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Effect of transfusion of washed red blood cells on serum potassium level in hemodialysis patients

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Background/aim: This study aimed to compare washed red blood cell (WRBC) transfusion versus nonwashed RBC (NWRBC) transfusion in terms of posttransfusion potassium levels in dialysis patients on a day when the patient did not receive dialysis.

Materials and methods: The patients were randomly assigned into two groups, i.e. those receiving WRBCs (n = 21) and those receiving NWRBCs (n = 17). Both groups received one unit of RBCs. Serum potassium and sodium levels were measured before and at the 1st, 2nd, 3rd, 4th, and 6th hours after transfusion.

Results: In the WRBC group, the changes in the serum potassium levels at the 3rd, 4th, and 6th hours after transfusion were significant compared with pretransfusion levels. In the serum potassium levels mean decreases by 0.38 ± 0.57 mEq/L at the 3rd hour (P = 0.006), by 0.32 ± 0.47 mEq/L at the 4th hour (P = 0.005), and by 0.32 ± 0.51 mEq/L at the 6th hour (P = 0.009) after transfusion were significant compared with the pretransfusion levels.

Conclusion: Although nonwashed RBC transfusion does not change serum potassium levels, washed RBC transfusion significantly reduces serum potassium levels. Washed RBC transfusion is considered to be safer in hemodialysis patients with hyperkalemia and anemia.

Key words: Washed red blood cells, hemodialysis patients, hyperkalemia

1. Introduction

Although anemia has been dramatically decreased in patients with chronic renal disease along with the availability of recombinant human erythropoietin, red blood cell (RBC) transfusion is frequently used, particularly to treat symptomatic anemia (1,2).

Blood components used in transfusion are exogenous sources of potassium and may lead to severe and unintentional potassium-related consequences after transfusion (3). Hyperkalemia can result in multiple negative effects in humans. These include muscle weakness, as well as respiratory muscle weakness in severe cases. However, the most feared consequences of hyperkalemia are its potentially fatal cardiac effects (3). Potassium load should be minimized in transfused RBCs. This is particularly important in individuals with cardiac and renal diseases that require limited potassium intake and in newborns. In subjects with normal renal function, 90%–95% of oral potassium is excreted through the kidneys (4). Potassium excretion is extremely impaired in patients with end-stage renal disease, and hyperkalemia is encountered frequently. Hence, potassium intake should be restricted in patients with chronic renal disease. RBC transfusion may lead to additional potassium load in these patients who are already prone to hyperkalemia.

Serum potassium concentration in RBC units increases substantially with time because of the potassium leak from the RBCs and RBC lysis (3). Thus, supernatant K^+ in RBCs increases with storage time at blood banks. In vivo erythrocyte lysis within 24 h after transfusion (particularly within the first 2 h after transfusion) also causes hyperkalemia (5). The amount of potassium in a unit of stored RBCs is low compared to whole blood (6). Preservatives, storage temperature, and duration have an

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effect on the potassium concentration of stored RBCs (7). Washing stored RBCs before transfusion is a recommended method to reduce the potassium load (8–10).

Washed RBCs are obtained by removing plasma, and thus potassium, by washing erythrocytes with 0.9% sodium chloride using automatic cell washers. Potassium load can be minimized in washed RBC transfusions. When transfusion is necessary in hemodialysis patients, washed RBCs are recommended during dialysis-free intervals in order to avoid transfusion-associated hyperkalemia (8–10). Nevertheless, studies on the effects of washed RBCs on actual change in serum potassium concentration (in the receiver) are limited.

The present study aimed to evaluate serum potassium level after nonwashed RBC or washed RBC transfusions in the dialysis-free period (on a day when the patient did not receive dialysis) in patients receiving hemodialysis treatment.

2. Materials and methods

Thirty-eight patients on chronic hemodialysis (3 times a week) at Haydarpaşa Numune Training and Research Hospital and requiring RBC transfusion (24 h after the last hemodialysis) were included in the study. Approval of the local ethics committee and written informed consent of the patients were obtained for the study.

