BIOCHEMICAL CHANGES IN STORED WHOLE BLOOD: AN OBSERVATIONAL STUDY IN A TERTIARY HOSPITAL BLOOD BANK

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ABSTRACT

Several studies are going on to study the effects of transfusing stored RBCs on recipients. Several biochemical changes occur in stored blood, which may have some medical effects on the recipients. The biochemical changes may vary from donar to donar as well as from Blood bank to Blood bank. Also effects of transfused RBCs will vary from recipient to recipient. Lot of clinical trial should be taken before assessing the safety of stored RBCs.

OBJECTIVES

To study the various biochemical changes occurring in a stored whole blood.

MATERIAL AND METHODS

Analysis of biochemical changes occurring in stored whole blood in 20 voluntary donars was done in a Blood bank of a Tertiary Hospital.

RESULTS

Of the 6 biochemical parameters studied, only significant changes were seen in potassium and albumin after storage. There was a significant decrease in albumin concentration and steady increase in potassium values.

CONCLUSION

Certain biochemical changes do occur in stored whole blood over a duration of storage. As the demand for blood is high due to various medical conditions, the treating consultant should be aware of the biochemical changes seen in stored whole blood.

KEYWORDS

Blood Bank, Stored Blood, Whole Blood.

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INTRODUCTION

Proper preservation and long-term storage of Red Blood Cells (RBCs) is needed to ensure a readily available safe blood supply for transfusion medicine. As per the Food and Drug Administration norms, red cells can be stored up to 42 days. If blood has been stored for long periods according to some studies, the risk of complications after transfusion increases.[1,2,3] During storage, in fact, preserved blood cells undergo progressive structural and functional changes that may reduce red cell function and viability after transfusion.[4,5,6]

Release of oxygen from RBCs is decreased during storage.[1,2,3] Certain chemicals like histamine, lipids and cytokines are released by leucocytes during storage, which directly affect physical and metabolic functions of RBCs.[4,5,6] Also the potassium value is increased in stored blood.[7] There are evidences which suggests the risk of serious complications and death in critically ill patients, especially in patients who are undergoing cardiac surgery who have received massive transfusion.[4,6]

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It leads to decreased RBCs size, decrease in 2, 3 DPG stores and RBCs will become more rigid. Also fluid will become more acidotic.[8,9,10]

The only important electrolyte change in stored blood is that of potassium. During blood storage, there is a slow but constant leakage of K from cells into the surrounding plasma. In patients in which renal function is affected due to any reason, even small amount of K fluctuations can be dangerous and relatively fresh or washed red cells are indicated. Due to a higher K content of stored blood, blood <5 days old is recommended by Ono et al.[7] for neonatal exchange and top-up transfusion.

In this study, changes in some biochemical parameters in whole blood stored in blood bank in a resource limited setting were studied.

MATERIAL AND METHODS

This study was conducted in Bharati Vidyapeeth Deemed University Medical College and Hospital, Sangli, which is a Tertiary Hospital. Blood (450ml) was drawn from twenty healthy volunteer donors into Citrate Phosphate Dextrose Adenine (CPDA-1) anticoagulant and placed on the quarantine shelf of the blood bank refrigerator. The donors were 20 in number; they had their ages ranging from 20 to 28 years (Mean age 25.2 yrs.). The donors were all male and tested negative for: HCV, HbsAg, Syphilis and HIV 1 and 2.

The blood was kept for 28 days and samples were evaluated on days 1, 7, 14, 21 and 28.

Blood bag of 450ml, which contains CPDA-1 was used. Most blood collection bags (Adult) contain 63ml CPDA anticoagulant, which is sufficient to anticoagulate and ensure

the viability of blood cells in 450ml ± 10% blood for up to 28-35 days when the blood is stored at 2-8°C.[1,2,3]

Blood bags were carefully stored in a quarantine shelf in the Blood bank with temperature ranging from 2-6°C.

These biochemical parameters were measured using LWC 100 Fully Automated Random Acesss Clinical Analyzer. The concentration of the electrolytes, sodium, potassium and chloride was measured by Prolyte electrolyte analyser by Diamond Diagnostics. The procedures were followed as contained in the standard operating manual.

