MacoSpin

- en centrifug, två studier

Eller: det var en gång en väldigt busig centrifug,
som trots allt gav riktigt fina resultat!

Hanna-Stina Ahlzén och Linda Larsson

of
Blodkomponentenheten
Karolinska Universitetssjukhuset, Huddinge

KAROLINSKA
UNIVERSITETSLABORATORIET

VI ÄR EN DEL AV
STOCKHOLMS
LÄNS LANDSTING

A long time ago in a galaxy far, far away…

- Hade Blodkomponentenheten vid Karolinska Universitetssjukhuset följande förutsättningar:
  - Mer än 80 000 påsar helblod skulle tappas varje år från 3 fasta blodcentraler och 5 mobila enheter
  - Inget helblod fick ligga kvar över natt, utan all plasma och erytrocytkoncentrat skulle produceras under tappningsdagen

  För att det tighta tidsschemat skulle gå ihop, hade Bloddonation egna chaufförer som transporterade blodet till produktionslokalerna i Huddinge, samt mycket kompetent produktionspersonal.

  - Det fanns egentligen bara ***ett problem***:

Centrifugerna var gamla och hade sett bättre dagar.

Bakgrund

- Vi hade ett desperat behov av nya centrifuger.
- **Macospin, MacoPharma,** hade just kommit ut på marknaden. Vi beslöt oss för att utvärdera den, och titta på:
  - Erytrocyternas kvalitet jämfört med den befintliga centrifugen Sorvall RC12BP på likvärdiga centrifugeringsprogram
  - Erytrocyternas kvalitet från MacoSpin vid ett g-tal nära maximal centrifugkapacitet

Studie 1: MacoSpin vs. Sorvall

Evaluation of RBC quality from whole blood processed on the novel blood centrifuge MacoSpin

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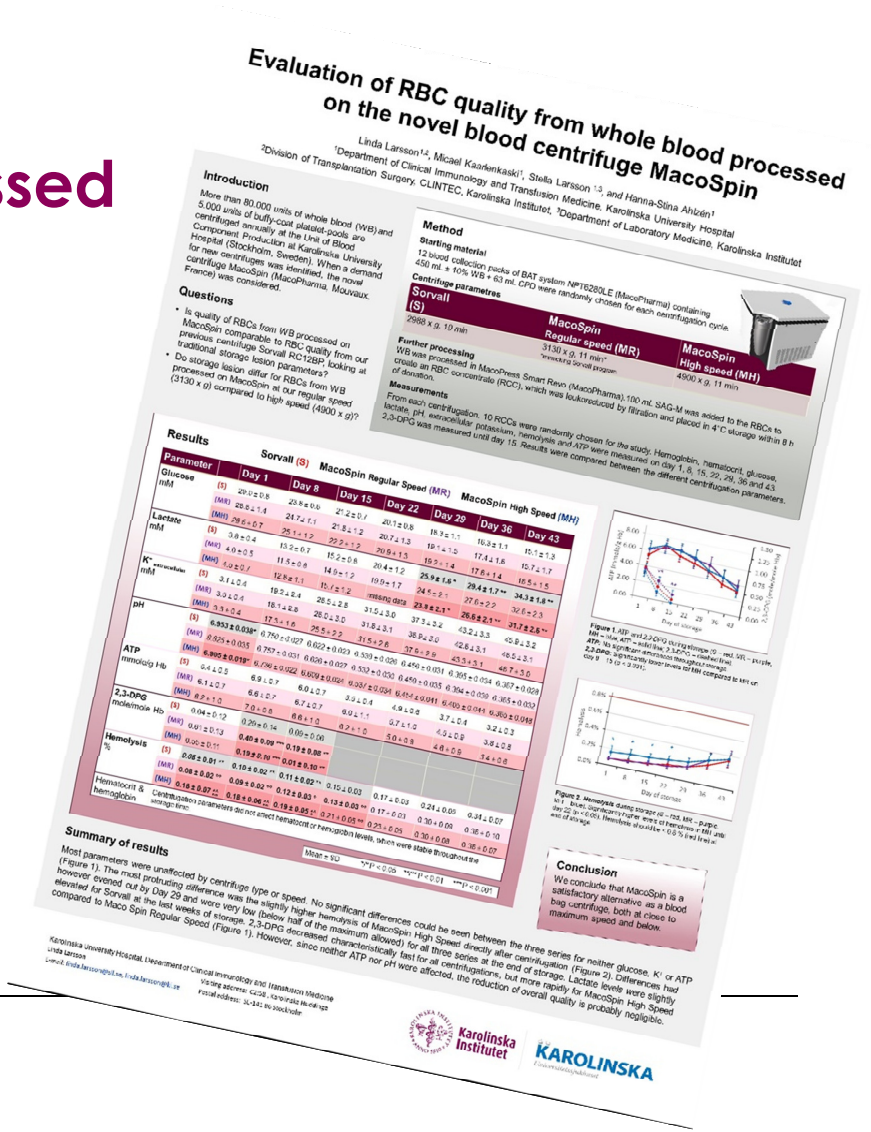
Evaluation of RBC quality from whole blood processed on the novel blood centrifuge MacoSpin

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Introduction

More than 80,000 units of whole blood (WB) and 5,000 units of buffy-coat platelet-pools are centrifuged annually at the Unit of Blood Component Production at Karolinska University Hospital (Stockholm, Sweden). When a demand for new centrifuges was identified, the novel centrifuge MacoSpin (MacoPharma, Mouvaux, France) was considered.

Questions

- Is quality of RBCs from WB processed on MacoSpin comparable to RBC quality from our previous centrifuges Sorvall RC12BP, looking at traditional storage lesion parameters?
- Do storage lesion differ for RBCs from WB processed on MacoSpin at our regular speed (3130 x g) compared to high speed (4900 x g)?

Method

Starting material

12 blood collection packs of BAT system NPT6280LE (MacoPharma) containing 450 ml. + 10% WB + 63 ml. CPD were randomly chosen for each centrifugation cycle.

Centrifuge parameters

Sorvall (S)	MacoSpin Regular speed (MR)	MacoSpin High speed (MH)
2988 x g, 10 min	3130 x g, 11 min*	4900 x g, 11 min

*reduced to Sorvall program

Further processing

WB was processed in MacoPress Smart Revo (MacoPharma), 100 mL SAG-M was added to the RBCs to create an RBC concentrate (RCC), which was leukoreduced by filtration and placed in 4°C storage within 8 h of donation.

Measurements

From each centrifugation, 10 RCCs were randomly chosen for the study. Hemoglobin, hematocrit, glucose, lactate, pH, extracellular potassium, hemolysis and ATP were measured on day 1, 8, 15, 22, 29, 36 and 43. 2,3-DPG was measured until day 15. Results were compared between the different centrifugation parameters.

Results

Sorvall (S) MacoSpin Regular Speed (MR) MacoSpin High Speed (MH)

