs and 93–100 ml PLT hyperconcentrates containing $2.8\text{--}3.0 \times 10^{11}$ PLTs collected on Trima Accel V5.2. As in Leipzig, 80 ml SAGM were manually added to the RBCs post-donation followed by manual leukoreduction through the filter supplied with the set. The PLTs collected in Porto were automatically diluted by the Trima Accel V5.2 system after rinseback and donor disconnection with 124–133 ml of platelet additive solution. The products collected in the study were not transfused but were stored and evaluated over storage time at each site.

RBC collection is the same in V5.1 and V5.2, and the RBC leukoreduction filter used post-collection is identical for V5.1 and V5.2. Collection of PLTs and/or plasma, which occurs prior to the collection of an RBC unit on Trima, does not affect how the system collects the RBC product either with standard (V5.1) or hyperconcentrated (V5.2) PLTs, and will not affect the RBC outcomes.

Collection Procedures on Trima Accel V6.0

Trima Accel V6.0 used in the test procedures has 2 new features: i) automatic leukoreduction occurs as the 80% Hct RBC product is collected through an in-line leukoreduction filter (Pall, Port Washington, NY, USA) rather than by post-collection gravity filtration; and ii) automatic addition of RBC storage solution through the filter into the RBC product bag after RBC collection and donor disconnection, referred to as metered addition of RBC storage solution. The storage solution addition process uses the existing pumps on the Trima Accel to deliver the solution to the collected product. The solution is passed through the filter after filtration of the red cells, thereby recovering many of the RBCs that would otherwise remain

in the filter. The final RBC product requires no further processing prior to storage and transfusion. At each site, the same RBC and PLT products were targeted for collection on Trima Accel V6.0 and V5.1/5.2.

Subjects

The study was performed from January through April 2011 at the Institute of Transfusion Medicine, University Hospital and Clinics, Leipzig (Germany), and from September 2010 through April 2011 at the Blood Transfusion and Transplantation Center, IPST, IP, Porto (Portugal). All volunteer donors fulfilled the selection criteria of the German and Portuguese guidelines [16, 17]. Because of the requirement to collect both an RBC and PLT product in the study procedures, most of the donors in Leipzig and all in Porto were males. The individual donors donated a PLT and RBC unit in a single collection procedure twice, once in the control (Trima Accel V5.1 or V5.2) arm and once in the test (Trima Accel V6.0) arm. The PLT and RBC products collected within a site had similar volumes and yields. The order of the control and test collections was randomized, and collections were at least 9 weeks apart.

Sampling

A pre-apheresis sample from the donor was obtained from the sampling bag in the inlet line of the Trima Accel tubing set to determine donor parameters (infectious disease markers, blood type, complete blood count, iron status) before each session. The post-procedure sample was taken via the manifold close to the needle within 5 min after completing the procedure. At the Leipzig site, an additional donor sample was taken and analyzed between 7 and 12 days after collection to examine the regeneration of donor hematological parameters. Due to the paired study approach, each donor was sampled also 9 weeks after the first procedure. This gave information on the one hand about the progress of regeneration and on the other hand about the baseline values of the second procedure with the other Trima Accel version.

Assessment of RBC Units

The in vitro RBC function parameters measured were pH, plasma free Hb, plasma potassium, and adenosine triphosphate (ATP) (in Leipzig only). The parameters were measured on days 1, 21, and 42 of storage.

Cell Counts

Hct and total Hb were determined in Leipzig using the Cell-Dyn Ruby (Abbott, Chicago, IL, USA) and in Porto using a Beckman Coulter Hematology Analyzer, LH 750 (Fullerton, CA, USA).

Residual White Blood Cells

Residual white blood cells (rWBCs) in the RBC unit after filtration were measured at Leipzig by flow cytometry (FACS-C II, Becton Dickinson, San Jose, CA, USA) on day 1 only. In Porto, rWBC were also determined by flow cytometry (Beckman Coulter FC 500) on day 1 only.

pH

The pH of the RBC units were measured in Leipzig at 37 °C using the inoLab pH System 720 (WTW GmbH, Weilheim, Germany) and in Porto at 37 °C using the Rapid Lab 348 System (Siemens, Munich, Germany).