RESULTS

Parameters	Day 1	Day 7	Day 14	Day 21	Day 28	Total	F value	P value
Total protein g/dl	7.12	6.98	6.93	6.83	6.74	6.92	1.401	0.264 ns
Albumin g/dl	4.29	4.10	3.89	3.78	3.61	3.934	2.991	0.021*
Na mEq/L	139.82	136.02	131.82	128.98	126.53	132.63	1.954	0.118ns
K mEq/L	4.02	6.11	8.55	10.28	12.43	8.278	15.234	0.000***
Cl mEq/L	98.62	95.97	93.40	92.67	91.12	94.29	1.817	0.169ns
pH	7.44	7.35	7.00	6.79	6.74	7.064	1.380	0.086**ns**
Mean test of significance for Biochemical Parameters for all the days								

ns = Not Significant * = Significant at P < 0.05 *** = Significant at P < 0.01

MEAN VALUES OF BIOCHEMICAL PARAMETERS

At the end of the study period as shown in (Table 1-6), the mean biochemical parameters (Table 7) were obtained as follows: Total protein (6.92g/dL), Albumin (3.934g/dL), Na (132.63mEq/L), K (8.278mEq/L), Cl (94.29mEq/L). Analysis of variance showed that at the end of the study period, significant differences were noted in effect of storage on two out of five parameters studied. Albumin (F=2.991, P<0.021) and potassium (F=15.234, P<0.001) storage was not found to exert any influence on other parameters. There was a significant decrease in albumin concentration and steady increase in potassium values.

DISCUSSION

Certain changes occur in some biochemical parameters of stored whole blood. Some of the parameters are increased as compared to their initial values on day of collection while some are decreased. This is comparable with the work done by Cohl et al. who using Coulter Gen. S. on 40 K_3 (Tripotassium ethylenediamine tetra acetate). Potassium is the only electrolyte whose concentration increases due to leakage from cells into surrounding plasma. Potassium loss is also due to acidotic environment.[2,3,4,5,6,8]

In severe kidney disease even small amount of potassium fluctuations can be dangerous and relatively fresh or washed red cells are indicated. Sodium on the contrary reduced, suggesting that sodium in stored whole blood may produce adverse effect after transfusion. The increase in potassium value and reduction in sodium value simply indicates the preference of component therapy to whole blood transfusion.

CONCLUSION

Certain biochemical changes do occur in stored whole blood over a duration of storage. Previous studies suggested that ultimate result due to various biochemical changes results in ATP depletion.[11,12,13,14] Therefore, adenine is added to the anticoagulant CPDA-1, prolonging the duration of storage.[15,16,17,18,19]

BIBLIOGRAPHY

1. Koch CG, Li L, Sessler DI, Figueroa P, Hoeltge GA, et al. (2008) Duration of red cell storage and complication after cardiac surgery. N Engl J Med 358:1229-1239.
2. Mollison PL. "Other unfavourable effect of Transfusion." In: Blood Transfusion in Clinical Medicine. 6th ed. Oxford, Blackwell Scientific Publication. 584–586 (1979).
3. Carmer RA, Sohmer PR, Leng BS, Moore GL, Nelson EJ, Simon TL. Transfusion 28:157–161 (1988).
4. Cohl SD, Saleem A, Makkaoui DE (1981). Effects of storage of blood on stability of hematologic parameters. Am J Clin Pathol 76:67-69.
5. Lave EM, Jones H, Williamson LM, et al. "Serious hazards of transfusion." Annual Report. ISDM 09532789 3X. (2000).
6. Hebert PC, Chin-Yee I. Clinical consequences of prolonged blood storage; should old red cell be transfused in critically ill patients? In: Vincent J-L, ed. Yearbook of Intensive Care and Emergency Medicine. Berlin, Heidelberg: Springer-Verlag 2000;494–506.
7. Vamvakas EC and Carven JH. Length of storage of transfused red cells and postoperative morbidity in patients undergoing coronary artery bypass graft surgery. Transfusion 2000 Jan;40(1):101-9.
8. Guidelines for the Blood Transfusion Services in the United Kingdom, 5th Edn. The Stationery Office Ltd., 2001.
9. Kuter DJ, Cebon J, Harker LA, et al. Transfusion 39:321–332.
10. Bonaventura J (2007). Clinical implications of the loss of vasoactive nitric oxide during red blood cell storage. Proc Natl Acad Sci U S A 104:19165-19166.
11. Bennett–Guerrero E, Veldmom TH, Doctor A (2007). Evolution of adverse changes in stored RBCs. PNAS 104:7063-7068.
12. Hess JR (2006). An update on solutions for red cell storage Vox Sanguinis 91:13-19.
13. Bruce-Chwatt LJ (1972). Blood transfusion and tropical disease. Tropical Diseases Bulletin 69:825-862.
14. Thon IN, Schubert P, Duguay M, Serrano K, Un S, et al. (2008). Comprehensive proteomic analysis of protein changing during platelet storage requires complementary proteomic approaches. Transfusion 48:425-435.
15. Ono T, Kitaguchi K, Takehara M, Shiliba M, Hayami K (1981). Serum-constituents analyses: effect of duration and temperature of storage of clotted blood. Clinical chemistry 27:35-38.
16. Hankinson SE, London SJ, Chute CG (1989). Effect of transport conditions on the stability of biochemical markers in blood. Clinical Chemistry 35:2313-2316.
17. Heins M, Heil W, Withold W (1995). Storage of serum or whole blood samples? Effects of time and temperature on 22 serum analytes. Eur J Clin Chem Clin Biochem 33:231-238.
18. Shields CE (1969). Effects of adenine on stored erythrocytes evaluated by autologous and homologous transfusion. Transfusion 9:115-119.
19. Monica C (2000). District Laboratory Practice in Tropical countries. Part 2 Blood transfusion practice Great Britain 348-361.

