

THE DIFFERENCE IN POTASSIUM LEVELS IN FRESH BLOOD BAGS WITH BLOOD BAGS STORED AT PKU MUHAMMADIYAH GAMPING HOSPITAL

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Abstract

Blood transfusion, one of them, is a process of transferring blood components containing glucose, lactate, and potassium. During storage, blood cells undergo metabolic changes such as decreased blood pH, hemolysis, and increased potassium levels. One of the complications of transfusion that must be avoided is hyperkalemia due to the release of potassium. This study aimed to determine differences in stored blood potassium levels and PRC QC results during 11 days of storage. This was an analytic observational study with a cross sectional approach. A T-test was used to analyze the difference. In addition, PRC blood quality control (QC) was also carried out for stored blood according to standards. This study used 40 samples of fresh blood bags obtained from UTD PMI Yogyakarta City. The mean potassium level in fresh blood bags was 4.373 ± 0.417 mmol/L (3.70-5.50) and the average potassium level in blood bags stored for 6 days was 8.290 ± 0.275 mmol/L (7.80-8.90). There was a significant difference in potassium levels between fresh blood bags and blood bags stored for 6 days ($p = 0.000$). The overall QC PRC result is 50% which indicates the need for improvement in terms of the blood component separation process.

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INTRODUCTION

Blood transfusion is the process of transferring blood or its components from a donor to another person (recipient). Implementation of transfusion, in addition to moving blood cells can also divert: glucose, lactate and potassium to the recipient. There are several types of blood for transfusion based on the duration of its storage, namely: fresh, new and stored blood. Fresh blood is fresh blood taken from a donor, which is up to six (6) hours after collection. New blood is stored between six (6) hours to six (6) days after being taken from the donor. Stored blood is blood stored for more than six (6) days after being taken from the donor. Fresh blood is preferred because it has a more stable metabolism than stored blood, but fresh blood is limited and difficult to obtain in a short time. Stored blood is easily available at any time, but the levels of potassium, ammonia and lactic acid are higher (Asryani, Yaswir, & Rofinda, 2018).

During storage, blood cells undergo metabolic changes, thus, storage in vitro must be considered in an effort to reduce the changes that occur in blood cells during storage, because the environment is very different from in vivo (Sukorini, Martani, & Triyono, 2023); (Saragih, Adhayanti, Lubis, & Hariman, 2019).

Changes that occur during storage are decreased concentrations of Adenosine 5'-triphosphate (ATP) and 2,3-diphosphoglycerate (2,3-DPG), decreased blood pH, increased

concentrations of potassium and lactate, changes in the shape of erythrocyte cells, loss of viability of erythrocytes and hemolysis (Hess & Beyer, 2007); (Yoshida, Prudent, & D'Alessandro, 2019).

Several studies have shown that there is a significant increase in potassium levels in stored blood. Ratcliffe et al⁴ reported an increase in potassium and lactate levels, and a corresponding decrease in sodium and glucose during blood storage (Kim, Kwon, & Kim, 2021); (Hawkins & Sesok-Pizzini, 2017); (Morgan & Shaikh, 2018).

Smith et al analyzed potassium levels from PRC supernatants, reporting that levels increased with storage time, namely initially 7.3 mEq/L (1 mEq/L=1 mmol/L) and in the first week (0–7 days) of storage, mean potassium levels 19mEq/L, in the second week (8–14 days) 31.5 mEq/L and between 15–28 days of storage 39.9 mEq/L (Wardhana, Lestari, Wande, Herawati, & Mahartini, 2022); (Yamada et al., 2021).

In research by Uvizl et al, it was found that potassium levels in stored PRC increased gradually from 4.0 mmol/L on the first day to 40.5 mmol/L on the 35th day (Antwi-Baffour et al., 2019). Increased levels of potassium in stored blood usually rarely cause clinical problems but can be fatal when transfused: in a massive state, which is exchanged to neonates or by priming cardiopulmonary bypass (Sultan et al., 2018).

Complications that can occur are hyperkalemia which results in abnormal heart rhythms and risks: variations in heart rhythms (arrhythmias), rapid vibrations (fibrillation) of the heart chambers (ventricles) until the heart stops beating (cardiac arrest). However, hyperkalemia due to transfusion depends not only on the concentration of potassium in blood component units, but also on the volume and rate of blood administration (Antwi-Baffour et al., 2019). Biochemical changes that occur in stored blood need to be considered before being transfused to someone.

Blood quality control is a critical function of the production of blood components and provides evidence that blood components meet specifications. Quality control (QC) is carried out on stored blood components and problems are often identified after they occur. Quality control is the monitoring of all blood component production processes against specified requirements to ensure that the process remains under control. This provides a mechanism for early identification of potential problems and increases assurance that the quality of the final blood component will meet specifications (Anggini, Sepvianti, & Wulandari, 2019).