Parameter		Day 1	Day 8	Day 15	Day 22	Day 29	Day 36	Day 43
Glucose mM	(S)	29.0 ± 0.8	25.8 ± 0.9	21.2 ± 0.7	20.1 ± 0.8	18.9 ± 1.1	16.9 ± 1.1	15.1 ± 1.3
	(MR)	28.8 ± 1.4	24.7 ± 1.1	21.8 ± 1.2	20.7 ± 1.3	19.1 ± 1.0	17.4 ± 1.6	15.7 ± 1.7
	(MH)	28.6 ± 0.7	25.1 ± 1.2	22.2 ± 1.2	20.9 ± 1.5	19.2 ± 1.4	17.6 ± 1.4	16.5 ± 1.6
Lactate mM	(S)	3.8 ± 0.4	13.2 ± 0.7	15.2 ± 0.8	20.4 ± 1.2	25.9 ± 1.6*	29.4 ± 1.7**	34.3 ± 1.8**
	(MR)	4.0 ± 0.5	11.5 ± 0.8	14.9 ± 1.2	19.9 ± 1.7	24.1 ± 2.1	27.6 ± 2.2	32.6 ± 2.3
	(MH)	4.0 ± 0.7	12.8 ± 1.1	15.7 ± 1.2	missing data	23.8 ± 2.1*	26.6 ± 2.1**	31.7 ± 2.5**
K^+ extracellular mM	(S)	3.1 ± 0.4	19.2 ± 2.4	26.5 ± 2.8	31.5 ± 3.0	37.3 ± 3.2	43.2 ± 3.3	49.2 ± 3.2
	(MR)	3.0 ± 0.4	18.1 ± 2.6	25.5 ± 2.2	31.8 ± 3.1	38.9 ± 2.0	43.2 ± 3.3	48.2 ± 3.1
	(MH)	3.1 ± 0.4	17.3 ± 1.6	26.0 ± 3.0	31.5 ± 2.6	37.5 ± 2.9	42.6 ± 3.1	46.7 ± 3.0
pH	(S)	6.933 ± 0.038*	6.750 ± 0.027	6.622 ± 0.023	6.533 ± 0.026	6.450 ± 0.031	6.365 ± 0.054	6.267 ± 0.029
	(MR)	6.924 ± 0.035	6.757 ± 0.031	6.628 ± 0.027	6.533 ± 0.030	6.450 ± 0.035	6.364 ± 0.056	6.265 ± 0.033
	(MH)	6.902 ± 0.019*	6.756 ± 0.022	6.629 ± 0.024	6.537 ± 0.034	6.454 ± 0.041	6.403 ± 0.041	6.360 ± 0.048
ATP mmol/g Hb	(S)	0.4 ± 0.5	6.9 ± 0.7	6.0 ± 0.7	5.0 ± 0.4	4.9 ± 0.8	3.7 ± 0.4	3.2 ± 0.3
	(MR)	6.1 ± 0.7	6.6 ± 0.7	6.7 ± 0.7	6.0 ± 1.1	5.7 ± 1.2	4.5 ± 0.8	3.8 ± 0.8
	(MH)	6.2 ± 1.0	7.0 ± 0.8	6.6 ± 1.0	6.2 ± 1.0	5.0 ± 0.9	4.8 ± 0.8	3.4 ± 0.6
2,3-DPG mole/mole Hb	(S)	0.04 ± 0.12	0.29 ± 0.14	0.09 ± 0.06				
	(MR)	0.01 ± 0.13	0.40 ± 0.09**	0.19 ± 0.08**				
	(MH)	0.00 ± 0.11	0.15 ± 0.10**	0.01 ± 0.10**				
Hemolysis %	(S)	0.06 ± 0.01**	0.10 ± 0.02**	0.11 ± 0.02**	0.15 ± 0.03	0.17 ± 0.03	0.24 ± 0.05	0.34 ± 0.07
	(MR)	0.06 ± 0.02**	0.09 ± 0.02**	0.12 ± 0.03*	0.13 ± 0.03**	0.17 ± 0.03	0.30 ± 0.09	0.36 ± 0.10
	(MH)	0.16 ± 0.07**	0.18 ± 0.06**	0.19 ± 0.05**	0.21 ± 0.05**	0.23 ± 0.05	0.30 ± 0.08	0.36 ± 0.07
Hematocrit & hemoglobin	Centrifugation parameters did not affect hematocrit or hemoglobin levels, which were stable throughout the storage time.							

Mean ± SD *=p < 0.05 **=p < 0.01 ***p < 0.001

Summary of results

Most parameters were unaffected by centrifuge type or speed. No significant differences could be seen between the three series for neither glucose, K^+ or ATP (Figure 1). The most profounding difference was the slightly higher hemolysis of MacoSpin High Speed directly after centrifugation (Figure 2). Differences had however evened out by Day 29 and were very low (below half of the maximum allowed) for all three series at the end of storage. Lactate levels were slightly elevated for Sorvall at the last weeks of storage. 2,3-DPG decreased characteristically fast for all centrifugations, but more rapidly for MacoSpin High Speed compared to Maco Spin Regular Speed (Figure 1). However, since neither ATP nor pH were affected, the reduction of overall quality is probably negligible.

Conclusion

We conclude that MacoSpin is a satisfactory alternative as a blood bag centrifuge, both at close to maximum speed and below.

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Karolinska Institutet KAROLINSKA

Frågeställning

- **Är kvaliteten** på erytrocyter från helblod som centrifugerats i **MacoSpin jämförbar** med kvaliteten från vår befintliga centrifug **Sorvall RC12BP?**

- **Är kvaliteten likvärdig** mellan erytrocyter från helblod som centrifugerats på MacoSpin vid vårt **ordinarie g-tal** (3130 x *g*) jämfört med riktigt **högt g-tal** (4900 x *g*)?

Metod

Utgångsmaterial

12 st helblod (450 mL ± 10% helblod + 63 mL CPD, NPT6280LE (MacoPharma)) valdes slumpmässigt ut för varje centrifugeringscykel.

Centrifugeringsparametrar

Sorvall (S)	**MacoSpin,** Regular speed **(MR)**	**MacoSpin,** High speed **(MH)**
2988 x *g*, 10 min	3130 x *g*, 11 min (motsv. Sorvall)	4900 x *g*, 11 min

Produktion av erytrocytkoncentrat

- Separation i MacoPress Smart Revo (MacoPharma)
- 100 mL SAG-M
- Leukocytfiltrering
- 4 ℃ blodkyl inom 8 h från tappning

Metod, fortsättning

Analyser

- 10 st e-konc från varje centrifugeringscykel provtogs:
- Dag 1, 8, 15, 22, 29, 36 och 43:
  - Hb, EVF, hemolys, glukos, laktat, pH, $K+_{extracell}$ och ATP
  - 2,3-DPG (dag 1, 8, 15)
  - Leukocyter (dag 1)
- Dag 43:
  - Bakteriekontroll

Resultat

Results

Sorvall (S) MacoSpin Regular Speed (MR) MacoSpin High Speed (MH)

Parameter		Day 1	Day 8	Day 15	Day 22	Day 29	Day 36	Day 43
Glucose mM	(S)	29.0 ± 0.8	23.8 ± 0.6	21.2 ± 0.7	20.1 ± 0.8	18.3 ± 1.1	16.3 ± 1.1	15.1 ± 1.3
	(MR)	28.6 ± 1.4	24.7 ± 1.1	21.8 ± 1.2	20.7 ± 1.3	19.1 ± 1.5	17.4 ± 1.6	15.7 ± 1.7
	(MH)	29.6 ± 0.7	25.1 ± 1.2	22.2 ± 1.2	20.9 ± 1.3	19.2 ± 1.4	17.6 ± 1.4	16.5 ± 1.5
Lactate mM	(S)	3.8 ± 0.4	13.2 ± 0.7	15.2 ± 0.8	20.4 ± 1.2	**25.9 ± 1.6 ***	**29.4 ± 1.7 ****	**34.3 ± 1.8 ****
	(MR)	4.0 ± 0.5	11.5 ± 0.8	14.9 ± 1.2	19.9 ± 1.7	24.5 ± 2.1	27.6 ± 2.2	32.6 ± 2.3
	(MH)	4.5 ± 0.7	12.8 ± 1.1	15.7 ± 1.2	missing data	**23.8 ± 2.1 ***	**26.6 ± 2.1 ****	**31.7 ± 2.6 ****
K^+ extracellular mM	(S)	3.1 ± 0.4	19.2 ± 2.4	26.5 ± 2.8	31.5 ± 3.0	37.3 ± 3.2	43.2 ± 3.3	45.9 ± 3.2
	(MR)	3.5 ± 0.4	18.1 ± 2.8	26.0 ± 3.0	31.8 ± 3.1	36.9 ± 3.0	42.6 ± 3.1	46.5 ± 3.1
	(MH)	3.5 ± 0.4	17.3 ± 1.6	25.5 ± 2.2	31.5 ± 2.6	37.9 ± 2.9	43.3 ± 3.1	46.7 ± 3.0
pH	(S)	**6.953 ± 0.038***	6.750 ± 0.027	6.622 ± 0.023	6.539 ± 0.026	6.456 ± 0.031	6.395 ± 0.034	6.367 ± 0.028
	(MR)	6.925 ± 0.035	6.757 ± 0.031	6.626 ± 0.027	6.532 ± 0.030	6.459 ± 0.035	6.394 ± 0.039	6.365 ± 0.032
	(MH)	**6.905 ± 0.019***	6.736 ± 0.022	6.609 ± 0.024	6.537 ± 0.034	6.454 ± 0.041	6.405 ± 0.044	6.365 ± 0.048
ATP mmole/g Hb	(S)	5.4 ± 0.5	6.9 ± 0.7	6.0 ± 0.7	5.5 ± 0.4	4.9 ± 0.6	3.7 ± 0.4	3.2 ± 0.3
	(MR)	6.1 ± 0.7	6.6 ± 0.7	6.7 ± 0.7	6.0 ± 1.1	5.7 ± 1.0	4.5 ± 0.9	3.8 ± 0.8
	(MH)	6.2 ± 1.0	7.0 ± 0.8	6.6 ± 1.0	6.2 ± 1.0	5.0 ± 0.9	4.6 ± 0.9	3.4 ± 0.6
2,3-DPG mole/mole Hb	(S)	0.64 ± 0.12	0.29 ± 0.14	0.09 ± 0.06				
	(MR)	0.61 ± 0.13	**0.40 ± 0.09 *****	**0.19 ± 0.08 ****				
	(MH)	0.55 ± 0.11	**0.19 ± 0.10 *****	**0.01 ± 0.10 ****				
Hemolysis %	(S)	**0.08 ± 0.01 ****	**0.10 ± 0.02 ****	**0.11 ± 0.02 ****	0.15 ± 0.03	0.17 ± 0.03	0.24 ± 0.05	0.34 ± 0.07
	(MR)	**0.08 ± 0.02 °°**	**0.09 ± 0.02 °°**	**0.12 ± 0.03 °**	**0.13 ± 0.03 °°**	0.17 ± 0.03	0.30 ± 0.09	0.36 ± 0.10
	(MH)	**0.16 ± 0.07 ** °°**	**0.18 ± 0.06 ** °°**	**0.19 ± 0.05 ** °**	0.21 ± 0.05 °°	0.23 ± 0.05	0.30 ± 0.08	0.36 ± 0.07
Hematocrit & hemoglobin	Centrifugation parameters did not affect hematocrit or hemoglobin levels, which were stable throughout the storage time.							