The patients were randomized into two study groups by drawing lots as those receiving washed RBC transfusion (WRBC group, n = 21) and those receiving nonwashed RBC transfusions (NWRBC group, n = 17). Change in serum potassium level over time was evaluated in each group, and the serum potassium level at each time point after transfusion was compared with the serum potassium level before transfusion.

Patients were not using drugs (beta blocker agents, beta adrenergic agents, insulin, preparations containing potassium, etc.) affecting potassium blood levels in either group.

Both groups received only one unit of RBCs after their last hemodialysis (after 24 h). For the blood collected from the donor (200 mL), citrate-phosphate-dextrose-adenine-1 (CPDA-1) solution was used as the storage solution at the blood bank. The mean period of storage of blood was 16.1 ± 3.2 days for the WRBC group and 14.6 ± 2.6 days for the NWRBC group. A COBE 2991 Blood Cell Processor (COBE BCT Laboratories, Lakewood, CO, USA) device was used at the blood bank to obtain WRBCs. Washing solution was 1000 mL of 0.9% sodium chloride and the washing procedure was performed once for each unit of RBCs. The device was adjusted and used in accordance with the protocol recommended by the manufacturer. Centrifugation was performed at a temperature of 4 °C and at 3000 rpm for 10 min. The WRBCs were transfused to the patients within 30 min after completion of the procedure.

All patients underwent electrocardiography monitoring during blood transfusions. Blood was transfused at a rate of 3 mL/min in both groups.

Serum hemoglobin, hematocrit, platelet, blood urea nitrogen (BUN), and creatinine levels were assessed prior to the blood transfusion. In addition, serum potassium and sodium levels were measured before the transfusion and at the 1st, 2nd, 3rd, 4th, and 6th hours after transfusion. Blood samples were taken from the arm without a fistula. Measurements were performed at a biochemistry laboratory using a Roche-Hitachi autoanalyzer.

2.1. Statistical analysis

NCSS (Number Cruncher Statistical System) 2007 and PASS (Power Analysis and Sample Size) 2008 statistical software (Kaysville, UT, USA) were used for statistical analyses. In addition to the descriptive statistical methods (mean, standard deviation, median, frequency, ratio), the Kolmogorov–Smirnov test was used to assess the normality of study data. Intergroup comparisons for normally distributed parameters were performed using an independent samples t-test, and the Mann–Whitney U test was used for nonnormally distributed parameters. The paired samples t-test was used to evaluate changes in the values from pretransfusion to follow-up measurements. Categorical variables were evaluated using the Yates continuity correction test and Fisher's exact test. A two-tailed P-value of <0.05 was considered to be statistically significant.

3. Results

The study comprised 38 patients including 22 females and 16 males. Twenty-one patients were assigned to the WRBC group and 17 patients were assigned to the NWRBC group. Patient characteristics are provided in Table 1.

There were no differences between the two groups in terms of age, BMI, sex, the degree of hypertension, diabetes, time and frequency of hemodialysis, and hemoglobin, hematocrit, platelet, BUN, sodium, and creatinine levels before transfusion. There were no events related to hyperkalemia.

Pre- and posttransfusion 6th hour serum potassium levels of the groups are demonstrated in Table 2. In the WRBC group, the changes in the serum potassium levels at the 1st and 2nd hour after transfusion were not significant as compared with the pretransfusion serum potassium level (P = 0.136 and P = 0.068, respectively). A mean decrease by 0.38 ± 0.57 mEq/L at the 3rd hour (P = 0.006), by 0.32 ± 0.47 mEq/L at the 4th hour (P = 0.005), and by 0.32±0.51 mEq/L at the 6th hour (P = 0.009) after transfusion were found to be significant as compared with the pretransfusion level (Figure; Table 2).

Table 1. Characteristics of the patient groups.