RESEARCH METHODS

This study is an analytical observational study with a cross sectional approach that aims to analyze differences in observed variables. The data collection method used was to collect 40 samples of fresh blood bags from UTD PMI Yogyakarta City. The use of T-tests in data analysis provides insight into significant differences between the observed groups. In addition, blood quality control (QC) is also carried out using the PRC method to ensure the quality of blood stored according to standards. Through the application of the T-test, this study can identify differences that exist in certain variables in the fresh blood bag sample. The existence of a blood quality control process with the PRC method also ensures that the data obtained is reliable and has high quality in accordance with established standards. Thus, this study not only provides information regarding differences in variables, but also guarantees the quality of the data used in the analysis.

RESULTS AND DISCUSSION

Result

This research was conducted at the Blood Transfusion Unit (BTU) of the Indonesian Red Cross (IRC) Yogyakarta City and the Hospital Blood Bank Unit (HBBU) PKU Muhammadiyah Gamping Hospital with sample material of 40 blood bags in the UTD PMI Yogyakarta City. This study was conducted to determine the potassium levels of fresh blood bags compared to the potassium levels in stored blood for 6 days, and QC PRC of stored blood for 11 days was also carried out.

Based on the blood type in this study, there were 13 bags of blood type A, 10 bags of blood type B, 14 bags of blood type O and 3 bags of blood type AB.

The normality test showed that potassium levels in fresh blood and blood stored for 6 days were normally distributed. The detailed results of blood potassium levels are shown in table 1. The potassium level in fresh blood bags has a minimum value of 3.70 (mmol/L), a maximum value of 5.50 (mmol/L), an average value of 4.373 (mmol/L) and standard deviation value of 0.417. Potassium levels in blood bags stored for 6 days with a minimum value of 7.80 (mmol/L), a maximum value of 8.90 (mmol/L), an average value of 8.290 (mmol/L) and a standard deviation value of 0.275. The results of the difference test were tested using the t-test because the data were normally distributed ($p = 0.000$).

Table 1. Profile description of potassium levels in blood bags

	N	Minimum (mmol/L)	Maximum (mmol/L)	Mean (mmol/L)	Std. Deviation
Potassium level pre	40	3,70	5,50	4,373	0,417
Potassium level post	40	7,80	8,90	8,290	0,275

Quality Control examination in this study used 4 PRC samples aged 11 days. QC examination of PRC products includes examination of blood volume, hemolysis, hemoglobin level, hematocrit level and examination of bacteria. The examination results showed failure in the parameters of hemoglobin and hematocrit examination. The Hemoglobin value in PRC products complies with the specifications required in Permenkes Number 91 of 2015, namely ≥ 45 gr/dl while the hematocrit value is 65% - 75%.

Discussion

During storage, PRC blood bags will damage erythrocytes and affect the recipient's in vivo metabolism (Balasubramanyam, Basavarajegowda, Hanumanthappa, Negi, & Harichandrakumar, 2021). The results of this study showed that there was a significant difference between fresh blood potassium levels and stored potassium levels for 6 days ($p = 0.000$). The results of this study were not much different from the research conducted by Arsyani et al for blood stored for 14 days.

PRC potassium levels stored for 4-14 days were significantly different from storage > 14 days because it was estimated that the amount of ATP and glucose in the blood bag was still sufficient for cell metabolism and the pH had not decreased too much at 4-14 days of storage. The process of cell metabolism continues as storage time increases, the levels of ATP and glucose in the blood bag will decrease because they are used for cell metabolism whose energy comes from the glycolysis process. Lactic acid as a result of glycolysis will continue to accumulate causing the environment to become acidic (lower pH). A decrease in pH will further inhibit the work of the Na^+/K^+ ATPase pump so that PRC potassium levels will increase in proportion to the storage time (Opoku-Okrah, Acquah, & Dogbe, 2015).

According to previous studies, there was no difference in storage for 6 days with fresh blood bags, this was related to the hemogenesis process between the anticoagulants in the blood bags. The application of strict quality control at the storage temperature of blood also prevents the possibility of hemolysis.

The hemolysis index is the ratio between the hemoglobin content of the plasma and the hemoglobin in the blood in the bag, which is determined by calculating the percentage of hemolysis. Hemolysis percentage was calculated using hemoglobin in plasma, hematocrit, and total hemoglobin in packed red cells (RRC). Percent hemolysis = plasma hemoglobin x (100 - hematocrit) / total hemoglobin (Hashemi Tayer et al., 2017).

Hemolysis is an important marker in evaluating the storage quality of blood. Regulation of the Minister of Health of the Republic of Indonesia Number 91 of 2015 concerning standard

blood transfusion services recommends that the acceptable hemolysis index in red blood cell components is $<0.8\%$.

Giving blood bags containing high levels of potassium causes hyperkalemia. Hyperkalemia is a potentially life-threatening condition characterized by increased concentrations of potassium in the blood and is a rare complication of blood transfusions (Montford & Linas, 2017).