Mean ± SD */° P < 0.05 **/°° P < 0.01 *** P < 0.001

Resultat

Hb och EVF

- Ingen signifikant skillnad mellan de tre serierna (S, MR och MH)

Hemolys

- Högre för MacoSpin High speed (jmf med Sorvall och MacoSpin Regular Speed) t.o.m. dag 22
- Ingen signifikant skillnad fr.o.m dag 29
- Lägre än hälften av tillåtet värde (0,8%) vid förvaringstidens slut

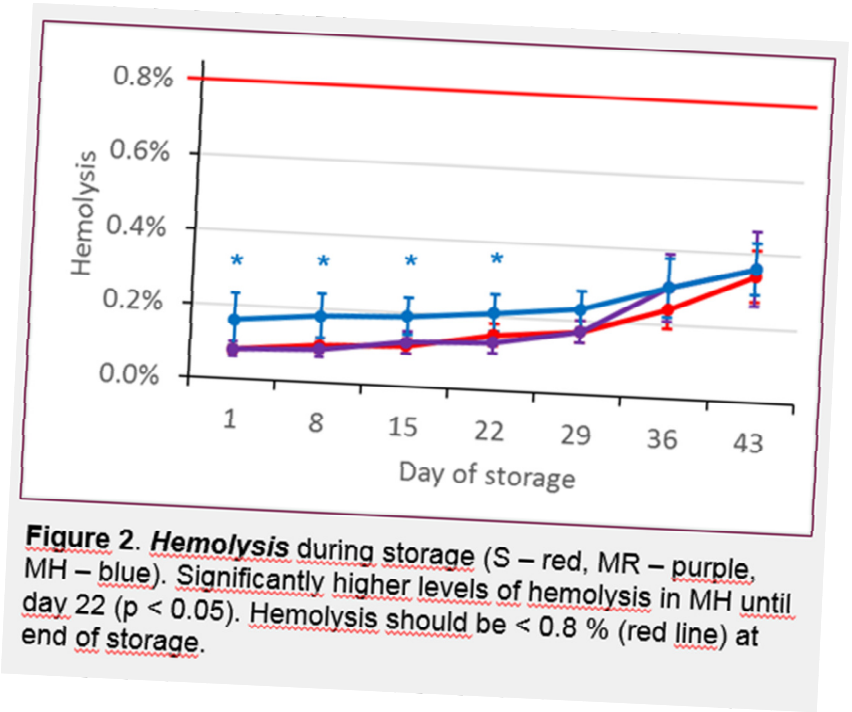


Figure 2. ***Hemolysis*** during storage (S – red, MR – purple, MH – blue). Significantly higher levels of hemolysis in MH until day 22 ($p < 0.05$). Hemolysis should be < 0.8 % (red line) at end of storage.

Resultat

Glukos, K+

- Ingen signifikant skillnad mellan de tre serierna (S, MR och MH)

Laktat

- Liten men signifikant högre nivå för S (jmf med MH) från dag 29 till förvaringstidens slut.

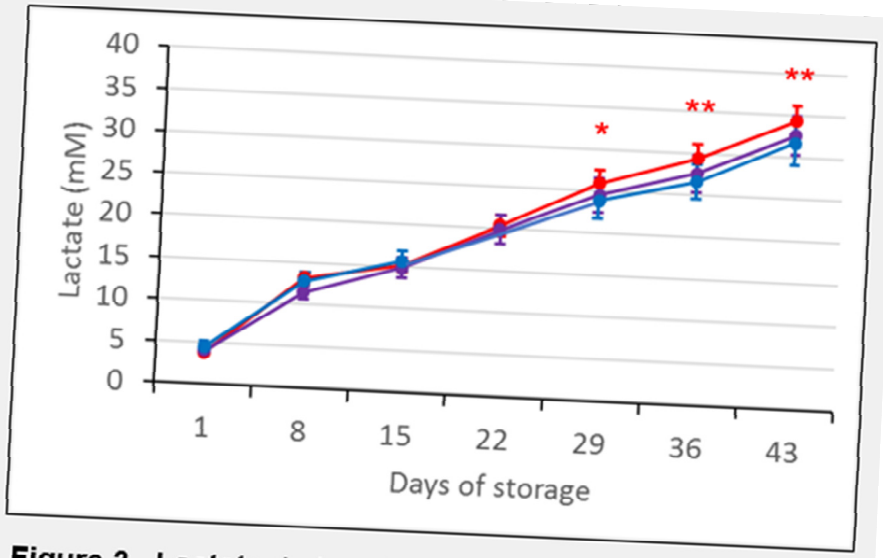


Figure 3. Lactate during storage (S – red, MR – purple, MH – blue). Significantly higher levels for S compared to MH from day 29 and onwards (* $p < 0.05$, ** $p < 0.01$).

Resultat

ATP

- Ingen signifikant skillnad mellan de tre serierna (S, MR och MH)

2,3-DPG

- MH sjönk signifikant snabbare jämfört med MR från dag 8.