	WRBC group (n = 21)	NWRBC group (n = 17)	P
Age, years	56.66 ± 18.56	55.41 ± 15.04	0.823 [a]
BMI, kg/m^2	27.4 ± 4.5	26.4 ± 4.9	0.35
Sex			
Male, n (%)	7 (33.3)	9 (52.9)	0.375 [c]
Female, n (%)	14 (66.7)	8 (47.1)	
Hypertension, n (%)	15 (71.4)	12 (70.6)	1.000 [d]
Diabetes mellitus, n (%)	7 (33.3)	6 (35.3)	1.000 [c]
Hb, g/dL	8.34 ± 1.14	8.06 ± 1.44	0.506 [a]
Posttransfusion Hb, g/dL	9.2 ± 1.2	9.11 ± 0.93	0.713 [a]
Hematocrit, %	24.57 ± 3.43	24.82 ± 2.75	0.811 [a]
Platelets, ×10^3/μL	272.43 ± 139.24 (227)	300.47 ± 132.39 (290)	0.284 [b]
BUN, mg/dL	72.85 ± 32.34 (63.0)	69.41 ± 25.43 (75.0)	0.747 [b]
Sodium, mEq/L	134.71 ± 5.33	137.29 ± 5.14	0.141 [a]
Chloride, mEq/L	108.40 ± 7.27	107.93 ± 5.40	0.838 [a]
Creatinine, mg/dL	5.89 ± 4.22 (3.9)	5.70 ± 3.23 (5.6)	0.849 [b]

Values are presented as mean and standard deviation (median) or number (%) as appropriate. NWRBC: Nonwashed red blood cells; WRBC: washed red blood cells; Hb: hemoglobin; BUN: blood urea nitrogen; BMI: body mass index.
[a] Independent samples t-test, [b] Mann–Whitney U test, [c] Yates continuity correction test, [d] Fisher's exact test.

Table 2. Serum potassium levels before and after transfusion in the study groups.

	Before transfusion	6th hour after transfusion	P
WRBC group, (K) mEq/L	5.91 ± 0.56	5.59 ± 0.74	0.009
NWRBC group, (K) mEq/L	5.60 ± 0.46	5.61 ± 0.59	0.926

Paired samples t-test. NWRBC, Nonwashed red blood cells; WRBC, washed red blood cells.

In the NWRBC group, the changes in the potassium levels at the 1st, 2nd, 3rd, 4th, and 6th hours after transfusion were not significant as compared with the pretransfusion level (P = 0.326, P = 0.100, P = 0.694, P = 0.589, and P = 0.926, respectively) (Figure).

When the groups were compared at each time point, no differences were determined in terms of serum potassium levels.

Moreover, the change in the plasma sodium concentrations over time was not statistically significant in either group. The changes in the sodium levels in both the NWRBC group and WRBC group at the 1st and 6th hours after transfusion were not significant as compared with the pretransfusion level (P = 0.423, P = 0.478, P = 0.213, and P = 0.68, respectively).

4. Discussion

The impacts of washed RBC transfusion on serum potassium levels were investigated in this study. We examined the potassium levels in patients over a large period of time, such as 1, 2, 3, and 6 h after transfusion. Searching the literature on this subject, we did not find such a large population study compared with our study.

In the present study, serum potassium level was found to be significantly lower at the 3rd, 4th, and 6th hours after WRBC transfusion as compared with the pretransfusion levels in the patients. The reason for hypokalemia after WRBC transfusion is as follows: during the storage of blood in cold medium (2–6 °C) at the blood bank, the Na^+/K^+ pump is paralyzed and the potassium in the erythrocytes leaks into the plasma. Potassium leakage out

