Original Research Paper

Volume - 15 | Issue - 04 | April - 2025 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Biochemistry

ASSESSMENT OF ELECTROLYTES AND pH CHANGES IN STORED BLOOD

J. Phani Shankar	Jr Resident, Biochemistry Department, Dr PSIMS & RF.
V. Durga Prasad	Professor & HOD, Biochemistry Department, Dr PSIMS & RF.
E. Suresh	Associate Professor, Biochemistry Department, Dr PSIMS & RF.
Jasmine Sultana	Incharge of Blood transfusion Medicine, Dr PSIMS & RF.
V Kalyan Chakravarthy	Professor, Pathology Department, Dr PSIMS & RF

ABSTRACT **Introduction:** Blood transfusion can be an immediate life saving measure in several acute conditions such as hemorrhage and anemia. However, various post transfusion complications are observed in patients, which may be associated with the storage conditions of the collected blood. Electrolytes play a major role in maintaining homeostasis within the cells. Potassium is the most important extracellular cation responsible for maintenance of the cell integrity. Prolonged and improper storage of blood can lead to leakage of electrolytes, thus changing the cell morphology. This can adversely affect the patients who receive such blood. This study helps us analyze the effect of blood storage on electrolyte levels. **Materials and Methods:** For the study, 10ml of blood was collected from 30 blood bags containing CPDA-1 at the time of blood donation from 30 different volunteers. This blood containing the CPDA-1 was divided into 4parts of 2ml and each 2ml sample was stored in segments. All the samples were stored at 4°C. Samples were tested to check for changes in the electrolyte (Na+, K+, Cl-) levels, along with PH and lactate on day 0, 7, 14 and 28. Students t test was used to compare baseline with subsequent weeks for changes in the electrolyte, PH and lactate levels. **Results:** Average sodium level on day 0 was 142.34mEq/l. There was a significant decrease and it was measured at 123mEq/l on day 28. Average potassium level on day 0 was 4.66mEq/l. A significant spike was observed in potassium levels. The final reading of potassium level on day 28 was 15.37mEq/l. Average chloride level on day 0 was 101mEq/l which significantly declined to 92.01mEq/l. There is a significant change in PH and lactate from baseline. **Conclusions:** Though blood is stored in proper conditions, biochemical changes occur within the cells due to prolonged storage and thus affects its viability.

KEYWORDS : Stored blood, sodium, potassium, lactate

INTRODUCTION

During blood storage for transfusions, biochemical changes occur that impact the blood's functionality.[1] Recent clinical studies suggest that blood units stored for extended periods (often defined as 14–21 days) may be harmful to recipients, potentially increasing morbidity and mortality rates.[2] Storage systems aim to minimize damage to the metabolic machinery and membrane while maintaining sufficient ATP and adenosine concentrations to improve post-transfusion outcomes. Common anticoagulants include ACD (acid, citrate and dextrose), CPD (citrate, phosphate, and dextrose), and CPDA-1 (citrate, phosphate, dextrose, and adenine). Citrate functions as an anticoagulant and buffer, influencing intracellular pH. Dextrose facilitates ATP production through glycolysis and supports red cell membrane integrity, extending shelf life.[3] The "storage lesion" encompasses various changes that occur in RBCs as they age while stored in additives like citrate phosphate dextrose adenine (CPDA) at 2-6 degrees Celsius for 35 days.[4] These changes lead to red blood cell degradation. Lactic acid and potassium accumulate, 2-3 BPG, ATP, pH and glycolysis rate declines.[5,6] Sodium, an extracellular cation, regulates blood volume and maintains nerve and muscle functions. Sodium levels exceeding 145mEq/l cause hypernatremia leading to a hyperosmolar state. Increased extracellular sodium results in cellular dehydration as intracellular fluid moves to extracellular spaces. Hyponatraemia (sodium below 135 mEq/l) can cause cellular edema, potentially affecting the central nervous system and leading to depression and cerebral edema.[7] Potassium level changes is the most significant electrolyte alterations in stored blood. Potassium, an intracellular cation, regulates heartbeat, muscle function, and is crucial for neuron transmission. In stored blood, K+ gradually leaks from cells into the surrounding plasma. Increase in potassium levels can be dangerous during transfusion. In patients with severe kidney disease, even minor K+ concentration fluctuations can lead to adverse complications and potentially fatal. Severe complications and mortality are more likely in critically ill patients, particularly those requiring cardiac surgery and extensive blood transfusion.[8] Regular monitoring of biochemical parameters such as sodium, potassium, chloride, pH, and lactate in stored blood may enhance patient safety.

