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Evaluation of the haematological quality of stored blood intended for transfusion: the case of three blood banks in Kinshasa

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RESUME:
L'objectif de cette étude était de déterminer la qualité hématologique du sang stocké destiné à la transfusion. L'étude était prospective et expérimentale, basée sur l'évaluation de la qualité hématologique du sang stocké destiné à la transfusion, et s'est déroulée entre le 11 octobre et le 11 janvier 2024. Nous avons collecté dix poches de sang auprès de donneurs volontaires, après un examen physique de ceux qui remplissaient les conditions requises. Au total, 10 poches de sang de 250 ml ont été collectées à Malueka, l'un des sites de collecte de sang de la clinique de Ngaliema. Les paramètres de l'hémogramme et l'étude de la morphologie érythrocytaire ont été déterminés avant stockage et ces résultats ont été utilisés comme références. Chaque unité de sang a ensuite été divisée en 3 pour être stockée dans trois banques de sang différentes. Un intervalle de 7 jours a été observé pour chaque série d'analyses d'hémogramme. La morphologie érythrocytaire a été réalisée jusqu'au jour 35 pour évaluer la qualité du sang stocké dans les trois sites. Les variances de chaque série de 6 déterminations ont été utilisées pour évaluer quantitativement la qualité du sang. Le test de Snedecor File a été appliqué pour comparer les différentes variances enregistrées dans chaque banque de sang.

Mots clés : Sang, conservation, hématologique, transfusion, Kinshasa

ABSTRACT :
The aim of this study was to determine the haematological quality of stored blood intended for transfusion. The study was prospective and experimental, based on the evaluation of the haematological quality of stored blood intended for transfusion, and took place between 11 October and 11 January 2024. We collected ten bags of blood from volunteer donors, following a physical examination of those who met the required conditions. A total of 10 250 mL blood bags were collected in Malueka, one of the Ngaliema clinic's blood collection sites. The haemogram parameters and the erythrocyte morphology study were determined before storage and these results were used as references. Each unit of blood was then divided into 3 for storage in three different blood banks. An interval of 7 days was observed for each series of haemogram analysis. Erythrocyte morphology was performed up to day 35 to assess the quality of the blood stored in the three locations. The variances of each series of 6 determinations were used to assess blood quality quantitatively. The Snedecor File test was applied to compare the different variances recorded in each blood bank.

Keywords : Blood, conservation, haematological, transfusion, Kinshasa.

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I. INTRODUCTION

Blood transfusion is a replacement therapy that consists of replacing a patient's blood component. It plays an essential role in the treatment of anaemia(1, 2). According to statistics for 2020, of the 118,5 million blood donations collected worldwide, 40% are in high-income countries where 16% of the world's population lives(3).

In the 47 countries in Africa, 80-100% of blood donations come from voluntary donors. The proportion of whole blood separated into blood components was 63,4% in 2019. Whole blood was transfused in 27,3% of cases(4).
In the Democratic Republic of Congo (DRC), approximately 9406 bags of blood collected from volunteer donors are transfused each year(5).

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Transfusion is not a therapy devoid of risks, especially if transfusion rules are not observed with regard to blood collection, storage and use; the patient or recipient may run a greater risk than the expected benefit(6).

The greatest risks are immunological (erythrocyte incompatibility) and infectious (transmission of parasites (malaria) or viruses (viral hepatitis, AIDS, etc.)(7).

These accidents should not make us forget that transfusion saves thousands of human lives, thanks to the generosity of volunteer donors(8).

Blood transfusions may be needed at any time in medical facilities in town and country. To obtain blood supplies, the medical facilities responsible for collecting and storing blood proceed by collecting and storing units of blood. Blood is stored at a temperature of between 2 and 8°C, and its shelf life depends on the preservative solution contained in the bag. This is 35 days if the bags contain CPDA (Citrate - Phosphate - Dextrose - Adenine); 21 days for ACD (Acid-Citric-Dextrose)(9). Although these anticoagulants are preservatives, in the long term they lead to a cascade of phenomena that considerably alter the effectiveness of transfusion, the impact of which is directly linked to the length of storage.

The older the blood bags get, the more acidic they become and the less ATP they contain; the red blood cells gradually lose their biconcave shape and become spherical, crenellated and covered in spicules; they become rigid and lose their ability to deform to slip into the capillaries. Their deformability decreases irreversibly with storage time (9).

