



Comparison of hemoglobin and hematocrit levels at 1, 4 and 24 h after red blood cell transfusion



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ABSTRACT

Previous studies have shown that equilibration following a red cell transfusion had occurred by 24 h. A shorter time to follow the hemoglobin (Hb) and hematocrit (Hct) after transfusion may help physicians to provide earlier and more pertinent treatment. This was a prospective study conducted from December 2014 to August 2015. This research aimed to determine the equilibration time point of the level of Hb and Hct after one unit red blood cell (RBC) transfusion. Patients were randomized into three groups and Hb level and Hct were assessed at one, four or 24 h after transfusion. The mean differences in Hb level and Hct before and after transfusion were compared between each group. Sixty patients were eligible for enrollment onto this study; 20 patients were therefore allocated to each group. The median age was 51 years old, male predominating (83.33%). The most common indication for transfusion was post-operative anemia (88.33%). There were no significant differences between the baseline characteristics baseline Hb, Hct and volume of RBC transfusion in each group. The mean differences in Hb (g/dl)/Hct (%) level at the different time points of one, four and 24 h were 1.21/3.62, 1.19/3.63, and 0.95/3.09 respectively ($P = 0.109$ and $P = 0.398$, respectively). The equilibration of Hb and Hct did not differ between one, four and 24 h after a RBC transfusion. The target Hb and Hct can be determined at one hour after transfusion.

1. Introduction

Almost 80 million units of whole blood are donated globally each year [1]. Red blood cell (RBC) transfusion is one important aspect of blood component therapy. RBC transfusion improves tissue oxygenation and it is indicated for treatment of both acute and chronic anemia in patients [2]. The recent AABB (formerly, the American Association of Blood Banks) guidelines recommended the transfusion of RBCs if the hemoglobin level (Hb) was less than 7 g/dl in hemodynamically stable hospitalized adult patients and less than 8 g/dl in patients who had either a preexisting cardiovascular disease or were undergoing orthopedic or cardiac surgery [3]. In addition symptoms of anemia in patients need to be considered before a transfusion decision is finalized [2,4].

Generally, one unit of RBCs usually raises the Hb approximately 1 g/dl or increases the hematocrit (Hct) by about 3% in an adult [4–6]. However, the time equilibration of blood concentration is reached after a RBC transfusion is unclear, the proposed time being 24 h [7]. In clinical practice physicians need a shorter time point to evaluate Hb or Hct for early management and reduce the time for hospitalization. A previous study found that two units of RBC transfusion in medical inpatients not actively bleeding raised the Hb by $2 + 0.2$ g/dl and was not significantly different at 15 min, one hour, two hours and 24 h [6].

A common practice in our institution is to follow-up with Hb and Hct after RBC transfusion at four hours but we did not find any evidence to support this procedure. This research was aimed at determining the point at which equilibration of Hb and Hct after red cell transfusion was reached. An indication of an accurate shorter time to equilibration of

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Hb and Hct after transfusion may help physicians to provide earlier or adjunctive treatment and lead to a better outcome for patients.

2. Materials and methods

This was a prospective study conducted at Chiang Mai University Hospital. The inclusion criteria were inpatients of more than 15 years of age who received one unit of RBC. Exclusion criteria were patients with uncontrolled bleeding or active hemolysis, patients who had RBC alloantibodies, patients at risk of excess blood loss such as those with hemophilia, patients with coagulopathy or thrombocytopenia. Informed consents were completed by all patients before enrollment. This study was approved by the Human Research Ethics Committee of Faculty of Medicine, Chiang Mai University (study code MED-2557-02543).

Baseline characteristics were recorded in eligible patients. These characteristics were used to create three random groups by block randomization. Hb level and Hct were ascertained in the three groups at one, four or 24 h after RBC transfusion. The number required in the population for statistical viability was calculated using a matched pair method from a previous study [6], a two-sample paired-means test base. After calculation for an α error of 0.05, a power of the test of 80%, and a standard error of 0.15 the sample population needed to be 20 patients in each group.