Plasma Hb

In Leipzig, free Hb was measured in the supernatant after centrifugation and removal of RBCs using the spectrophotometer LS 500 (Dr. Lange Meßplatz, Germany). Percent hemolysis (hemolysis rate) was calculated from plasma free Hb according to the following formula:

$$\text{Hemolysis (\%)} = \left(\frac{(100 - \text{Hct (\%)}) \times \text{plasma Hb (mg/dl)}}{\text{total Hb (mg/dl)}} \right) \quad (1).$$

Free Hb for the Porto RBCs was measured in Leipzig using cryopreserved supernatants of the blood samples.

Table 1. Main outcomes for the V51/V5.2 (V5) control and V6.0 test procedures in Leipzig and Porto

	Inlet volume processed ^a , ml	PLT collection time ^b , min	RBC collection time (+ V6.0 filtration) ^c , min	RBC V5 manual filtration/V5+6.0 SAGM addition time ^d , min	Total RBC collection and preparation time ^e , min	Total collection and preparation time ^f , min
Leipzig – Trima V5.1						
n	13	13	13	13	13	13
Median	2,734	42.5	7.2	10.9	18.9	61.1
Mean	2,669	42.4	7.4	12.9	20.3	62.7
SD	312	6.3	0.8	5.1	5.5	7.8
Leipzig – Trima V6.0						
n	13	13	13	11	11	11
Median	2,693	41.9	11.8	5.0	17.1	59.0
Mean	2,606	43.5	12.3	4.9	17.3	61.5
SD	246	9.4	1.3	0.6	1.4	10.8
Porto – Trima V5.2						
n	20	20	21	20	20	19
Median	2,723	48.7	6.0	17.0	22.8	69.1
Mean	2,815	46.9	6.0	16.4	22.3	69.1
SD	324	13.2	0.7	2.3	2.1	14.0
Porto – Trima V6.0						
n	21	21	21	21	21	21
Median	2,938	50.5	11.4	7.1	18.6	69.1
Mean	2,939	50.4	11.4	7.1	18.5	68.9
SD	436	10.0	0.4	0.9	1.0	10.3

^aTotal inlet volume (blood + anticoagulant) processed to collect RBCs and PLTs.

^bTime required by the system to collect PLTs.

^cTime required by the system to collect RBCs (including in-line filtration for V6.0 procedures).

^dTime required by site staff to add SAGM and filter V5 RBC products, or for V6.0 to automatically add SAGM to the RBC products.

^eTotal time required to collect and prepare RBC products for storage or transfusion.

^fTotal time required to collect and prepare RBC and PLT products.

Plasma Potassium Ion Concentration

In Leipzig, potassium was measured in the supernatant fluid after centrifugation of RBCs using the Roche Modular System (Roche Diagnostik GmbH, Mannheim, Germany). Potassium concentration for the Porto RBC units was also measured in Leipzig using cryopreserved supernatants of the blood samples.

ATP Concentration

ATP was measured in Leipzig using the enzymatic method with test kits from Greiner Diagnostik GmbH (Bahlingen, Germany). Results are expressed in units of imol of ATP per gram of Hb in the RBC product. ATP was not determined in Porto.

Regeneration of Hematological Parameters

Blood count regeneration determined by 7- to 12-day post-procedure complete blood counts of donors was done at Leipzig to identify potential differences between the outcomes of the 2 collection processes.

Statistics

The sample size needed to detect a difference in percent hemolysis between test and controls on day 42 of 0.4%, with 95% probability and 90% power, was determined to be 26 pairs. This assumed the standard deviation (SD) of the within-subject difference between control and test measures to be $\leq 0.6\%$. Paired hemolysis data from the 2 sites were pooled and analyzed using the paired t-test or Wilcoxon signed rank test. The sample sizes in Leipzig (13 pairs) and in Porto (21 pairs) were selected to meet the local requirements for validation of blood components collected using modified systems. Data are expressed as median and mean $\pm$ SD.

Comparisons between V5.1/5.2 and V6.0 data were done using paired t-tests or, if the data was not normally distributed, using the Wilcoxon signed rank test for determination of differences in medians. For differences between sites, the independent t-test or, if the data were not normally distributed, the Wilcoxon rank sum test were used. Determination of normality and the inferential testing were done using NCSS 2004 (NCSS, Kaysville, USA). Differences were determined using two-tailed tests, and were considered statistically significant for p values < 0.05 .