These alterations linked to the shelf-life of blood bags intended for transfusion have a significant impact on clinical practice. They are a factor in short- and long-term mortality, because transfusion quality requires that the patient should be able to receive the transfusion that corresponds to his or her situation and that effectively corrects the deficit from which he or she suffers without causing any inconvenience (6). A number of studies in this field have looked at the haematological profile of blood donors, but very few have reported data on the quality of the blood stored for transfusion, given that the haemogram plays a key role in transfusion, making it possible both to secure the medical selection of donors and to guarantee the curative quality of blood products. With this in mind, this study seeks to answer the question of whether the length of time blood intended for transfusion is stored affects the haematological quality of this blood stored in 3 blood banks in Kinshasa.

Don't sudden changes and untimely disconnections in the electrical circuit have an impact on the haematological quality of the blood to be transfused?
The aim of this study was therefore to determine the haematological quality of stored blood intended for transfusion.

II. METHODS

The study was prospective and experimental, based on the haematological quality of stored blood intended for transfusion, and ran from 11 October 2023 to 11 January 2024. We collected ten bags of blood from volunteer donors, following a physical examination of those who met the required conditions. A total of 10 250mL blood bags containing Citrate Phosphate Dextrose Adenine (CPDA) were collected in Malueka, one of the Ngaliema clinic's blood collection sites. After homogenisation of the contents of each bag, the haemogram parameters and erythrocyte morphology were determined before storage, and these results were used as references. The blood was checked for any abnormalities at the time of collection. Each unit of blood was then divided into 3 for storage in three different blood banks at a storage temperature of between 2 and 6°C. An interval of 7 days was observed for each series of haemogram analyses. Erythrocyte morphology was carried out up to day 35 to assess the qualitative aspect of the blood stored in the three locations.

III. RESULTS

Socio-demographic data

Table 1: Distribution of results by gender

Survey parameters		Frequency	Percentage
Sex	Male	6	60,0
	Female	4	40,0
	Total	10	100,0

Table 1 shows that males were more represented, with 6 cases (60%), compared with 4 cases (40%) for females.

Table 2: Distribution of results by age group

Research parameters		Frequency	Percentage
Age groups (years)	19 – 29	8	80,0
	30 – 40	1	10,0
	41 – 51	1	10,0
	Total	10	100,0

Table 2 shows that the 19-29 age group was the most represented, with 8 cases (80%); the 30-40 and 41-51 age groups were the least represented, with 1 case each.

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Biological parameter data

Table 3: Presentation of means and variances in haemoglobin levels by site and day

SITES	N	D_0		D_7		D_{14}		D_{21}		D_{28}		D_{35}		Var
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	
CNTS	10	14,4	1,34	13,8	1,3	13,5	1,4	13,2	1,2	12,7	1,0	12,1	1,0	0,67
Ngaliema	10	14,4	1,34	14,0	1,26	13,3	1,08	12,6	0,86	12,4	0,9	12,0	0,97	0,90
OMECO	10	14,4	1,3	13,9	1,4	13,5	1,3	12,7	1,0	**12,3**	**1,2**	11,1	1,5	1,44

Legend : N= Frequency ; SD = Standard deviation ; $\bar{x}$ = Average ; Var = Variance

Table 3 shows that the highest variance in haemoglobin level was for the OMECO Blood Bank (0,67).

Tableau 4: Comparaison des variances

Parame-ters	N	Var and F	CNTS	Ngaliema	OMECO	CNTS	Ngaliema	OMECO
Hb	**6**	**Var**	0,67	0,9	1,44	0,67	0,9	1,44
		F	**0,74**		**2,15**		**1,6**	
Hct	**6**	**Var**	6,72	8,83	12,88	6,72	8,83	12,88
		F	**1,31**		**1,92**		**1,46**	
RBC	**6**	**Var**	0,1	0,08	0,09	0,1	0,08	0,09
		F	**1.25**		**1.11**		**1.13**	
PLT	**6**	**Var**	1043593667	1031809667	3808349667	1043593667	1031809667	3808349667
		F	**1,01**		**3,65**		**3,69**	
MCV	**6**	**Var**	7,26	4,56	9,26	7,26	4,56	9,26
		F	**1,59**		**1,28**		**2,03**	
MCHC	**6**	**Var**	0,04	0,11	0,05	0,04	0,11	0,05
		F	**2,75**		**1,25**		**2,2**	

Legend : Var : Variance ; Hb = hemoglobin ; Hct : Hematocrit ; RBC : Red blood cell ; PLT : Platelet ; MCV : Mean corpuscular volume ; MCHC : Mean corpuscular hemoglobin concentration.

Table 4 shows that none of the 3 sites exceeded the tabulated value threshold at the 95% confidence level.