The baseline characteristics of patients were collected before RBC transfusion. These included age, sex, height, body weight, body surface area, body mass index, blood group, Hb, Hct, creatinine clearance, and indication for transfusion. Factors were also collected that might affect Hb levels after RBC transfusion including intravenous fluid administration, diuretic use, fever during transfusion periods, history of congestive heart failure, and transfusion volume. All blood samples were analyzed using the central laboratory machine of Chiang Mai University Hospital (LH780, Unicel DXH800, ADVIR 2120 and ADVIR 2120i).

The red cell donor units in our study were all non-leukocyte depleted, non-irradiated pack red cell units. The mean volume of each unit was 260 (180–340) ml. from 450 ml. whole blood collection. The mean red blood cell content measured by hematocrit was 68% and the median age was 14 days. These parameters of the red cell donor units were comparable in each study group.

Descriptive analysis was used to present patient characteristics and laboratory values. Categorical variables were reported as frequencies. Continuous variables with normal distribution were reported as mean \pm SD while non-normally distributed variables were reported as medians.

A Chi-square test was used for comparison of baseline characteristics that were nominal variables. A one-way ANOVA test and a Mann Whitney U test were used for analysis of continuous variables between groups. A repeated measure ANOVA was used to compare pre- and post-transfusion data in each group. Statistical significance was accepted if the P-value was less than 0.05. SPSS version 17.0 was used in this study.

3. Results

Sixty patients were enrolled from December 2014 to August 2015. The median age was 51 years with 50 male patients (83.33%). The most frequent indication for transfusion was post-operative anemia in 53 patients (88.33%) who had undergone total knee arthroplasty and the median transfusion volume was 260 ml. The median Hb and Hct before transfusion were 8.6 gm/dl (range 5.8–11 gm/dl) and 26.5% (range 17.0–33.4%), respectively.

There were 20 patients in each of the 3 groups. The 3 groups, 1, 2 and 3, denoted one, four and 24 h after transfusion for follow-up of Hb and Hct. The baseline Hb (g/dl) /Hct (%) in Groups 1, 2, and 3 were comparable at 8.60/26.65, 8.50/26.30, and 8.60/26.05 respectively. These were no other significant differences between baseline characteristics in the three groups (Table 1).

Table 1

Baseline characteristics of study population. Groups 1–3 defined by time of assessment of hemoglobin and hematocrit at one, four and 24 h after a transfusion of 1 unit of RBC.

	Group 1 N = 20	Group 2 N = 20	Group 3 N = 20	P- Value*
Age (year)				
Median	51	49	53.5	0.950
Min-max	15–90	17–85	17–90	
Male (%)	18 (90)	16 (80)	16 (80)	0.750
Weight (kg)				
Median	55.00	60.00	62.50	0.476
Min-Max	45–80	40–82	45–75	
Body Surface Area (m ²)				
Median	1.59	1.65	1.69	0.635
Min-max	1.37–1.89	1.03–1.88	1.41–1.88	
Cr Clearance (ml/min/ 1.73 m ²)				
Median	97.50	111.50	104.50	0.950
Min-Max	25–161	10–147	35–147	
Volume of Blood Transfusion (ml)				
Median	260.00	262.50	257.50	0.638
Min-Max	200–300	180–290	220–340	
Indication of Transfusion (Post-Operative Anemia) (%)	17 (85)	20 (100)	16 (80)	0.194
History of Congestive Heart Failure (%)	1 (5)	0 (0)	1 (5)	1.000
Diuretic Using (%)	2 (10)	1 (5)	4 (20)	0.480
Fever Near Transfusion (%)	7 (35)	5 (20)	8 (40)	0.693
Intravenous Fluid More Than 50% Total Body Volume (%)	12 (60)	10 (50)	10 (50)	0.849
Blood Group (%)				
A	3 (15)	6 (30)	3 (15)	0.477
B	6 (30)	2 (10)	5 (25)	
AB	0 (0)	0 (0)	1 (5)	
O	11 (55)	12 (60)	11 (55)	
Baseline Hemoglobin (g/ dl)				
Median	8.60	8.50	8.60	0.553
Min-Max	5.80–11.00	6.30–9.50	7.20–10.80	
Baseline Hematocrit (%)				
Median	26.65	26.30	27.05	0.570
Min-Max	17.90–33.40	18.70–29.10	22.20–32.60	