MATERIALS AND METHODS

The present study is a crosssectional study with a duration 60 days, done after the approval of the institutional ethical clearance. A total of 30 patients were recruited in our study. Blood is collected from patient volunteers who were negative for malaria, HIV, HCV, Hepatitis B and syphilis in donation camps.

Inclusion Criteria:

Donors who are willing for the study and age between 18yrs to 60years.

Exclusion Criteria:

Donors who are not willing to give consent for the study. Age group<18 and >60 years. Donors with conditions like anemia, chronic diseases like CAD, CVD, CKD. Donors screened positive for HIV, HCV, HEPATITIS B, MALARIA, and SYPHILIS will be excluded from the study.

Procedure

A total of 30 healthy volunteers will be providing 350 to 450 ml of blood collected in citrate phosphate dextrose adenine (CPDA) with all safety measures. Individual pack will be undergoing serological testing for viral markers, syphilis and malaria. Segments of 30 donor units will be properly stored in an isolation shelf at a temperature of 4° Celsius. Stored blood is monitored at regular intervals of 0, 7, 14, and 28 days respectively. The sample assessed on day 0 considered as control. Whole blood will be centrifuged at 2000 rpm for 2 minutes and plasma is collected in plain tube. Electrolytes sodium, potassium, chloride will be measured in sensacore. P^H and lactate will be measured in an Arterial blood gas analyser.

Statistical Analysis

Data has been analyzed by using the prism graph pad version 9 and presented as mean ±SD. Students t test is used to compare means of all parameters between base line and at 7, 14 and 28 days. P<0.05 is considered statistically significant.

RESULTS

Table 1: Mean Sodium Values On Days 0,7,14 And 28 Respectively.

	Sodium (Mean ± SD)	t Value	p Value
Baseline	142.34±2.98	10.83	<0.001*
7 Days	135.49±2.97		
Baseline	142.34±2.98	21.93	<0.001*

14 days	129.38±2.16		
Baseline	142.34±2.98	28.24	<0.001*
28 days	123.99±2.25		

Table 1 results indicate that the mean sodium levels at the baseline on the day of collection were 142.34±2.98, which gradually decreased to 135.49±2.97, 129.38±2.16, and 123.99±2.25 on days 7, 14, and 28 respectively. Application of a t-test revealed a significant difference between the baseline sodium values and the sodium values on days 7, 14, and 28.

Table 2: Mean Potassium Values On Days 0,7,14 and 28 Respectively.

	Potassium (Mean ± SD)	t Value	p Value
Baseline	4.66±0.63	-12.57	<0.001*
7 Days	7.71±1.37		
Baseline	4.66±0.63	-22.63	<0.001*
14 days	12.49±1.98		
Baseline	4.66±0.63	-35.59	<0.001*
28 days	15.37±1.83		

Table 2 results indicate that the mean potassium levels at the baseline on the day of the collection were 4.66±0.63, which gradually increased to 7.71±1.37, 12.49±1.98, and 15.37±1.83 on days 7, 14, and 28, respectively. Application of a t-test revealed a significant difference between the baseline potassium values and the potassium values on days 7, 14, and 28.

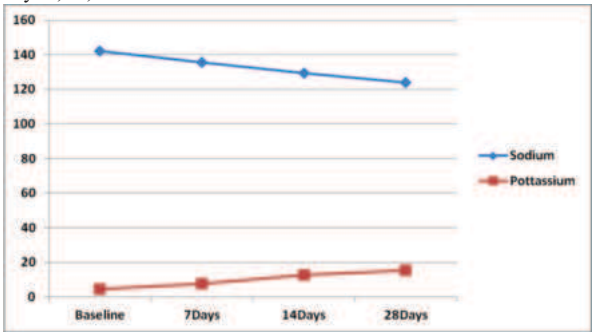

Figure 1: Trend Of Sodium And Potassium On Days 0,7,14 And 28 Respectively.