The results of blood PRC QC in this study contained 1 bag of PRC products that did not pass the hemoglobin level where the hemoglobin level was measured below specifications. The low hemoglobin level in this PRC product (bag 2) is also accompanied by the failure of the hematocrit level which is less than specification. In blood products, if the hematocrit level is below specification, it can be concluded that the concentration of red blood cells is not reached or the blood product has an excess of plasma composition. In this PRC product, it is found that the hemoglobin level is below specification, indicating an insufficient number of red blood cells so that during the process of separating the blood components, a lot of plasma will be left in the PRC product. Separation of blood components at PMI Yogyakarta City is still carried out using a manual tool, namely a plasma extractor by flowing the plasma into the satellite bag and leaving the plasma in the main bag as high as 2 cm so that if the red blood cell component is not enough then a lot of plasma will be left in the main bag.

In another PRC product (bag 4), the hemoglobin level was within specification but the hematocrit level was below specification. This is still related to the process of separating blood components which is done manually so that the separation of blood components is not done based on the specific gravity of each blood component. It is different if the separation of components is done using an automatic separation tool where the tool will separate each blood component based on its specific gravity. Therefore it is highly recommended that UDD PMI Yogyakarta City can separate 100% blood components using an automatic separator. Currently UDD PMI Yogyakarta City only has one automatic separator which cannot be used for 100% blood bags.

In examining blood volume, it was found that all PRC samples had passed QC, this was because UDD PMI Yogyakarta City used blood scales at 100% of donations in the building and product releases had been implemented so that all distributed products were confirmed to be volume according to specifications. The use of this blood scale also aims to homogenize the anticoagulants in the blood bag and the donor blood taken can mix well so as to reduce the possibility of hemolysis. Implementation of strict quality control at blood storage temperature also prevents the possibility of hemolysis, where UDD PMI Yogyakarta City has conducted qualification and validation of blood storage equipment and routine temperature monitoring. This is in accordance with the results of the hemolysis examination which showed results according to specifications.

Examination of bacterial contamination was only carried out on anaerobic bacteria because of the availability of reagents at the time of the study, the results showed no bacterial contamination. The application of double disinfection of arms and a closed system in blood processing has been implemented according to the applicable quality system.

Table 2. Quality Control Examination

No	Pemeriksaan Fisik					Pemeriksaan Hematologi					Pemeriksaan Kontaminasi Bakteri		Hasil	
	Jenis Kantong Darah	No. Darah	Golongan	Tanggal Pengambilan	Kada luars	LAB EL	Be rat (gr)	Vol um (ml)	Inp eksi He mol isi s	Hem oglo bi n > 45 g/uni t	Hem atokr it 65-75%	Ae ro ro b		anae rob
1	DB	S470 9495 A	O (+)	03/06 /23	03/0 7/23	LEN GKA P	28 4,6 9 gr	232 ,59 ml	0,4 %	53,9 6 gr/un it	69,8 %	Ne g	Tdk Dila kuka n	LU LU S
2	DB	S475 3016 A	A (+)	03/06 /23	03/0 7/23	LEN GKA P	27 6,5 4 gr	225 ,15 ml	0,17 %	39,2 gr/un it	58,2 %	Ne g	Tdk Dila kuka n	Tid ak Lul us
3	DB	S476 1929 A	B (+)	03/06 /23	03/0 7/23	LEN GKA P	28 9,3 7 gr	236 ,87 ml	0,26 %	51,2 gr/un it	65,4 %	Ne g	Tdk Dila kuka n	LU LU S
4	DB	S470 6291 A	O (+)	03/06 /23	03/0 7/23	LEN GKA P	29 2,3 3 gr	239 ,57 ml	0,38 %	49,6 gr/un it	62,5 %	Ne g	Tdk Dila kuka n	Tid ak Lul us
Diperiksa Oleh : Rifka						% QC yang diterima		100 %	75 %	75%	75%	10 0 %	100 %	75 %
Dicek Oleh : Yuli						Hasil		100 %	100 %	75%	50%	10 0 %		50 %

Based on the table above, the overall QC PRC failure was 50% which indicated the need for improvement in terms of the process of separating blood components. The use of an automatic separator is highly recommended for all blood products.

CONCLUSION

The study revealed noteworthy findings regarding potassium levels in blood bags. Fresh blood bags demonstrated an average yield of 4.373 ± 0.417 mmol/L (3.70-5.50), while those stored for 6 days exhibited a significantly higher average potassium level of 8.290 ± 0.275 mmol/L (7.80-8.90), as indicated by a p-value of 0.000. This stark contrast emphasizes the impact of storage duration on potassium levels, suggesting potential implications for blood transfusion practices. Furthermore, the overall Quality Control (QC) Pre-Transfusion Compatibility (PRC) result stood at 50%, signaling a need for improvement in the blood component separation process. To enhance accuracy, it is recommended that the process of obtaining donor blood and storing blood bags align with the standards outlined in the Ministry of Health Regulation No 91 of 2015. Addressing these concerns will contribute to the overall quality and safety of blood transfusion procedures.

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