The overall mean increase in Hb and Hct after transfusion of one unit of RBC were 1.12 g/dl and 3.44% respectively. The mean increase in Hb (g/dl) /Hct (%) were 1.21/3.62 in Group 1, 1.19/3.63 in Group 2, and 0.95/3.09 in Group 3, respectively. There were no significant differences in the changes in Hb levels and Hct between the three groups (Figs. 1 and 2), (P = 0.109 and 0.398, respectively).

4. Discussion and conclusion

This study aimed to compare differences in Hb and Hct before and after one unit of RBC transfusion at various times. The results showed no significant difference in values of Hb and Hct at one, four and 24 h after the transfusion. Therefore, assessment of Hb and Hct at one hour after transfusion can indicate the equilibrium status of blood volume just as effectively as at 24 h.

This study differed to previous studies in that the design involved the randomization of patients with similar baseline characteristics into 3 groups. The previous studies were cohort studies in which Hb and Hct were followed in each patient at the different time points after transfusion [6,8–10]. To the contrary in this study the patients were only examined for Hb and Hct at one time after transfusion. The baseline characteristics, including variables that could disturb the equilibration of blood concentration such as body weight, body surface area, renal function, diuretic use and volume of transfusion, were similar between

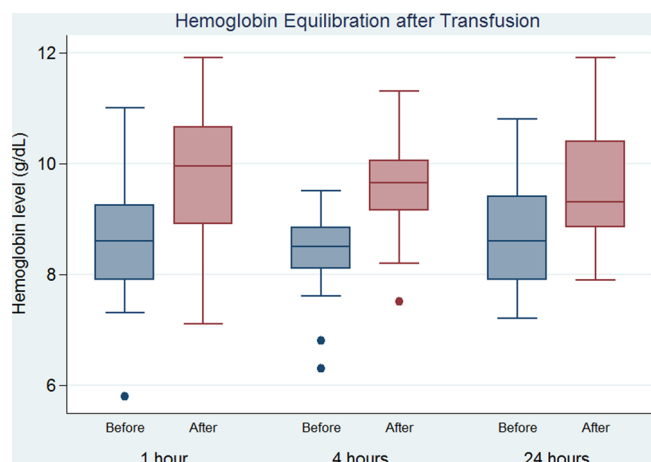


Fig. 1. Graph presenting difference and distribution in hemoglobin (Hb) before and after transfusion of one unit of packed red cells in the study population divided by the length of time after transfusion. The blue graph box represents baseline Hb and the red graph box represents Hb after transfusion. The graph box indicates the distribution of data ranging from the 25th to 75th percentile with an internal line showing the median value, while the external line shows the upper and lower adjacent values respectively, the data extraneous to that of the major population. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