Results

Donor Characteristics

In Leipzig, 15 experienced hemapheresis donors were enrolled in the study and completed the first collection; 13 completed the paired study (11 male and 2 female donors). In Porto, 25 experienced hemapheresis donors were enrolled in the study and completed the first collection; 21 completed the paired study (all were male, as none of the potential female donors could provide the selected combination of products). Donor age averaged 40 ± 12 years in Leipzig and 38 ± 10 years in Porto. All donor blood values were within the normal range before the test and control procedures. Significant differences were seen for Hct and PLT and total blood volumes between Leipzig and Porto donors due to higher Hct ($p <$

Table 2. RBC product data (Hb yield, RBC rWBC, RBC volume)

	Hb yield, g/unit	RBC rWBC, × 10 ⁶	RBC volume, ml
Leipzig – Trima V5.1			
n	12	13	13
Median	57	0.10	282
Mean	55	0.21	278
SD	5	0.34	16
Leipzig – Trima V6.0			
n	13	13	11
Median	66	0.07	329
Mean	66	0.14	328
SD	3	0.16	3
Porto – Trima V5.2			
n	21	21	21
Median	51	0.09	270
Mean	51	0.10	271
SD	2	0.07	6
Porto – Trima V6.0			
n	21	21	21
Median	61	0.03	319
Mean	61	0.09	319
SD	3	0.11	10

0.0001) and lower PLT ($p < 0.0001$) pre-procedure values and smaller blood volumes ($p = 0.01$) for Porto donors. All procedures were well tolerated by the subjects. Vital functions (monitoring of pulse, body temperature, blood pressure, oxygen saturation) of donors before, during, and after apheresis were comparable between test (V6.0) and control (V5.1/5.2) runs (data not shown).

Apheresis Procedures

Table 1 summarizes the main outcomes for the V5.1/V5.2 control and V6.0 test procedures in Leipzig and Porto. Larger inlet volumes were processed during procedures at Porto compared to Leipzig ($p = 0.01$) due to the higher targeted PLT yield and the lower PLT counts in donors at Porto. Similar volumes were processed to obtain the PLT and RBC products in the V5.1/V5.2 and V6.0 procedures at each site ($p > 0.05$). PLT collection times were longer at Porto due to (as mentioned above) Porto's higher yields and lower PLT pre-count donors. PLT collection times were slightly but not statistically significantly longer for V6.0 than for V5.1/V5.2 collections at Leipzig ($p = 0.44$) and Porto ($p = 0.20$). RBC collections took 5 min longer with V6.0 than with V5.1/V5.2 procedures at each site. This is due to the Trima-controlled setup time for the in-line filtration in V6.0. RBC collections also took slightly longer for both V5.1 and V6.0 procedures in Leipzig because of the higher yield of RBCs targeted. More than offsetting this at both sites was the longer time to manually add storage solution to the V5.1/V5.2 RBCs compared to Trima Accel V6.0 with automated SAGM addition. The column 'Total RBC Collection and Preparation Time' (table 1)

Table 3. PLT product data on day 1 = day after production (PLT yield, PLT rWBC, PLT volume)

	PLT yield, × 10 ¹¹	PLT rWBC, × 10 ⁶	PLT volume, ml
Leipzig – Trima V5.1			
n	12	13	13
Median	3.08	0.17	246
Mean	3.01	0.26	244
SD	0.18	0.23	12
Leipzig – Trima V6.0			
n	13	13	13
Median	3.16	0.10	248
Mean	3.11	0.12	250
SD	0.23	0.12	11
Porto – Trima V5.2			
n	20	20	20
Median	2.71	0.11	94
Mean	2.71	0.15	96
SD	0.32	0.14	4
Porto – Trima V6.0			
n	21	21	20
Median	2.80	0.14	94
Mean	2.84	0.21	96
SD	0.31	0.27	3

shows that the time required to collect and prepare the RBCs was shorter at both Leipzig (17 vs. 20 min; $p = 0.0085$) and Porto (18.5 vs. 22.3 min; $p < 0.0001$). Total collection and preparation times for the V5.1/V5.2 and V6.0 PLT and RBC products were not statistically different in Leipzig ($p = 0.30$) or Porto ($p = 0.10$). Note that the 5 min needed for the Trima to automatically add PLT additive solution to the Porto PLT hyperconcentrates is not included.