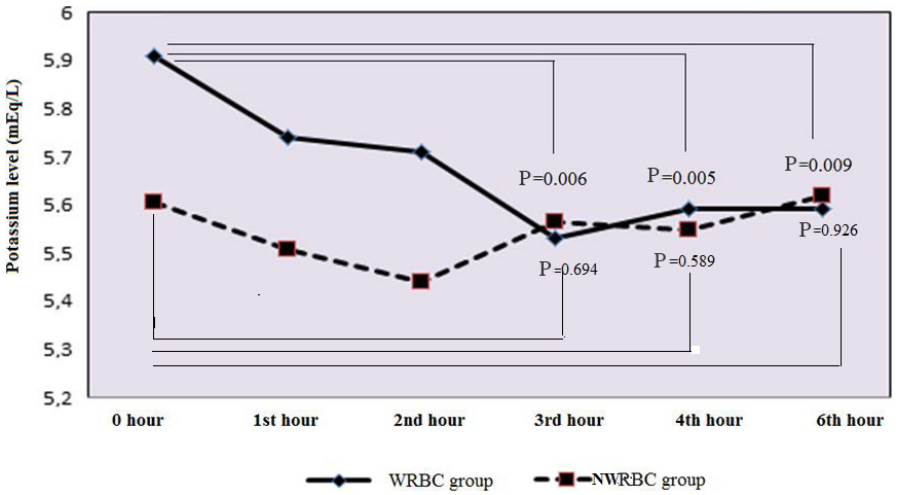

Figure. Change in the serum potassium levels after transfusion in the study groups.

of the cell progressively continues after a 3-day storage period and extracellular concentration may reach up to 50 mEq/L (11). Some of it reenters the erythrocytes during rewarming or transfusion of the blood; however, excessive potassium causes temporary hyperkalemia in the receiver. Excessive potassium in the plasma is removed during the washing procedure. Potassium content of the erythrocytes, which is normally 7 mEq/10^{12} erythrocytes, is decreased up to 4 mEq/10^{12} erythrocytes in WRBCs. The Na-K ATPase pump is reactivated after transfusion in the erythrocytes that have become poor in potassium and the serum potassium in the receiver passes into the donor erythrocytes and causes hypokalemia (12–14).

Although there are not large population studies on this subject, Schlarmann et al. (15) determined significant potassium elevations in the dialysis-free period after transfusion of washed RBCs in 10 anemic dialysis patients, different from the present study. The authors transfused 2 U of washed RBCs over 30 min, which is a fast rate and has a much higher potassium load than in this study. The differences in the results of the studies are probably due to the different conditions used. Additionally, Schlarmann et al. only reported measurements immediately after and 1 h after the transfusion and not 3–6 h after the transfusion, the time points at which decreased K levels were found in the present study.

Serum potassium levels did not change statistically over the monitoring period of dialysis patients 6 h following NWRBC transfusion. This may be preferred in patients whose serum potassium levels are not within dangerous limits. However, the risk of hyperkalemia with RBC transfusion will continue in patients with high basal serum potassium levels. In these cases, using methods that decrease serum potassium levels could be recommended. These methods include fresh RBC transfusion or using potassium adsorption filters, altered storage solution, and also WRBCs (16,17). As observed in our study, serum potassium levels were decreased significantly when WRBCs were transfused within 30 min after the washing procedure.

Disadvantages of WRBCs include high cost, long preparation period, necessity of equipment and experienced staff, decreased shelf-life for a unit of blood, and loss of some of the erythrocytes during the washing procedure (13). Weiskopf et al. (18) reported that despite the 24-h shelf-life of WRBCs, potassium might be reelevated within this period; however, initial potassium concentration was preserved within the first 6 h. Therefore, it would be appropriate to transfuse WRBCs as soon as possible after the washing procedure.

In conclusion, one unit of washed RBC transfusion at an appropriate infusion rate may be much safer than nonwashed RBC transfusion in adult patients with renal failure. This is a possible solution for patients with hemodialysis who are exposed to potassium load. Therefore, RBCs may be given after a washing procedure if it is necessary in hemodialysis patients with hyperkalemia and anemia.

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