Table 3: Mean Chloride Values On Days 0,7,14 And 28 Respectively.

	Chloride (Mean ± SD)	t Value	p Value
Baseline	101.38±1.39	8.09	<0.001*
7 Days	99.01±1.71		
Baseline	101.38±1.39	11.06	<0.001*
14 days	96.57±2.39		
Baseline	101.38±1.39	24.23	<0.001*
28 days	92.01±2.04		

Table 3 results indicate that the mean chloride levels at the baseline on the day of the collection were 101.38±1.39, which gradually decreased to 99.01±1.71, 96.57±2.39 and 92.01±2.04 on days 7, 14, and 28, respectively. Application of a t-test revealed a significant difference between the baseline and chloride values on days 7, 14, and 28.

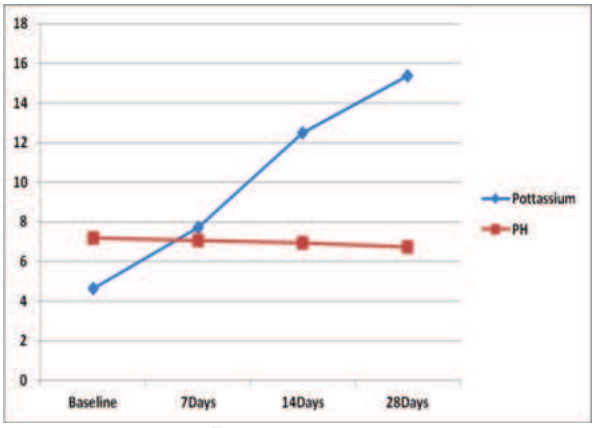

Figure 2: Trend of P^H and Potassium on days 0,7,14 and 28 respectively.

Table 4: Mean p^H Values On Days 0,7,14 And 28 Respectively.

	P^H (Mean ± SD)	t Value	p Value
Baseline	7.19±0.8	11.89	<0.001*
7 Days	7.06±0.06		
Baseline	7.19±0.8	16.13	<0.001*
14 days	6.94±0.06		
Baseline	7.19±0.8	23.12	<0.001*
28 days	6.75±0.09		

Table 4 results indicate that the mean PH levels at the baseline on the day of the collection were 7.19±0.8, which gradually decreased to 7.06±0.06 , 6.94±0.06 and 6.75±0.09 on days 7, 14, and 28, respectively. Application of a t-test revealed a significant difference between the baseline PH values and the PH values on days 7, 14, and 28.

Table 5: Mean Lactate Values On Days 0,7,14 And 28 Respectively.

	Lactate (Mean ± SD)	t Value	p Value
Baseline	9.35±1.26	-6.94	<0.001*
7 Days	11.17±1.38		
Baseline	9.35±1.26	-16.65	<0.001*
14 days	13.93±1.13		
Baseline	9.35±1.26	-29.42	<0.001*
28 days	17.12		

Table 5 results indicate that the mean lactate levels at the baseline on the day of the collection were 9.35±1.26, which gradually increased to 11.17±1.38, 13.93±1.13 , and 17.12 on days 7, 14, and 28, respectively. Application of a t-test revealed a significant difference between the baseline lactate values and the lactate values on days 7, 14, and 28.

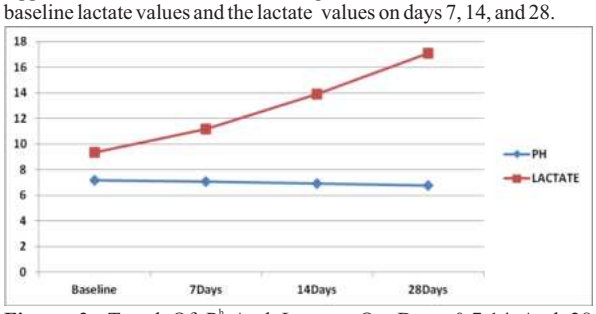

Figure 3: Trend Of P^h And Lactate On Days 0,7,14 And 28 Respectively.