Final Products

Table 2 shows the RBC product data (Hb yield, rWBC, RBC volume) after the addition of 80 ml SAGM and manual filtration in the case of V5.1/5.2 products, and in-line filtration and automated addition of SAGM for V6.0 products. The apheresis RBC units, resuspended in SAGM, after collection with V6.0 have, compared to V5.1/5.2 units, a significantly higher mean volume (18%) and approximately 20% more Hb per unit.

All RBC products, those filtered manually for the V5.1/5.2 collections and those filtered during collection in V6.0 collections, at both sites met the requirement of containing fewer than 1×10^6 rWBCs. Table 3 summarizes the PLT product data on day 1 (day after production) (PLT yield, rWBC, PLT volume). The differences in PLT yield and PLT volume with V5.1 (Leipzig) vs. V5.2 (Porto) are due to the differences in targeted collection yield and concentrations (Leipzig – standard volume, Porto – hyperconcentrated volume). Residual WBC counts were similar in the 2 sites, but 1 Porto V6.0 PLT product contained 1.2×10^6 rWBC.

Table 4. Storage parameter/primary RBC measures (percent hemolysis, free potassium (K⁺), ATP) for test and control RBC products stored in SAGM after 1, 21, and 42 days of storage

Parameters	Percent hemolysis			K ⁺ in supernatant, mmol/l			ATP, μ mol/g Hb		
	day 1	day 21	day 42	day 1	day 21	day 42	day 1	day 21	day 42
Leipzig – Trima V5.1									
n	9	12	12	13	13	13	13	13	13
Median	0.12	0.16	0.22	5.1	37.2	53.7	3.62	3.66	2.13
Mean	0.11	0.17	0.23	4.9	38.1	53.5	3.61	3.57	2.18
SD	0.08	0.12	0.12	0.8	5.0	5.6	0.66	0.48	0.50
Leipzig – Trima V6.0									
n	11	12	10	13	13	13	13	13	13
Median	0.16	0.20	0.28	5.6	41.0	55.8	3.44	3.46	2.13
Mean	0.17	0.23	0.28	5.8	41.7	55.8	3.46	3.52	2.10
SD	0.09	0.10	0.07	0.7	4.0	5.2	0.44	0.49	0.46
Porto – Trima V5.2									
N	21	21	21	21	21	19			
Median	0.04	0.10	0.26	3.3	35.6	50.2			
Mean	0.04	0.11	0.28	3.4	35.6	50.7			
SD	0.02	0.04	0.13	0.5	3.4	3.2			
Porto – Trima V6.0									
n	20	21	19	20	21	21			
Median	0.11	0.18	0.28	3.5	35.5	51.4			
Mean	0.12	0.17	0.37	3.5	36.3	52.3			
SD	0.05	0.06	0.19	0.6	3.1	3.8			

RBC Storage Outcomes

Table 4 shows the primary RBC measures (percent hemolysis and free potassium) for test and control products stored in SAGM after 1, 21, and 42 days of storage. All RBC units in Leipzig and Porto fulfilled the primary outcome parameter – percent hemolysis in the RBC units after 42 days of storage of less than 0.8% of initial red cell Hb per unit). There were small differences in hemolysis rates between V5.1/V5.2 and V6.0 products at Leipzig and Porto on days 1, 21, and 42, but they reached statistical significance only in Porto where the average hemolysis rates for V5.2 and V6.0 products were 0.28 and 0.37%, respectively. There were also small differences in supernatant potassium concentration in both sites, which reached statistical significance only in Porto with the V5.2 product averaging 50.7 mmol/l and the V6.0 product averaging 52.3 mmol/l. The ATP levels, which were available only for Leipzig RBC products, were not statistically different at any day of storage. The levels for 42-day stored products from both V5.1 and V6.0 platforms averaged 60% of day-1 levels. The pH values at 37 °C at both sites decreased over storage from 6.9 to 6.4, with very little difference between sites.