Bag No.	Day 1	Day 7	Day 14	Day 21	Day 28
1	6.8	6.72	6.65	6.61	6.56
2	7.7	7.41	7.36	7.30	7.12
3	7.1	7.00	6.98	6.95	6.92
4	6.9	6.78	6.75	6.72	6.65
5	6.3	5.8	6.2	5.7	6.0
6	6.78	6.65	6.52	6.49	6.40
7	6.92	6.86	6.79	6.74	6.65
8	7.00	6.91	6.68	6.65	6.34
9	7.13	7.06	7.00	6.90	6.87
10	7.15	7.12	7.06	7.01	6.94
11	7.34	7.25	7.20	7.13	7.02
12	7.39	7.28	7.14	7.06	6.98
13	7.25	7.15	7.10	7.02	6.90
14	7.46	7.32	7.16	7.04	6.83
15	7.14	7.03	6.98	6.95	6.90
16	7.30	7.21	7.16	7.04	6.99
17	7.12	7.04	6.99	6.95	6.92
18	7.04	6.98	6.92	6.89	6.83
19	6.89	6.72	6.67	6.34	6.01
20	7.67	7.34	7.26	7.19	7.02

Table 1: Changes in Parameter Total Protein g/dL (N. Range: 6.6 – 8.8g/dl)

Bag No.	Day 1	Day 7	Day 14	Day 21	Day 28
1	3.54	3.46	3.41	3.35	3.10
2	4.12	4.03	3.89	3.62	3.43
3	4.01	3.89	3.80	3.71	3.60
4	3.97	3.57	3.52	3.40	3.34
5	3.6	3.5	3.4	3.3	3.20
6	4.2	4.00	3.58	3.40	3.21
7	3.99	3.70	3.42	3.26	3.10
8	4.89	4.60	4.34	4.01	3.89
9	5.1	4.93	4.70	4.32	4.05
10	5.0	4.78	4.39	4.01	3.97
11	4.5	4.32	4.01	3.98	3.80
12	4.3	4.04	3.95	3.90	3.67
13	4.6	4.35	4.29	4.05	4.00
14	3.87	3.60	3.51	3.30	3.12
15	4.16	4.02	3.98	3.90	3.85
16	4.35	4.19	4.06	3.98	3.91
17	4.80	4.56	4.34	4.15	4.01
18	4.56	4.42	4.30	4.21	4.03
19	4.07	3.98	3.90	3.86	3.71
20	4.13	4.02	3.95	3.90	3.34

Table 2: Changes in Parameter Albumin g/dL (Normal range: 3.5 to 5.2g/dl)

Bag No.	Day 1	Day 7	Day 14	Day 21	Day 28
1	141.2	138.1	133.4	131.2	129.1
2	139.1	137.2	132.1	130.0	128.2
3	138.6	136.1	131.8	130.1	126.3
4	140.5	135.6	133.2	132.3	128.4
5	137.3	135.3	128.5	129.2	125.6
6	139.5	136.1	133.0	127.2	126.8
7	141.2	138.2	134.1	130.3	127.0
8	140.6	136.2	132.1	129.5	126.5
9	143.2	138.1	134.2	131.3	129.1
10	137.3	132.4	128.3	126.1	124.5
11	139.5	133.6	129.2	127.3	126.1
12	140.1	137.2	133.1	127.2	125.8
13	142.3	139.1	136.2	130.4	128.2
14	145.2	139.3	136.2	131.3	129.4
15	141.0	137.2	134.1	130.4	127.3
16	138.3	135.1	130.2	127.7	124.2
17	136.5	130.2	127.1	125.2	123.3
18	137.2	134.1	129.3	127.1	125.2
19	138.6	135.2	130.1	128.2	126.1
20	139.2	136.1	130.2	127.5	123.4