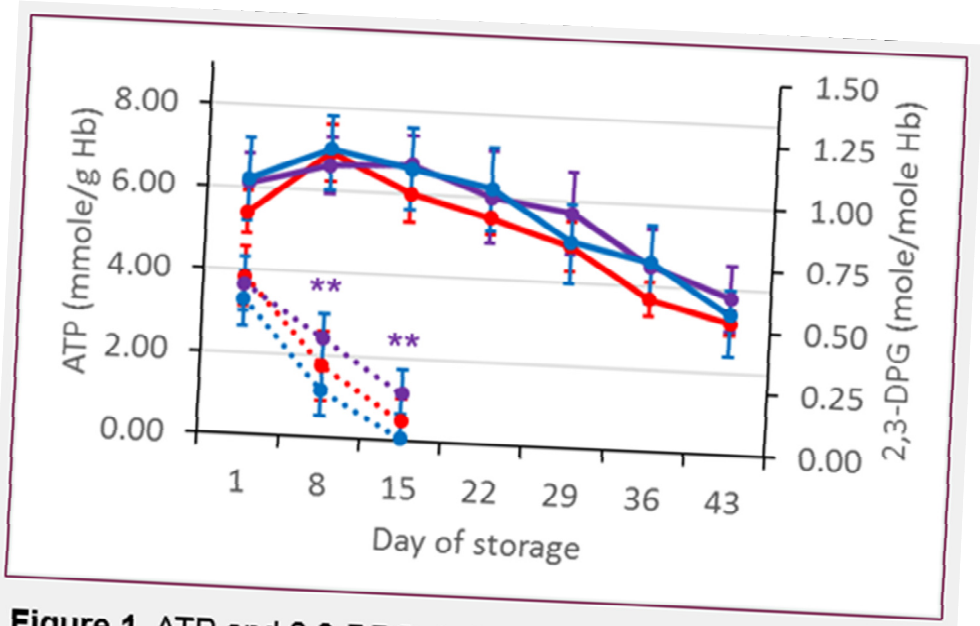


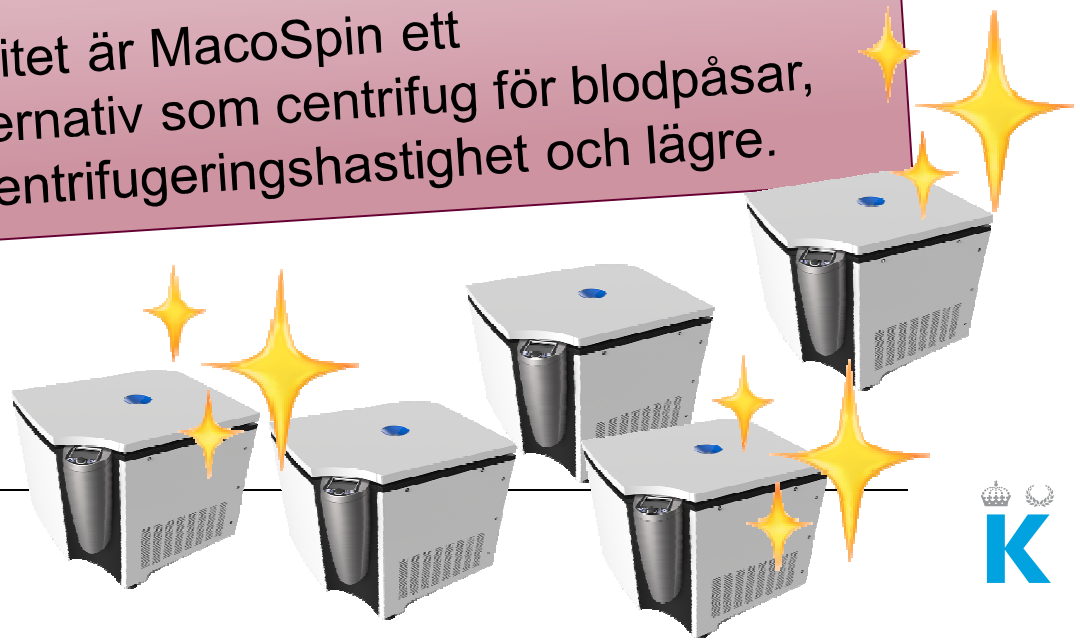
Figure 1. ATP and 2,3-DPG during storage (S – red, MR – purple MH – blue; ATP – solid line; 2,3-DPG – dashed line).
ATP: No significant differences throughout storage.
2,3-DPG: Significantly lower levels for MH compared to MR on day 8 – 15 ($p < 0.001$).

Slutsats

Erytrocyternas metabolism verkar inte påverkas nämnvärt av varken centrifugfabrikat eller hastighet. Eftersom inga dramatiska skillnader kunde ses för varken glukos, laktat, ATP eller pH, är den snabbare minskningen av 2,3-DPG för MH troligtvis inte av stor funktionell betydelse.

Sett till erytrocytkvalitet är MacoSpin ett tillfredsställande alternativ som centrifug för blodpåsar, både vid maximal centrifugeringshastighet och lägre.

Gött! Det funkar!
Vi köper nya centrifuger!



Bakgrund

- Hur kunde vi utnyttja MacoSpin för att effektivisera vår process?
- För att hinna med att ta hand om 80 000 helblod per år, inom 8 timmar från tappning, behöver vi enkla, snabba och standardiserade processer!
- En produktionslinje:
  - ✓ En produktionssite
  - ✓ Ett blodpåssystem
  - ✓ Ett centrifugeringsprogram
  - ✓ En typ av press
  - ✓ Ett pressprogram

VAD MER?

Autobalanseringsfunktion!

Studie 2 - Autobalansering

Centrifuge auto-balancing feature increases productio efficiency while maintaining blood component quality

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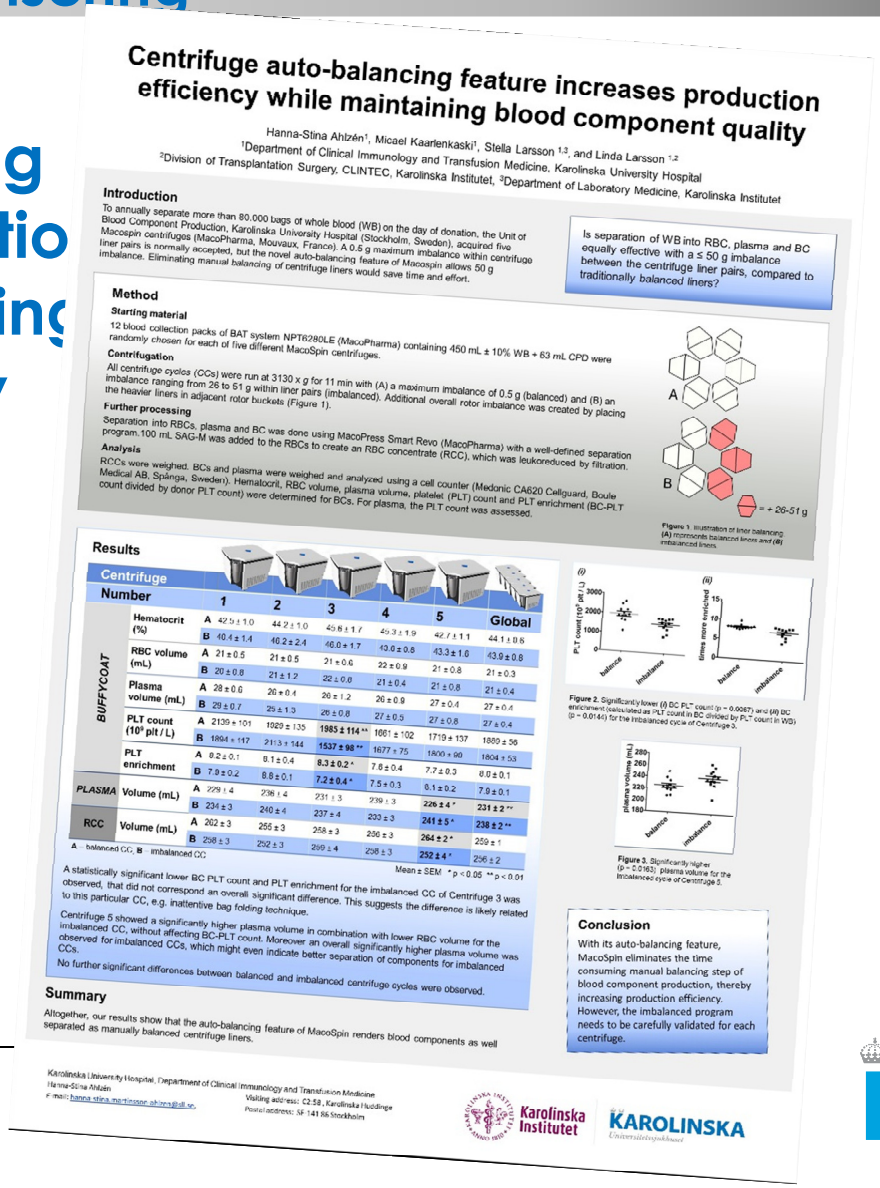

Centrifuge auto-balancing feature increases production efficiency while maintaining blood component quality

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Introduction

To annually separate more than 80.000 bags of whole blood (WB) on the day of donation, the Unit of Blood Component Production, Karolinska University Hospital (Stockholm, Sweden), acquired five Macospin centrifuges (MacoPharma, Mouvaux, France). A 0.5 g maximum imbalance within centrifuge liner pairs is normally accepted, but the novel auto-balancing feature of Macospin allows 50 g imbalance. Eliminating manual balancing of centrifuge liners would save time and effort.

Is separation of WB into RBC, plasma and BC equally effective with a ≤ 50 g imbalance between the centrifuge liner pairs, compared to traditionally balanced liners?

Method

Starting material

12 blood collection packs of BAT system NPTB280LE (MacoPharma) containing 450 mL ± 10% WB + 63 mL CPD were randomly chosen for each of five different MacoSpin centrifuges.

Centrifugation

All centrifuge cycles (CCs) were run at 3130 x g for 11 min with (A) a maximum imbalance of 0.5 g (balanced) and (B) an imbalance ranging from 26 to 51 g within liner pairs (imbalanced). Additional overall rotor imbalance was created by placing the heavier liners in adjacent rotor buckets (Figure 1).

Further processing

Separation into RBCs, plasma and BC was done using MacoPress Smart Revo (MacoPharma) with a well-defined separation program. 100 mL SAG-M was added to the RBCs to create an RBC concentrate (RCC), which was leukoreduced by filtration.

Analysis

RCCs were weighed. BCs and plasma were weighed and analyzed using a cell counter (Medonic CA620 Celliguard, Boule Medical AB, Spånga, Sweden). Hematocrit, RBC volume, plasma volume, platelet (PLT) count and PLT enrichment (BC-PLT count divided by donor PLT count) were determined for BCs. For plasma, the PLT count was assessed.

A
B
= + 26-51 g

Figure 1. Illustration of liner balancing (A) represents balanced liners and (B) imbalanced liners.