Regeneration of Donor Hematological Parameters after Donation

At the Leipzig site, an additional donor sample was taken and analyzed between 7 and 12 days after each collection to examine the regeneration of donor hematological parameters. Due to the paired study approach, each donor was sampled also before the second procedure, i.e. 9 weeks after the first run. Although the RBCs units collected within test proce-

dures (V6.0) resulted in RBC products with about 20% higher volume and Hb content, there was no difference in the immediate post-procedure decrease in Hb, Hct, or RBCs for V5.1 vs V6.0 procedures, because the amount of donor blood volume withdrawal for both procedure options is approximately 450 ml. The higher Hb content is due to the filtration recovery improvement in V6.0 – SAGM solution is passed through the filter after completion of filtration, thereby recovering many of the RBCs that would otherwise remain in the filter and tubing (calculated saving of approximately 12 g Hb). There were also no significant differences in changes in the donors' mean corpuscular volume (MCV), mean corpuscular Hb (MCH), or MCH concentration (MCHC) between V5.1 and V6.0 procedures (data not shown). The immediate post-procedure decrease in Hct and Hb averaged 10% for both V5.1 and V6.0 collections, and this decrease persisted for the 7- to 12-day period post-procedure. The Hb concentrations in the donors had returned to their pre-RBC apheresis levels by the second procedure (9 weeks).

Discussion

This study provides data from 2 study sites for RBC plus PLT unit collections using the Trima Accel system V6.0 with the novel features of in-line filtration and automated addition of SAGM to the leukocyte-depleted RBC product. Procedures with Trima Accel V6.0 yielded a higher RBC content in collected RBC units than those performed using V5.1/V5.2 at both sites with no significant differences in decreases in the

donor RBC levels after the procedure. RBCs from V6.0 are flushed from the leukoreduction filter into the product bag during automated addition of SAGM, resulting in higher yields. The automated repeatable process for addition of storage solution removes the variables that can be associated with the gravity filtration process, such as temperature, head height, mixing of the additive solution, and variable losses in the filter.

The automated in-line filtration is an effective procedure for RBC units. There is no evidence in these data that the in-line filtration in V6.0 has any effect on the RBCs that would raise questions about their clinical safety or efficacy. Average percent hemolysis was greater in the V6.0 RBC products at each site on days 1, 21, and 42, and reached statistical significance in Porto; however, the magnitude of the difference and the levels of hemolysis were not clinically significant: day-42 hemolysis in Leipzig was $0.23 \pm 0.12\%$ for V5.1 RBCs and $0.28 \pm 0.14\%$ for V6.0 RBCs; in Porto it was $0.28 \pm 0.13\%$ for V5.2 RBCs and $0.37 \pm 0.19\%$ for V6.0 RBCs. These levels of hemolysis equal those seen in most studies of stored RBCs. A recent review of the hemolysis rate at the end of storage noted that the average percent hemolysis in 1,883 units of RBCs stored 42 days in SAGM was $0.34 \pm 0.22\%$ [14]. None of the products collected and stored for 42 days exceeded the European limit of 0.8% for hemolysis. Differences observed for RBC supernatant potassium ion concentration were small and clinically insignificant throughout the storage period.

The study data are in good agreement with recent data on the upgrade of Trima Accel V6.0 [10–12]. Sawyer et al. [10] found hemolysis rates on day 42 for AS-3-stored RBCs for Trima Accel V6.0 averaging 0.26%, and Windscheid and Rice [11] in 42-day SAGM-stored V6.0 RBCs showed an average hemolysis rate of 0.41%, similar to our results with SAGM-stored RBCs. Cancelas et al. [12] reported all Trima Accel V6.0 hemolysis rates to be less than 1% and showed high 24-hour radiolabel recoveries (>80%) for 42-day AS-3-stored V6.0 RBCs. Sawyer et al. [10] also found all Trima Accel V6.0 press-through-filtered RBCs to have $<1 \times 10^6$ rWBCs, and Cancelas et al. [12] noted that all were $<5 \times 10^6$ (the US leukoreduction limit).

Regarding post-procedure changes in Hb, Macher et al. [15] using Amicus and Trima Accel V5.2 to collect single

RBC units with PLT units, showed changes very similar to those shown here, a 9% average decrease in donor Hb post-procedure which was unchanged 14 days later but returned to within 3% of the pre-procedure level within 6 weeks.

Apheresis RBC products obtained by Trima Accel V5.1/5.2 and V6.0 meet national and European standards for blood products. They can be recommended for routine application. The concurrent collection of RBCs and PLTs can be an advantage for some transfusion recipients, because by co-administration of the 2 blood products, donor exposure and with that sensitization against tissue antigens is reduced. In addition to the PLT products, the RBC products are transfused after brief storage. This may be especially effective in patients with malignant hematological diseases. Patients receiving both RBCs and PLTs several times in the course of therapy can particularly benefit, as the exposure to foreign donors is reduced by half (thereby reducing both the infectious and immunologic risks of transfusion).