DISCUSSION

Blood transfusion becomes imperative and a life-saving measure in numerous emergency situations. Storage of blood leads to alterations in cellular integrity. This results in the efflux of potassium from the cell, accompanied by a reduction in sodium levels in the extracellular fluid and a decrease in chloride levels. CPDA aids in emulating the storage environment employed in blood preservation prior to transfusion. CPDA prevents coagulation and serves as an energy source, thereby increasing the viability of blood cells.[9] The study was conducted over a period of 28 days, aiming to observe changes in electrolyte pH levels of stored blood.

This study demonstrates numerous potential deleterious changes that occur in blood during storage. An exchange of content between plasma and red cells occurs due to prolonged contact of plasma with RBCs, leading to changes in analyte concentrations as well as dilution. Potassium levels increased within 7 days and continued to rise throughout the study duration.[10]

The current study observed an increase in plasma potassium level to 7.71 mmol/L within the first week and increase continued to 15.37 mmol/L at the end of the fourth week which was a significant rise from baseline. This indicates that blood transfusion after the first week of storage may not be safe for patients due to elevated potassium levels. During blood storage, there is a continuous efflux of potassium ions from cells into the surrounding plasma.[11] In cases of critical kidney disorder, a minor variations in potassium ion concentrations are potentially threatening, and relatively fresh or washed red cells are recommended. Potassium efflux is recognized as a secondary metabolic change that occurs due to cooling.[11] Based on the findings of the present study, monitoring of potassium ion concentration during blood storage for transfusion is recommended to enhance blood safety. Similar results were observed in previous studies by Nogueira D et al.[12], Oyet C et al.[4], Verma M et al.[13], and Adias TC et al.[11], which

demonstrated that potassium significantly increased throughout the storage period. The current study observed that a decrease in sodium levels was significant after 1 week (7 days) and further decreased significantly throughout the storage period. This result aligns with previous studies by Verma M et al., Nogueira D et al., and Opoku-Okrah C et al., which demonstrated that sodium levels decreased throughout the storage period.[13,12,14] Our results, however, contrast with a study conducted by Upadya UB et al., which demonstrated that sodium did not exhibit any significant changes due to storage time.[15]

Blood bank storage conditions decelerate cellular metabolism and energy requirements, allowing blood to be preserved for 35–42 days. This process impairs the sodium-potassium pump, causing potassium ions to exit the cell and sodium ions to enter through the semipermeable membrane.[12] These significant alterations could impact patients susceptible to low sodium levels, potentially increasing their risk of edema, particularly in individuals with low sodium intake or those experiencing diarrhea.[16] Based on these findings, it is advised to monitor sodium ion levels during blood storage for transfusion to enhance blood safety. A notable decline in chloride levels was observed from day 7, continuing through days 14 and 28 of blood storage. Our chloride results aligned with those reported by Namjoshi A et al. and Obisike UA.[17,18] This study has shown that the pH of stored blood decreases over time, with the reduction becoming more pronounced as storage duration increases. The pH drop is likely due to increased lactate levels resulting from glucose's anaerobic metabolism.[19,20] Stored cells must be kept alive through anaerobic respiration. In a typical biological system, the kidneys buffer the produced lactate, minimizing its impact on the system's pH. However, the absence of similar buffering capabilities in stored units leaves them vulnerable to pH reduction. The elevated lactate concentration and corresponding pH decrease could severely affect blood recipients, especially those receiving multiple units in a short period. This diminishes blood effectiveness and exposes recipients to potential transfusion-related morbidity and mortality.[4]

CONCLUSION

This study showed that variations to several hematological and biochemical parameters occur during the storage of blood, despite storing blood in CPDA bag, and subsequently may cause untoward risks to patients. It is better to give patients fresh blood which has been stored for less than seven days.