Results

		Centrifuge Number 1	2	3	4	5	Global
BUFFYCOAT	Hematocrit (%)	A 42.5 ± 1.0	44.2 ± 1.0	45.8 ± 1.7	45.3 ± 1.9	42.7 ± 1.1	44.1 ± 0.6
		B 40.4 ± 1.4	40.2 ± 2.4	40.0 ± 1.7	43.6 ± 0.6	43.3 ± 1.6	43.9 ± 0.8
	RBC volume (mL)	A 21 ± 0.5	21 ± 0.5	21 ± 0.6	22 ± 0.9	21 ± 0.8	21 ± 0.3
		B 20 ± 0.8	21 ± 1.2	22 ± 0.6	21 ± 0.4	21 ± 0.8	21 ± 0.4
	Plasma volume (mL)	A 28 ± 0.6	26 ± 0.4	26 ± 1.2	26 ± 0.9	27 ± 0.4	27 ± 0.4
		B 29 ± 0.7	25 ± 1.3	26 ± 0.8	27 ± 0.5	27 ± 0.8	27 ± 0.4
	PLT count (10^9 plt / L)	A 2139 ± 101	1929 ± 135	**1985 ± 114** **	1661 ± 102	1719 ± 137	1869 ± 56
		B 1894 ± 117	2113 ± 144	**1537 ± 98** **	1677 ± 75	1800 ± 90	1804 ± 53
	PLT enrichment	A 8.2 ± 0.1	8.1 ± 0.4	**8.3 ± 0.2** *	7.6 ± 0.4	7.7 ± 0.3	8.0 ± 0.1
		B 7.9 ± 0.2	8.8 ± 0.1	**7.2 ± 0.4** *	7.5 ± 0.3	8.1 ± 0.2	7.9 ± 0.1
PLASMA	Volume (mL)	A 229 ± 4	236 ± 4	231 ± 3	239 ± 3	**226 ± 4** *	**231 ± 2** **
		B 234 ± 3	240 ± 4	237 ± 4	233 ± 3	**241 ± 5** *	**238 ± 2** **
RCC	Volume (mL)	A 262 ± 3	255 ± 3	258 ± 3	256 ± 3	**264 ± 2** *	259 ± 1
		B 258 ± 3	252 ± 3	259 ± 4	258 ± 3	**252 ± 4** *	256 ± 2

A = balanced CC, B = imbalanced CC

Mean ± SEM * $p < 0.05$ ** $p < 0.01$

Figure 2. Significantly lower (i) BC PLT count ($p = 0.0087$) and (ii) BC enrichment (calculated as PLT count in BC divided by PLT count in WB) ($p = 0.0143$) for the imbalanced cycle of Centrifuge 3.

Figure 3. Significantly higher ($p = 0.0163$) plasma volume for the imbalanced cycle of Centrifuge 5.

A statistically significant lower BC PLT count and PLT enrichment for the imbalanced CC of Centrifuge 3 was observed, that did not correspond an overall significant difference. This suggests the difference is likely related to this particular CC, e.g. inattentive bag folding technique.

Centrifuge 5 showed a significantly higher plasma volume in combination with lower RBC volume for the imbalanced CC, without affecting BC-PLT count. Moreover an overall significantly higher plasma volume was observed for imbalanced CCs, which might even indicate better separation of components for imbalanced CCs.

No further significant differences between balanced and imbalanced centrifuge cycles were observed.

Summary

Altogether, our results show that the auto-balancing feature of MacoSpin renders blood components as well separated as manually balanced centrifuge liners.

Conclusion

With its auto-balancing feature, MacoSpin eliminates the time consuming manual balancing step of blood component production, thereby increasing production efficiency. However, the imbalanced program needs to be carefully validated for each centrifuge.

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Karolinska Institutet KAROLINSKA Universitetssjukhuset

Frågeställning

- Är separation av helblod till erytrocytkoncentrat, plasma och buffy coat lika effektiv om man har upp till 50 grams obalans mellan centrifugkopparna i ett par, jämfört med traditionellt balanserade centrifugkoppar?

Metod

Utgångsmaterial

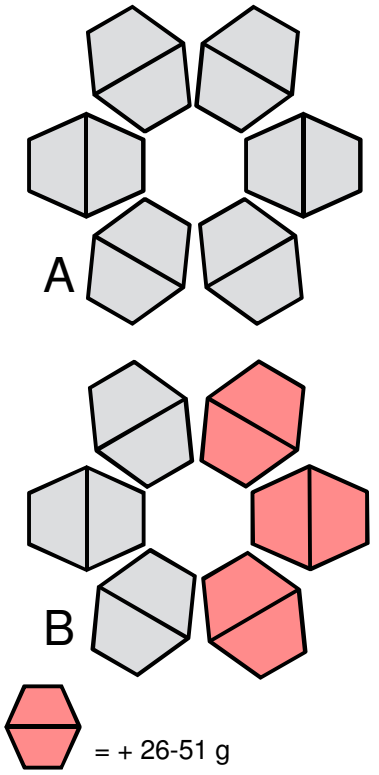
12 st helblod (450 mL ± 10% helblod + 63 mL CPD, NPT6280LE (MacoPharma)) valdes slumpmässigt ut för varje centrifugcykel (5 st centrifuger, 2 cykler/centrifug).

Centrifugeringsparametrar

- En balanserad (0,5 g) och en obalanserad (26-51 g skillnad) kördes per centrifug.
- Alla centrifugcykler (CC) kördes på 3130 x *g* i 11 min.

Produktion

- Separation i MacoPress Smart Revo (MacoPharma) till erytrocytkoncentrat (100 mL SAG-M), plasma och buffy coat.



Metod, fortsättning

Analys

- **Erytrocytkoncentrat**
  - Volym
- **Plasma**
  - Volym
  - TPK
- **Buffy coat**
  - Volym (total)
  - TPK
  - EVF
  - Volym (plasma)
  - Volym (celler)
  - Beräkning av anrikning av trombocyter (TPK i bc/givarens TPK)

Resultat

Results

Centrifuge Number			1	2	3	4	5	Global
BUFFYCOAT	Hematocrit (%)	A	42.5 ± 1.0	44.2 ± 1.0	45.6 ± 1.7	45.3 ± 1.9	42.7 ± 1.1	44.1 ± 0.6
		B	40.4 ± 1.4	46.2 ± 2.4	46.0 ± 1.7	43.6 ± 0.8	43.3 ± 1.6	43.9 ± 0.8
	RBC volume (mL)	A	21 ± 0.5	21 ± 0.5	21 ± 0.6	22 ± 0.9	21 ± 0.8	21 ± 0.3
		B	20 ± 0.8	21 ± 1.2	22 ± 0.8	21 ± 0.4	21 ± 0.8	21 ± 0.4
	Plasma volume (mL)	A	28 ± 0.6	26 ± 0.4	26 ± 1.2	26 ± 0.9	27 ± 0.4	27 ± 0.4
		B	29 ± 0.7	25 ± 1.3	26 ± 0.8	27 ± 0.5	27 ± 0.8	27 ± 0.4
	PLT count (10^9 plt / L)	A	2139 ± 101	1929 ± 135	**1985 ± 114 ****	1661 ± 102	1719 ± 137	1889 ± 56
		B	1894 ± 117	2113 ± 144	**1537 ± 98 ****	1677 ± 75	1800 ± 90	1804 ± 53
	PLT enrichment	A	8.2 ± 0.1	8.1 ± 0.4	**8.3 ± 0.2 ***	7.6 ± 0.4	7.7 ± 0.3	8.0 ± 0.1
		B	7.9 ± 0.2	8.8 ± 0.1	**7.2 ± 0.4 ***	7.5 ± 0.3	8.1 ± 0.2	7.9 ± 0.1
PLASMA	Volume (mL)	A	229 ± 4	236 ± 4	231 ± 3	239 ± 3	**226 ± 4 ***	**231 ± 2 ****
		B	234 ± 3	240 ± 4	237 ± 4	233 ± 3	**241 ± 5 ***	**238 ± 2 ****
RCC	Volume (mL)	A	262 ± 3	255 ± 3	258 ± 3	256 ± 3	**264 ± 2 ***	259 ± 1
		B	258 ± 3	252 ± 3	259 ± 4	258 ± 3	**252 ± 4 ***	256 ± 2

A – balanced CC, B – imbalanced CC

Mean ± SEM * $p < 0.05$ ** $p < 0.01$

A statistically significant lower BC PLT count and PLT enrichment for the imbalanced CC of Centrifuge 3 was observed, that did not correspond an overall significant difference. This suggests the difference is likely related to this particular CC, e.g. inattentive bag folding technique.

Centrifuge 5 showed a significantly higher plasma volume in combination with lower RBC volume for the imbalanced CC, without affecting BC-PLT count. Moreover an overall significantly higher plasma volume was observed for imbalanced CCs, which might even indicate better separation of components for imbalanced CCs.

No further significant differences between balanced and imbalanced centrifuge cycles were observed.