Table 3: Changes in Parameter Na mEq/L (Normal range: 135 to 145mEq/L)

Bag No.	Day 1	Day 7	Day 14	Day 21	Day 28
1	3.2	5.9	8.7	10.1	13.2
2	3.5	5.6	9.0	10.4	13.6
3	3.6	5.4	8.7	9.9	12.3
4	4.0	6.1	8.4	9.6	13.4
5	3.6	6.1	9.2	11.3	14.7
6	3.9	6.3	8.9	10.1	12.6
7	4.4	6.5	7.4	11.2	12.0
8	4.3	5.9	8.1	10.8	13.1
9	4.6	6.8	9.5	10.1	12.5
10	3.9	7.1	9.1	10.4	12.7
11	4.1	6.9	8.7	9.9	11.8
12	3.9	5.9	8.1	10.2	11.9
13	4.0	6.1	9.6	10.6	13.3
14	4.6	6.7	8.9	11.2	12.9
15	4.3	6.4	7.9	10.3	11.7
16	4.2	5.1	7.3	9.4	10.8
17	4.1	5.9	8.4	10.0	12.1
18	4.5	6.0	8.7	10.1	11.7
19	3.8	5.4	7.9	9.8	10.9
20	3.9	6.1	8.4	10.2	11.3

Table 4: Changes in Parameter K mEq/L (Normal range: 3.5 to 5.5mEq/L)

Bag No.	Day 1	Day 7	Day 14	Day 21	Day 28
1	97.8	96.1	94.8	92.1	90.3
2	102.0	98.1	96.3	93.3	91.2
3	100.1	97.4	95.2	94.1	92.0
4	104.3	100.0	97.2	96.5	94.1
5	97.6	95.4	92.2	91.1	90.4
6	96.7	93.2	92.1	91.8	90.6
7	95.8	93.6	91.0	90.2	89.1
8	98.3	96.1	94.7	93.1	91.3
9	100.1	97.6	95.2	93.1	91.2
10	101.2	99.0	96.4	93.2	91.2
11	99.4	97.1	96.2	94.1	93.0
12	98.6	96.5	95.1	93.3	92.8
13	97.4	95.1	93.2	92.0	90.7
14	95.8	94.1	92.1	91.6	90.2
15	96.3	93.2	92.1	91.0	90.5
16	98.2	96.3	95.2	91.2	90.1
17	99.0	95.0	93.6	92.2	91.1
18	102.3	98.2	96.1	94.2	92.3
19	96.7	94.1	93.2	92.1	90.2
20	94.8	93.2	92.1	91.2	90.1

Table 5: Changes in Parameter Cl mEq/L (Normal range: 98 to 110 mEq/L)

Bag No.	Day 1	Day 7	Day 14	Day 21	Day 28
1	7.49	7.45	7.38	7.01	6.94
2	7.12	7.09	7.04	7.02	6.99
3	7.52	7.38	7.30	7.24	7.10
4	7.23	7.18	7.14	7.06	7.00
5	7.41	7.23	7.17	7.12	7.04
6	7.18	7.10	7.02	6.98	6.90
7	7.14	7.05	7.01	6.95	6.92
8	7.45	7.38	7.32	7.25	7.14
9	7.31	7.24	7.20	7.15	7.10
10	7.48	7.36	7.20	7.16	7.02
11	7.35	7.30	7.24	7.20	7.15
12	7.20	7.15	7.10	7.08	7.00
13	7.39	7.30	7.26	7.24	7.18
14	7.46	7.37	7.30	7.25	7.11
15	7.29	7.20	7.16	7.12	7.10
16	7.30	7.25	7.20	7.14	7.07
17	7.23	7.20	7.11	7.05	6.99
18	7.34	7.28	7.21	7.14	7.08
19	7.30	7.23	7.16	7.10	7.04
20	7.15	7.06	7.02	7.00	6.98

Table 6: Changes in Parameter pH (Normal range: 7.20 to 7.60)