REFERENCES

1. Yalcin, O., Ortiz, D., Tsai, A. G., Johnson, P. C., & Cabrales, P. (2014). Microhemodynamic aberrations created by transfusion of stored blood. *Transfusion*, *54*(4), 1015-1027.
2. Roback, J. D. (2011). Vascular effects of the red blood cell storage lesion. *Hematology 2010, the American Society of Hematology Education Program Book*, *2011*(1), 475-479.
3. Arif, S. H., Yadav, N., Rehman, S., & Mehdi, G. (2017). Study of hemolysis during storage of blood in the blood bank of a tertiary health care centre. *Indian Journal of Hematology and Blood Transfusion*, *33*, 598-602.
4. Oyet, C., Okongo, B., Onyuthi, R. A., & Muwanguzi, E. (2018). Biochemical changes in stored donor units: implications on the efficacy of blood transfusion. *Journal of Blood Medicine*, 111-115.
5. Antonelou, M. H., Kriebardis, A. G., & Papassideri, I. S. (2010). Aging and death signalling in mature red cells: from basic science to transfusion practice. *Blood Transfusion*, *8*(Suppl 3), s39.
6. D'Alessandro, A., D'Amici, G. M., Vaglio, S., & Zolla, L. (2012). Time-course investigation of SAGM-stored leukocyte-filtered red bood cell concentrates: from metabolism to proteomics. *Haematologica*, *97*(1), 107.
7. Antwi-Baffour, S., Adjei, J. K., Tsyawo, F., Kyeremeh, R., Botchway, F. A., & Seidu, M. A. (2019). A study of the change in sodium and potassium ion concentrations in stored donor blood and their effect on electrolyte balance of recipients. *BioMed research international*, *2019*(1), 8162975.
8. Hardy, J. F., Moerloose, P. D., & Samama, C. M. (2006). Transfusion massive et coagulopathie-: physiopathologie et implications cliniques. *Canadian Journal of Anesthesia*, *53*, S40-S57.
9. Christian, S. G., Eze, E. M., & Nkom, N. E. (2019). Assessment of blood storage effect using cpda-1 on packed cell volume, oxyhaemoglobin and methaemoglobin in different abo/rhesus blood types. *International Blood Research & Reviews*, 1-15.
10. Zimrin, A. B., & Hess, J. R. (2009). Current issues relating to the transfusion of stored red blood cells. *Vox sanguinis*, *96*(2), 93-103.
11. Adias, T. C., Moore-Igwe, B., & Jeremiah, Z. A. (2012). Storage related haematological and biochemical changes of CPDA-1 whole blood in a resource limited setting. *J Blood Disord Transfus*, *3*(3), 124.
12. Nogueira, D., Rocha, S., Abreu, E., Costa, E., & Santos-Silva, A. (2015). Biochemical and cellular changes in leukocyte-depleted red blood cells stored for transfusion. *Transfusion Medicine and Hemotherapy*, *42*(1), 46-51.
13. Verma, M., Dahiya, K., Malik, D., Sehgal, P. K., Devi, R., Soni, A., & Ghalaut, V. G. (2015). Effect of blood storage on complete biochemistry. *J Blood Disord Transfus*, *6*(6), 1-4.
14. Clement, O. O., Safo, A. B. K., & Dogbe, E. E. (2015). Changes in potassium and sodium concentrations in stored blood. *The Pan African Medical Journal*, *20*.
15. Upadya, U. B., Seema, H. S., & Motakapalli, K. (2018). Effect of Blood Storage on Biochemical Parameters Assessed at Periodic Intervals in CPDA1 Blood Bags. *Journal of Clinical & Diagnostic Research*, *12*(10).
16. Metheny, N. (2012). *Fluid and electrolyte balance*. Jones & Bartlett Publishers.
17. Namjoshi, A., Bhatia, G. M., Chaudhari, A. S., & Trimbake, S. (2021). Effect of blood storage on electrolyte levels. *Int J Res Med Sci*, *9*(9), 438-42.
18. Obisike, U. A. (2016). Storage effect on serum electrolytes and ph in whole blood stored in traditional refrigerator. *Int J Sci Res*, *5*(3), 888-94.
19. Vandromme, M. J., McGwin, G., & Weinberg, J. A. (2009). Blood transfusion in the critically ill: does storage age matter?. *Scandinavian journal of trauma, resuscitation and emergency medicine*, *17*, 1-6.
20. D'Alessandro, A., Gevi, F., & Zolla, L. (2013). Red blood cell metabolism under prolonged anaerobic storage. *Molecular BioSystems*, *9*(6), 1196-1209.