Resultat

- Centrifug 3, obalanserad centrifugeringscykel:
  - statistiskt signifikant lägre TPK i buffy coaten
  - statistiskt signifikant lägre trombocytanrikning
- Dock *ingen* sammantagen signifikant skillnad för obalanserade centrifugeringscykler
- Troligtvis har någonting hänt under denna specifika centrifugeringscykel.

Results

Centrifuge Number			1	2	3	4	5	Global
BUFFYCOAT	Hematocrit (%)	A	42.5 ± 1.0	44.2 ± 1.0	45.6 ± 1.7	45.3 ± 1.9	42.7 ± 1.1	44.1 ± 0.6
		B	40.4 ± 1.4	46.2 ± 2.4	46.0 ± 1.7	43.6 ± 0.8	43.3 ± 1.6	43.9 ± 0.8
	RBC volume (mL)	A	21 ± 0.5	21 ± 0.5	21 ± 0.6	22 ± 0.9	21 ± 0.8	21 ± 0.3
		B	20 ± 0.8	21 ± 1.2	22 ± 0.8	21 ± 0.4	21 ± 0.8	21 ± 0.4
	Plasma volume (mL)	A	28 ± 0.6	26 ± 0.4	26 ± 1.2	26 ± 0.9	27 ± 0.4	27 ± 0.4
		B	29 ± 0.7	25 ± 1.3	26 ± 0.8	27 ± 0.5	27 ± 0.8	27 ± 0.4
	PLT count (10^9 plt / L)	A	2139 ± 101	1929 ± 125	**1985 ± 114 ****	1861 ± 102	1719 ± 127	1889 ± 56
		B	1894 ± 117	2113 ± 144	**1537 ± 98 ****	1677 ± 75	1800 ± 90	1804 ± 53
	PLT enrichment	A	8.2 ± 0.1	8.1 ± 0.4	**8.3 ± 0.2 ***	7.6 ± 0.4	7.7 ± 0.3	8.0 ± 0.1
		B	7.9 ± 0.2	8.8 ± 0.1	**7.2 ± 0.4 ***	7.8 ± 0.3	8.1 ± 0.2	7.9 ± 0.1

Resultat

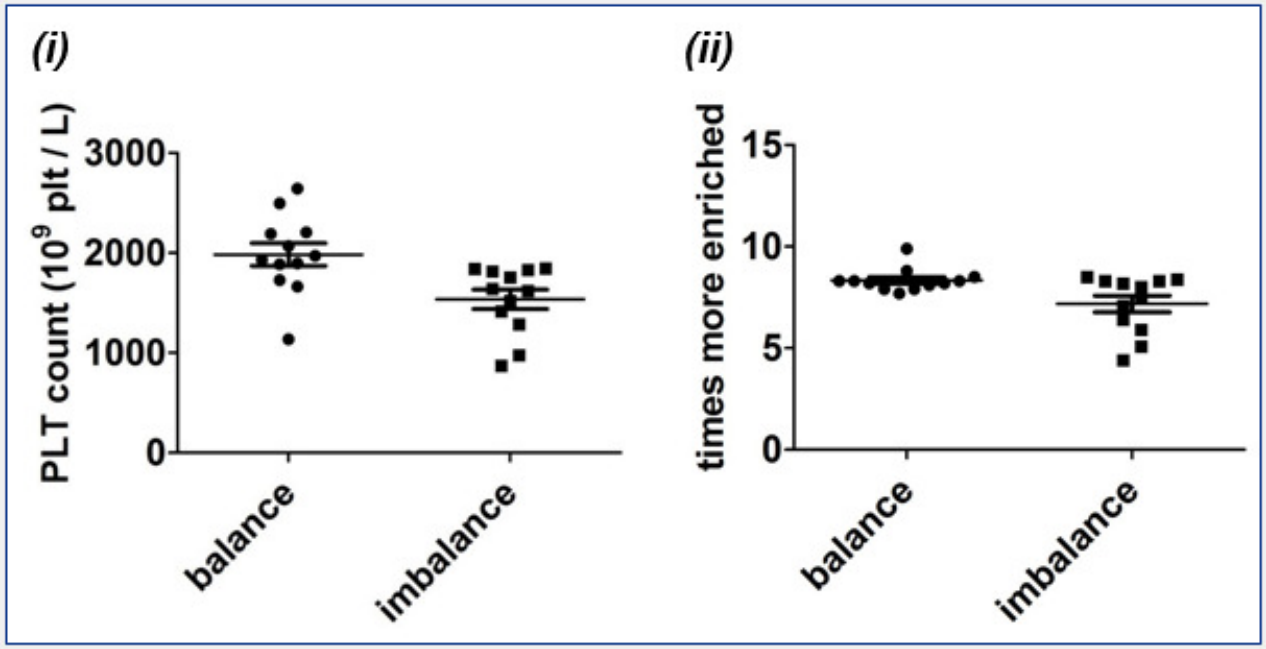
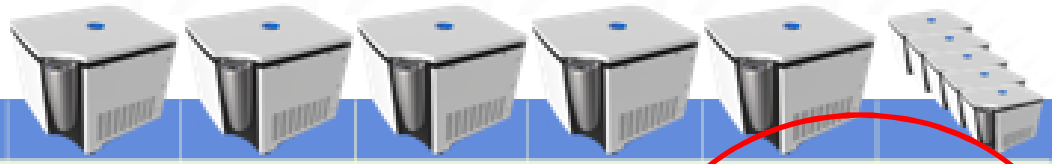


Figure 2. Significantly lower (***i***) BC PLT count (p = 0.0067) and (***ii***) BC enrichment (calculated as PLT count in BC divided by PLT count in WB) (p = 0.0144) for the imbalanced cycle of Centrifuge 3.

Resultat

- Centrifug 5, obalanserad centrifugeringscykel:
  - statistiskt signifikant högre plasmavolym
  - statistiskt signifikant lägre volym för erytrocytkoncentraten
  - ingen påverkan på TPK i buffy coaten
- Signifikant högre plasmavolym för obalanserade cykler även sammantaget
- Skulle *eventuellt* kunna indikera bättre separation vid obalans än vid balans

Results



Centrifuge Number			1	2	3	4	5	Global
PLASMA	Volume (mL)	A	229 ± 4	236 ± 4	231 ± 3	239 ± 3	226 ± 4 *	231 ± 2 **
		B	234 ± 3	240 ± 4	237 ± 4	233 ± 3	241 ± 5 *	238 ± 2 **
RCC	Volume (mL)	A	262 ± 3	255 ± 3	258 ± 3	256 ± 3	264 ± 2 *	259 ± 1
		B	258 ± 3	252 ± 3	259 ± 4	258 ± 3	252 ± 4 *	256 ± 2