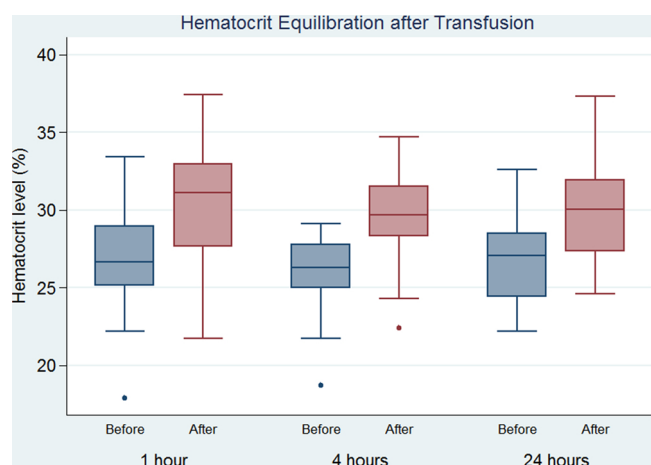


Fig. 2. Graph box presenting difference and distribution of hematocrit (Hct) before and after transfusion of one unit of packed red cells in study population divided by the length of time after transfusion. The blue graph box represents baseline Hct and the red graph box represents Hct after transfusion. The graph box indicates the distribution of data from the 25th to 75th percentile with the internal line showing the median value, while the external line shows the upper and lower adjacent values respectively, the data extraneous to that of the major population. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

groups.

In this study, all populations were Asian and the majority were middle aged male patients with post-operative anemia. However, the results were similar to previous studies carried out in different ethnic groups [6,8–10]. One study that was conducted in the United States included 39 anemic patients with an average age of 50 years; again there was a male predominance although it was markedly less. In that study each patient had a blood examination for Hb and Hct after two units of RBC transfusion at four time points (15 min, one hour, two hours and 24 h). The result showed no significant differences between time points [6]. Another study from Spain reported that they enrolled 32 patients, primarily male, with an average age of 60 years, predominantly with acute anemia from controlled gastrointestinal

hemorrhage. Each patient was examined by blood test after a transfusion of two units of RBC at five time points (15 min, 30 min, one hour, two hours, and 24 h). The results again showed no significant differences between time points [8]. These two studies also showed that age, sex, weight, body surface area and creatinine clearance did not affect the time of Hb and Hct equilibration after RBC transfusion [6,8]. Two studies in neonates also showed no differences in Hct at one and six hours [9] as well as 15 min and six hours [10] after 10 ml/kg RBC transfusion. To sum up, data from this study and previously mentioned studies [6,8–10] supported the concept of monitoring Hb and Hct within one hour of transfusion to assess the need for further intervention.

Conversely, some studies revealed conflicting data [10,11]. A cross-sectional study conducted in Bangladesh included 100 patients with a mean age of 24 years and showed a statistically significant difference in the mean increase of Hb at six hours (0.39 g/dl) and 24 h (1.14 g/dl) after transfusion [11]. However that study used one unit of fresh whole blood as therapy instead of RBC as did some other studies and this may well influence the results as the whole blood would contain plasma which would affect volume distribution in the body [6,8–10]. Another study in 40 neonates and young infants demonstrated that packed cell volume (PCV) at one-hour post transfusion was similar to that at six-hours but was significantly different from that at 12, and 24-h. The results also showed that Hct equilibration had occurred at 12 h after RBC transfusion [12]. The differences in age as well as causes of anemia and concurrent treatment may explain the variation in results among these trials.

There were some limitations, this study was not designed to follow the Hb and Hct at the different time points in the same patient. However, the baseline characteristics and confounding factors that might affect the results were not significantly different between groups. A further limitation is that the sample size in our study was small and in a future study the number of patients would be increased. In addition, other factors which were not assessed as a continuous variable could have had an impact on the outcomes, including volume of other fluids both intravenously and oral route, and assessment of blood volume of each patient. Another limitation was that the majority of the patients in this study were male with anemia from post-orthopedic surgery. Further studies could consider enrolling patients with various causes of anemia and also a larger sample size would give weight to the statistical significance and determine the concordance of the results.

In conclusion, the Hb level and Hct after transfusion of a unit of RBC were similar at one, four and 24 h indicating that equilibration of blood concentration was achieved by this time point.

Authorship contributions

K.K. collected and analyzed the data, and wrote the manuscript. A.T. designed the research, obtained the research grant, analyzed the data, and revised the manuscript. E.R. and K.F. wrote and revised the manuscript. S.H. wrote and revised the manuscript and gave critical comments. S.K. performed blood tests on the patients. A.L., D.P., T.R., C.C., and L.N. revised the manuscript. All authors approved final version of the manuscript.

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