Table 5 Summary of erythrocyte morphology in D_{35}

	Erythrocyte morphology								TOTAL
Parameters	Height anomaly		Form anomaly					ANNUL	100%
	M.RBC	M.RBC.	ECH.	OVAL.	RBC.R	EL.	DAC.		
Average D35									
OMECO	25,8	13	23	5	6,2	2	16	9	100%
CNTS	24	16	17	6	9	8	18	2	100%
Ngaliema	23	18	18	10	11	2	15	3	100%

Legend : M.RBC : microcytic red blood cell; M.RBC macrocytic red blood cell; ECH: Echinocyte; OVAL: Ovalocyte; RBC: Red blood cell roll; EL: Elliptocyte; DAC : Dacryocyte; ANNUL: Annulocyte.

Table 5 shows the different erythrocyte abnormalities observed on day 35 of blood storage in different blood banks. The most frequently observed abnormality is that of size, microcytic and macrocytic RBCs. On the one hand, the OMECO blood bank showed more microcytic RBCs in 25,8 cases on average. On the other hand, the Ngaliema clinic blood bank presented more cases of macrocytosis, 18 cases on average.

IV. DISCUSSION

The aim of this study was to determine the haematological quality of stored blood intended for transfusion. To achieve this, 10 blood samples were taken from the three blood banks involved in the study.

The aim was to check whether the quality of stored blood intended for transfusion was affected by changes due to storage time and sudden changes and interruptions to the electrical circuit in the blood banks.

The results were grouped into two categories: socio-demographic data and biological analysis data.

With regard to socio-demographic data, Table I shows that males were more represented with 6 cases (60%), compared with 4 cases (40%) for females. These results are in line with those established by other authors who consider that physiological constraints for women (pregnancy, breastfeeding and menstruation) are factors that restrict women from donating blood(10). There is every reason to believe that the donors in our study reflect these assertions.

Table 2 shows that the 19-29 age group was the most represented, with 8 cases, or 80%. In fact, this age group is that of active people with enough energy to withstand the

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withdrawal of a fairly large quantity of blood. It is also thought that this is the age at which haematopoiesis is most active. The average age of the donors was 26, with a standard deviation of ± 10 (see appendix).

With regard to biological analyses, the haemogram tests selected were haemoglobin, haematocrit, RBC and platelet counts, GMV and MCHF. For all of the above parameters except CCMH, high variances were observed for data from D_0, D_7, D_{14}, D_{21}, D_{28} and D_{35} from the Matete General Reference Hospital (OMECO) (see Table 13). However, statistically, these results do not show any significant difference because the F value tabulated for the 6 determinations in the numerator and denominator remains higher than that found after the ratio between the highest and lowest variance (5,05) (see Fisher's F table in appendix). The low value of the variances found at Ngaliema and at the CNTS can be justified by the fact that the storage conditions in these two establishments are almost the same and the control of the fridge temperature sheet in the two medical training establishments is regularly updated, as was noted during our visit when the samples used for the analyses were being collected. The results of this study corroborate those of A. Bushabu(6).

The red blood cell count remains almost constant throughout the storage period. This rate remains a parameter that is little influenced during storage. These results are similar to those of Daeron M. This stability may be due to the presence of the CPDA solution, recognised as the best anticoagulant for preserving RBCs(10).

Platelet count results show a gradual difference from D_0 to D_{35} in all blood banks (CNTS and Ngaliema compared to OMECO), the reasons previously mentioned for the other parameters are also valid for the case of platelets.

The respect of conservation is very important in the viability of red blood cells because of the variation of the cold chain in different blood banks. The consequence of this is the various erythrocyte anomalies observed. Concerning the qualitative evaluation, table 5 shows the different erythrocyte abnormalities observed on day 35 of blood storage in different blood banks. The most frequently observed abnormality is that of size, microcytic and macrocytic RBCs. On the one hand, the OMECO blood bank showed more microcytic RBCs in 25,8 cases on average. On the other hand, the Ngaliema clinic blood bank presented more cases of macrocytosis, 18 cases on average. These results reveal the quality of the red blood cells in the blood stored for 35 days. However, a question remains because we did not take into account the qualitative results on D_0 after sampling. This should have given an idea of the source of these RBC-related abnormalities. We suggest that other researchers could address this qualitative aspect of blood intended for transfusion while taking into account the results at sampling, i.e. on D_0.

V. CONCLUSION

- Our study focused on the haematological quality of stored blood intended for transfusion. After analysis of blood samples selected and distributed to 3 blood banks for storage, the results obtained and discussed are summarised as follows:
- The selected donors were predominantly male;
- The OMECO blood bank showed the highest variance of the three banks selected for the parameters concerned by the study;
- Erythrocyte morphology determined at D35 showed a predominance of abnormal shape.

Our results confirm the hypothesis that the length of time that bags of blood intended for transfusion are kept alters haematological quality with regard to the different preservatives used, and that fluctuations and temperature influence the quality and quantity of red blood cells.

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