Resultat

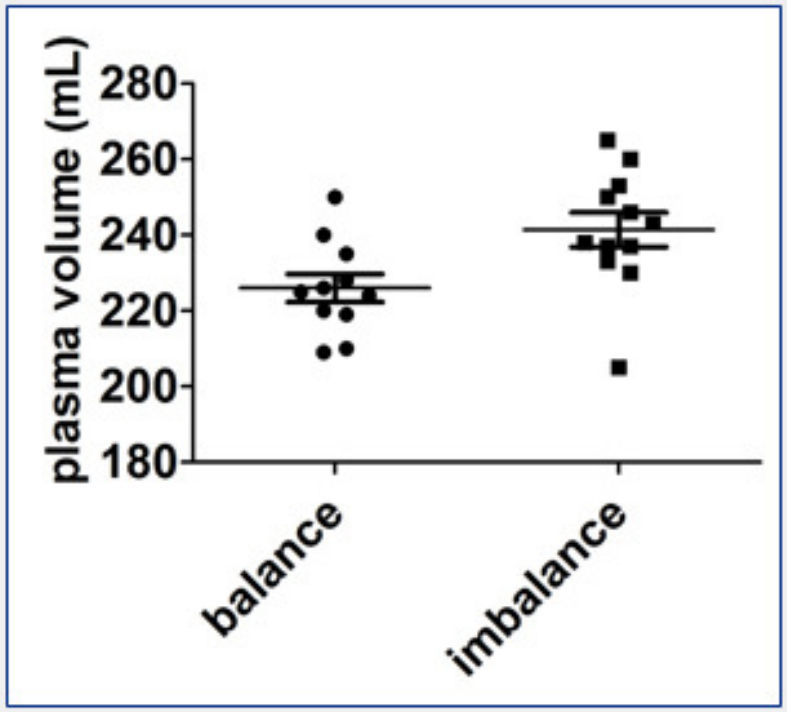
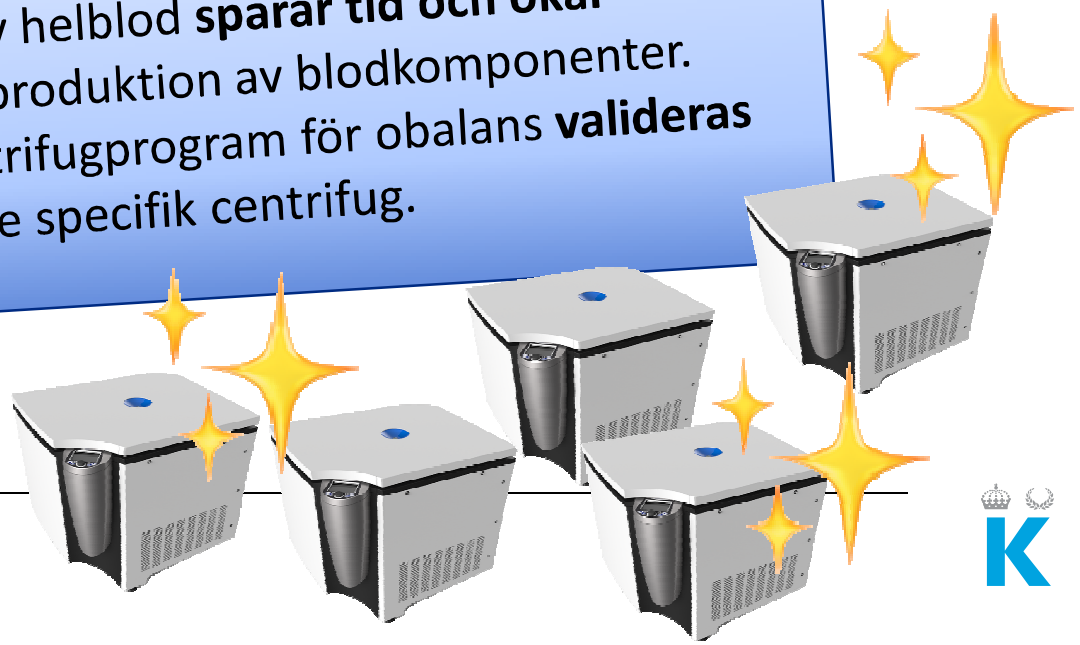


Figure 3. Significantly higher ($p = 0.0163$) plasma volume for the imbalanced cycle of Centrifuge 5.

Slutsats

MacoSpins autobalanseringsfunktion **fungerar tillfredsställande** och **eliminerar** det tidskrävande steget av **noggrann invägning** och balansering av centrifugkoppar, förutsatt att påsar med samma taravikt används så att vikten mellan de individuella helblodspåsarna inte skiljer mer än 50 g.

Autobalansering av helblod **sparar tid och ökar effektiviteten** vid produktion av blodkomponenter. Dock behöver centrifugprogram för obalans **valideras noggrannt** för varje specifik centrifug.



Läs mer!

Evaluation of RBC quality from whole blood processed on the novel blood centrifuge MacoSpin

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[2]Division of Transplantation Surgery, CLINTEC, Karolinska Institutet, [3]Department of Laboratory Medicine, Karolinska Institutet

Introduction

More than 80.000 units of whole blood (WB) and 5.000 units of buffy-coat platelet-pools are centrifuged annually at the Unit of Blood Component Production at Karolinska University Hospital (Stockholm, Sweden). When a demand for new centrifuges was identified, the novel centrifuge MacoSpin (MacoPharma, Mouvaux, France) was considered.

Questions

- Is quality of RBCs from WB processed on MacoSpin comparable to RBC quality from our previous centrifuge Sorvall RC12BP, looking at traditional storage lesion parameters?
- Do storage lesion differ for RBCs from WB processed on MacoSpin at our regular speed (3130 x *g*) compared to high speed (4900 x g)?

Method

Starting material

12 blood collection packs of BAT system NPT6280LE (MacoPharma) containing 450 mL ± 10% WB + 63 mL CPD were randomly chosen for each centrifugation cycle.

Centrifuge parametres		
Sorvall (S)	MacoSpin Regular speed (MR)	MacoSpin High speed (MH)
2988 x g, 10 min	3130 x g, 11 min* *mimicking Sorvall program	4900 x g, 11 min

Further processing

WB was processed in MacoPress Smart Revo (MacoPharma).100 mL SAG-M was added to the RBCs to create an RBC concentrate (RCC), which was leukoreduced by filtration and placed in 4°C storage within 8 h of donation.

Measurements

From each centrifugation, 10 RCCs were randomly chosen for the study. Hemoglobin, hematocrit, glucose, lactate, pH, extracellular potassium, hemolysis and ATP were measured on day 1, 8, 15, 22, 29, 36 and 43. 2,3-DPG was measured until day 15. Results were compared between the different centrifugation parameters.

Results

Sorvall (S) MacoSpin Regular Speed (MR) MacoSpin High Speed (MH)

Parameter		Day 1	Day 8	Day 15	Day 22	Day 29	Day 36	Day 43
Glucose mM	(S)	29.0 ± 0.8	23.8 ± 0.6	21.2 ± 0.7	20.1 ± 0.8	18.3 ± 1.1	16.3 ± 1.1	15.1 ± 1.3
	(MR)	28.6 ± 1.4	24.7 ± 1.1	21.8 ± 1.2	20.7 ± 1.3	19.1 ± 1.5	17.4 ± 1.6	15.7 ± 1.7
	(MH)	29.8 ± 0.7	25.1 ± 1.2	22.2 ± 1.2	20.9 ± 1.3	19.2 ± 1.4	17.6 ± 1.4	16.5 ± 1.5
Lactate mM	(S)	3.6 ± 0.4	13.2 ± 0.7	15.2 ± 0.5	10.4 ± 1.2	24.5 ± 2.1	27.6 ± 2.2	32.0 ± 2.3
	(MR)	4.0 ± 0.5	11.5 ± 0.8	14.0 ± 1.2	10.9 ± 1.7	**25.9 ± 1.6***	**29.4 ± 1.7****	**34.3 ± 1.8****
	(MH)	4.5 ± 0.7	12.8 ± 1.1	15.7 ± 1.2	missing data	**23.8 ± 2.1***	**26.6 ± 2.1****	**31.7 ± 2.6****
K^+ extracellular mM	(S)	3.1 ± 0.4	19.2 ± 2.4	26.5 ± 2.8	31.5 ± 3.6	37.1 ± 3.2	43.2 ± 3.3	46.9 ± 3.2
	(MR)	3.5 ± 0.4	18.1 ± 2.8	26.0 ± 3.0	31.8 ± 3.1	36.9 ± 3.0	42.6 ± 3.1	46.5 ± 3.1
	(MH)	3.5 ± 0.4	17.3 ± 1.6	25.5 ± 2.2	31.5 ± 2.6	37.9 ± 2.9	43.3 ± 3.1	46.7 ± 3.0
pH	(S)	**6.953 ± 0.038°**	6.750 ± 0.027	6.622 ± 0.023	6.539 ± 0.026	6.456 ± 0.031	6.395 ± 0.034	6.367 ± 0.028
	(MR)	6.925 ± 0.035	6.757 ± 0.031	6.626 ± 0.027	6.532 ± 0.030	6.459 ± 0.035	6.394 ± 0.039	6.365 ± 0.032
	(MH)	**6.905 ± 0.019°**	6.736 ± 0.022	6.609 ± 0.024	6.537 ± 0.034	6.454 ± 0.041	6.405 ± 0.044	6.365 ± 0.048
ATP mmole/g Hb	(S)	5.4 ± 0.5	8.9 ± 0.7	6.8 ± 0.7	5.5 ± 0.4	4.8 ± 0.6	3.7 ± 0.4	3.2 ± 0.3
	(MR)	6.1 ± 0.7	8.6 ± 0.7	6.7 ± 0.7	6.0 ± 1.1	5.7 ± 1.0	4.5 ± 0.9	3.8 ± 0.8
	(MH)	6.2 ± 1.0	7.0 ± 0.8	6.6 ± 1.0	6.2 ± 1.0	5.0 ± 0.9	4.6 ± 0.9	3.4 ± 0.6
2,3-DPG mole/mole Hb	(S)	0.64 ± 0.12	0.29 ± 0.14	0.09 ± 0.09				
	(MR)	0.64 ± 0.13	**0.40 ± 0.09 ### 0.19 ± 0.08 ##**					
	(MH)	0.56 ± 0.11	**0.19 ± 0.10 ### 0.01 ± 0.10 ###**					
Hemolysis %	(S)	**0.08 ± 0.01 ^^**	**0.10 ± 0.02 ^^**	**0.11 ± 0.02 ^^**	0.10 ± 0.03	0.17 ± 0.03	0.24 ± 0.03	0.34 ± 0.07
	(MR)	**0.09 ± 0.02 ^^**	**0.09 ± 0.02 ^^**	**0.12 ± 0.03 ^**	**0.13 ± 0.03 ^^**	0.17 ± 0.03	0.30 ± 0.09	0.36 ± 0.10
	(MH)	**0.16 ± 0.07 ^^**	**0.19 ± 0.06 ^^**	**0.19 ± 0.05 ^^**	0.21 ± 0.05 ^^	0.23 ± 0.05	0.30 ± 0.08	0.36 ± 0.07
Hematocrit & hemoglobin	Centrifugation parameters did not affect hematocrit or hemoglobin levels, which were stable throughout the storage time.							