In conclusion, the final RBC products obtained with the Trima Accel V6.0 meet the quality requirements for transfusion and have significantly higher Hb content than products collected on Trima Accel V5.1/V5.2. Hemolysis parameters of all RBC units through hypothermic storage are clinically insignificantly influenced by the change in filtration method, and all products were leukoreduced to levels below 1×10^6 rWBCs by the in-line filtration process on Trima Accel V6.0. All product specifications for both procedures and at both sites meet European, Portuguese, and German guidelines for blood components [13, 16, 17].

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Disclosure Statement

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References

- 1 Valbonesi M: Multicomponent collection (MCS): a new trend in transfusion medicine. *Int J Artif Organs* 1994;17:65–9.
- 2 Matthes G, Tofote U, Krause KP, Pawlow I, Kucera W, Lerche D: Improved red cell quality after erythroplasmapheresis with MCS-3p. *J Clin Apheresis* 1994;9:183–8.
- 3 Knutson F, Rider J, Franck V, Joie M, Högman M, Pamphilon D: A new apheresis procedure for the preparation of high-quality red cells and plasma. *Transfusion* 1999;39:565–71.
- 4 Matthes G: Red cell apheresis – new concepts of blood component processing. *Ther Apher* 1997;1: 22–8.
- 5 Elfath MD, Whitley P, Jacobson MS, Cranfill-Hupp K, Kemp DM, McNeil D, Sawyer S, Bell-Dize S, Gorlin JP, Kevy SV, McAteer JM: Evaluation of an automated system for the collection of packed RBCs, platelets, and plasma. *Transfusion* 2000;40:1214–22.
- 6 Matthes G: The potential of multicomponent blood donation. *La Transfusione del Sangue* 2000;45:173–83.
- 7 Bandarenko N, Rose M, Kowalsky RJ, Baston RK, Brecher ME, Elfath MD, Whitley P, Heminway M, Holme S: In vivo and in vitro characteristics of double units of RBCs collected by apheresis with a single in-line WBC-reduction filter. *Transfusion* 2001;41:1373–7.
- 8 Matthes G: Options and cost effectiveness of multicomponent blood donation. *Transf Apher Sci* 2002; 27:115–21.

- 9 Moog R: Implementation of concurrent red blood cell and platelet collection by apheresis in a university haemapheresis unit. *Transfus Med* 2004;14: 145–50.
- 10 Sawyer S, Whitley PH, Wellington MS, Vassallo RR, Clementi C, Fender L, Razatos A: In vitro evaluation of RBC units collected on the Trima Accel System with automated leukoreduction and metered addition of storage solution. *Transfusion* 2009;49(suppl 3):105A–6A.
- 11 Windscheid V, Rice J: In vitro quality of red blood cells collected with Trima Accel automated blood collection system version 6.0. *Vox Sang* 2011;101 (suppl 1):162.
- 12 Cancelas J, Rugg N, Friedman KD, Graminske S, Snyder EL, Corda T, Vassallo RR, Whitley PH, Fender L, Razatos LA: RBCs collected on Trima Accel with press-through RBC leukoreduction and addition of metered RBC storage solution. *Transfusion* 2009;49(suppl 3):38A.
- 13 Council of Europe Publishing: Guide to the Preparation, Use and Quality Assurance of Blood Components, 16th ed. Strasbourg, 2011.
- 14 Hess JR, Sparrow RL, van der Meer PF, Acker JP, Cardigan, Devine DV: Red blood cell hemolysis during blood bank storage: using national quality management data to answer basic scientific questions. *Transfusion* 2009;49:2599–603.
- 15 Macher S, Sipurnzynski-Budrass S, Roskopf, K, Semmelrock M, Prüller F, Griesbacher A, Lanzer G, Schmallmoser K: Influence of multicomponent apheresis on donors haematological and coagulation parameters, iron storage, and platelet function. *Vox Sang* 2012;103:194–200.
- 16 Richtlinie zur Gewinnung von Blut und Blutbestandteilen und zur Anwendung von Blutprodukten (Hämotherapie). *Bundesanzeiger* Nr. 209, 09/07/2010.
- 17 Decreto-Lei n. 267/2007de 24 de Julho, ANEXO VII – Critérios mínimos de elegibilidade de dados de sangue total e de componentes sanguíneos, *Diário da República*, 1.ª série – N. 141 – 24/07/2007.