Mean ± SD ^/#p < 0.05 ^^/##p < 0.01 ^^^/###p < 0.001

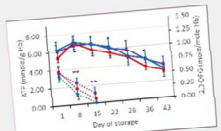

Figure 1. ATP and 2,3-DPG during storage (S – red, M/R – purple, MH – blue). ATP – solid line; 2,3-DPG – dashed line).
ATP: No significant differences through out storage.
2,3-DPG: Significantly lower levels for MH compared to MR on day 8 – 15 ($p < 0.001$).

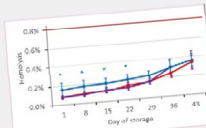

Figure 2. Hemolysis during storage (S – red, M/R – purple, MH – blue). Significantly higher levels of hemolysis in MH until day 22 ($p < 0.05$). Hemolysis should be < 0.8 % (180 litres) at end of storage.

Conclusion

We conclude that MacoSpin is a satisfactory alternative as a blood bag centrifuge, both at close to maximum speed and below.

Summary of results

Most parameters were unaffected by centrifuge type or speed. No significant differences could be seen between the three series for neither glucose, K^+ or ATP (Figure 1). The most protruding difference was the slightly higher hemolysis of MacoSpin High Speed directly after centrifugation (Figure 2). Differences had however evened out by Day 29 and were very low (below half of the maximum allowed) for all three series at the end of storage. Lactate levels were slightly elevated for Sorvall at the last weeks of storage. 2,3-DPG decreased characteristically fast for all centrifugations, but more rapidly for MacoSpin High Speed compared to Maco Spin Regular Speed (Figure 1). However, since neither ATP nor pH were affected, the reduction of overall quality is probably negligible.

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Centrifuge auto-balancing feature increases production efficiency while maintaining blood component quality

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[1]Department of Clinical Immunology and Transfusion Medicine, Karolinska University Hospital
[2]Division of Transplantation Surgery, CLINTEC, Karolinska Institutet, [3]Department of Laboratory Medicine, Karolinska Institutet

Introduction

To annually separate more than 80.000 bags of whole blood (WB) on the day of donation, the Unit of Blood Component Production, Karolinska University Hospital (Stockholm, Sweden), acquired five Macospin *centrifuges* (MacoPharma, Mouvaux, France). A 0.5 g maximum imbalance within centrifuge liner pairs is normally accepted, but the novel auto-balancing feature of Macospin allows 50 g imbalance. Eliminating manual balancing of centrifuge liners would save time and effort.

Is separation of WB into RBC, plasma and BC equally effective with a ≤ 50 g imbalance between the centrifuge liner pairs, compared to traditionally balanced liners?

Method

Starting material

12 blood collection packs of BAT system NPT6280LE (MacoPharma) containing 450 mL ± 10% WB + 63 mL CPD were randomly chosen for each of five different MacoSpin centrifuges.

Centrifugation

All *centrifuge* cycles (CCs) were run at 3130 x *g* for 11 min with (A) a maximum imbalance of 0.5 g (balanced) and (B) an imbalance ranging from 26 to 51 g within liner pairs (imbalanced). Additional overall rotor imbalance was created by placing the heavier liners in adjacent *rotor buckets* (*Figure 1*).

Further processing

Separation into RBCs, plasma and BC was done using MacoPress Smart Revo (MacoPharma) with a well-defined separation program.100 mL SAG-M was added to the RBCs to create an RBC concentrate (RCC), which was leukoreduced by filtration.

Analysis

RCCs were weighed. BCs and plasma were weighed and analyzed using a cell counter (Medonic CA620 Cellguard, Boule Medical AB, Spånga, Sweden). Hematocrit, RBC volume, plasma volume, platelet (PLT) count and PLT enrichment (BC-PLT count divided by donor PLT count) were determined for BCs. For plasma, the PLT count was assessed.

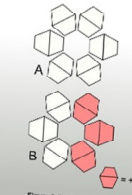

Figure 1. Illustration of liner balancing. (A) represents balanced liners and (B) imbalanced liners.

Results

Centrifuge Number			1	2	3	4	5	Global
BUFFYCOAT	Hematocrit (%)	A	42.5 ± 1.0	44.2 ± 1.0	45.6 ± 1.7	45.5 ± 1.0	42.7 ± 1.1	44.1 ± 0.6
		B	40.4 ± 1.4	46.2 ± 2.4	46.0 ± 1.7	43.8 ± 0.8	43.3 ± 1.6	43.9 ± 0.8
	RBC volume (mL)	A	21 ± 0.5	21 ± 0.5	21 ± 0.6	22 ± 0.9	21 ± 0.8	21 ± 0.3
		B	20 ± 0.8	21 ± 1.2	22 ± 0.8	21 ± 0.4	21 ± 0.8	21 ± 0.4
	Plasma volume (mL)	A	26 ± 0.6	26 ± 0.4	26 ± 1.2	26 ± 0.9	27 ± 0.4	27 ± 0.4
		B	29 ± 0.7	25 ± 1.3	26 ± 0.8	27 ± 0.5	27 ± 0.8	27 ± 0.4
	PLT count (10^3 pkt / L)	A	2139 ± 101	1929 ± 135	**1985 ± 114****	1661 ± 102	1719 ± 137	1889 ± 56
		B	1654 ± 117	2113 ± 144	**1537 ± 98****	1677 ± 75	1800 ± 90	1804 ± 53
	PLT enrichment	A	8.2 ± 0.1	8.1 ± 0.4	**8.3 ± 0.2***	7.6 ± 0.4	7.7 ± 0.3	8.0 ± 0.1
		B	7.9 ± 0.2	8.8 ± 0.1	**7.2 ± 0.4***	7.5 ± 0.3	8.1 ± 0.2	7.9 ± 0.1
PLASMA	Volume (mL)	A	229 ± 4	236 ± 4	231 ± 5	209 ± 3	**226 ± 4***	**231 ± 2****
		B	234 ± 3	240 ± 4	237 ± 4	233 ± 3	**241 ± 5***	**238 ± 2****
RCC	Volume (mL)	A	262 ± 3	255 ± 3	258 ± 3	256 ± 3	**264 ± 2***	259 ± 1
		B	256 ± 3	252 ± 3	255 ± 4	238 ± 3	**252 ± 4***	250 ± 2

A – balanced CC, B – imbalanced CC

Mean ± SEM *p < 0.05 **p < 0.01

A statistically significant lower BC PLT count and PLT enrichment for the imbalanced CC of Centrifuge 3 was observed, that did not correspond an overall significant difference. This suggests the difference is likely related to this particular CC, e.g. inattentive bag folding technique.

Centrifuge 5 showed a significantly higher plasma volume in combination with lower RBC volume for the imbalanced CC. without affecting BC-PLT count. Moreover an overall significantly higher plasma volume was observed for imbalanced CCs. which might even indicate better separation of components for imbalanced CCs.

No further significant differences between balanced and imbalanced *centrifuge* cycles were observed.

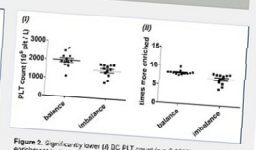

Figure 2. Significantly lower (i) BC PLT count ($p = 0.0067$) and (ii) BC enrichment (calculated as "PLT count in BC divided by "PLT count in WB) ($p = 0.0144$) for the imbalanced cycle of Centrifuge 3.

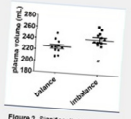

Figure 3. Significantly higher ($p = 0.0107$) plasma volume for the imbalanced cycle of Centrifuge 5.

Summary

Altogether, our results show that the auto-balancing feature of MacoSpin renders blood components as well separated as manually balanced centrifuge liners.

Conclusion

With its auto-balancing feature, MacoSpin eliminates the time consuming manual balancing step of *blood component production*, thereby increasing production efficiency. However, the imbalanced program needs to be carefully validated for each centrifuge.

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Frågor på det?

Tack för er uppmärksamhet!

***Foto: Thomas Bertheau**, Conroy Medical AB*