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Annals of Pediatrics & Child Health

Research Article

Assessment of Haemoglobin Concentration Increment after Packed Red Blood Cell (PRBC) Transfusion in Children seen at the Emergency Unit of a Tertiary Hospital in Southeast, Nigeria

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Submitted: 19 May 2025

Accepted: 19 June 2025

Published: 21 June 2025

ISSN: 2373-9312

Keywords

- Blood transfusion
- Children
- Emergency room
- Haemoglobin concentration
- Increment

Abstract

Severe anaemia in children is a life-threatening condition that is amenable to prompt blood transfusion. Previous data reported that the transfusion of 5 ml/kg body weight of packed red blood cell (PRBC) increased the haemoglobin (Hb) concentration by about 1g/dl. This study was aimed at assessing the increment in Hb concentration after PRBC transfusion in children using 10ml/kg body weight.

This was a longitudinal observational study carried out in the Children Emergency Room of a tertiary center in Nigeria and involved 108 children aged 1-10 years without active bleeding or significant haemolysis that were transfused with10ml/kg body weight of PRBC. The Hb concentration was measured using a portable haemoglobinometer before the blood transfusion,1,6, 12 ,24 and 48th-hour after blood transfusion.

The mean age of the participants was 4.6 ± 2.7 years with a male to female ratio of 1:0.7. A total of 52.8% and 59.2% of the participants had pre-transfusion Hb levels of 5g/dl or less and received between 150-250mls of packed red cells respectively. The mean pre-transfusion Hb concentration was 5.1±1.4 g/dl while the mean post-transfusion Hb concentration was10.5 ±1.3g/dl. Accordingly, transfusion of 10ml/kg body weight of PRBC increased Hb concentration from its baseline by approximately 5g/dl. In conclusion, there is a Hb rise of 5g/dl after transfusion of 10ml/kg of PRBC..

INTRODUCTION

Blood transfusion is an important treatment modality for severe anaemia. In paediatrics care, transfusion of packed red blood cell (PRBC) or whole blood to increase the oxygen carrying capacity of haemoglobin (Hb) in order to correct or prevent tissue hypoxia in the management of severe anaemia is a well-known practice [1]. Severe malaria is the most common cause of severe anaemia requiring blood transfusion in Nigerian children [2,3]. Other indications for blood transfusion in children include; sepsis, severe acute malnutrition and sickle cell anaemia [4]. Previous data showed that the transfusion of 5 ml/kg body weight of PRBC increases the haemoglobin (Hb) concentration by about 1g/dl [5]. However, the above assumption does not take into account the variances in the Hb concentration of the packed red blood cell transfused. Also, the formula-based calculation of transfusion volume in children has not been precise in low income setting like ours due to unavailability of paediatric blood pack and limited availability of equipment that control the rate and volume of transfused blood.

Parvis et al. [6], reported a Hb increment of 1.92g/dl following transfusion of patients in intensive care unit. Audu et al. [7], in Abuja, Nigeria reported haematocrit increment of 14.7 % (approximately Hb concentration of 4.9g/dl) following PRBC transfusion. However, Oseni et al. [8], in Owo, South-west Nigeria reported a haematocrit increment of 11.5% (approximately Hb concentration of 3.8 g/dl) following transfusion of 15ml/kg body weight of sedimented red cells.

METHODOLOGY

A longitudinal observational study involving108

children aged 1-10 years admitted to Children Emergency Room of a tertiary care center with indications for PRBC transfusion from September 2020 to February 2021. All patients with significant haemolysis or active bleeding were excluded.

A structured pre-tested questionnaire was used to obtain information on socio-demographics. Informed consent was obtained from caregivers, weight, height/length, and temperature of each participant was measured. The exact volume of blood to be transfused was measured using the blood weighing scale. Capillary blood sample was collected for Hb estimation using a portable haemoglobinometer (VERI-Q RED haemoglobinometer, South Korea) [9].

All the required equipment such as single-use lancet, pen-shaped painless lancet device, 70% alcohol pads, micro-pipettes, portable haemoglobinometer, and micro-cuvettes were assembled and hand hygiene was performed using soap and water and hands dried using a single-use towel. Putting on a well fitted single-use glove, located the site of puncture (middle finger or ring finger), which was cleaned with 70 % alcohol in accordance with WHO guideline [10]. Lidocaine gel was used to relieve pain. The site was allowed to dry so that the blood oozing out after puncture was not diluted and as such preventing error in Hb reading. The site was punctured using a painless lancet device set at a depth of 1.5 mm or less for participants less than 8 years and 2.4 mm or less for participants > 8years [10]. The capillary blood of about seven micro litres (µLs) was collected without squeezing the finger using a micro-pipette. The blood was introduced immediately onto the micro-cuvette of the already assembled haemoglobinometer which displayed Hb result of the participant on the screen within 5 seconds and the value recorded in the participant's study proforma. This Hb assessment was repeated using the already mentioned steps just before blood transfusion (baseline Hb) 1,6,12,24 and at 48 hours after blood transfusion and each value recorded appropriately in the study proforma of participants. A total of 42 µLs of blood was used in the six serial capillary blood sampling and this blood volume was not significant to cause iatrogenic anaemia when compared to other methods of Hb estimation [11].

The portable haemoglobinometer chamber was kept clean and dry and the micro-cuvettes stored in an air-tight container to ensure accuracy. The device was standardized after every tenth participant; two tests were done and values compared for quality control purposes using the laboratory auto-analyzer method [12]. The duration of storage of blood product, haemoglobin concentration of donor blood and pre-transfusion haemoglobin of participant and post-transfusion Hb were each recorded in the study proforma

Data Analysis

The data collected were entered into IBM statistics, version 25 Chicago, USA. Accuracy of the data entered was ensured by double-check entry approach. Descriptive statistics (mean and standard deviation) were calculated for continuous variables while frequency and percentage were calculated for categorical variables. To further gain more information, some continuous variables (Age, BMI, Pre-Transfusion Hb, Donors Hb, Volume of PRBC transfused and Duration of storage of PRBC) were categorized and their descriptive statistics (frequency and percentages) calculated. Mean difference in the Hb at different post-transfusion times were determined using repeated sample Analysis of variance (ANOVA) while ordinary ANOVA/independent t-test was used to ascertain mean differences in Hb among categories of sex, Age, BMI, Pre-transfusion Hb concentration, Donors Hb concentration, Volume of PRBC transfused and duration of storage of PRBC. A multivariate regression model was adopted to ascertain the independent predictors of changes in Hb concentration such as sex, Age, BMI, Pre-transfusion Hb concentration, Donors Hb concentration, Volume of PRBC transfused and duration of storage of PRBC. The level of significance was taken as $p< 0.05$.

RESULTS

The mean age of the participants was 4.6 ± 2.7 years with a male to female ratio of 1:0.7. The mean weight ± SD of the participants was 18.3 ± 6.6kg. The mean height ± SD was 104.3 ± 26.1cm with a range of 70-160cm. The mean SD volume of PRBC transfused was 183.3±65.4ml. The pre-transfusion Hb concentration was 5.1±1.4g/dl while the post-transfusion Hb concentration was 10.2±1.5g/dl (Table 1 and Table 2).

The duration of storage of PRBC was between 1-4days for 68 participants (63%) whereas 40 participants (37%) received PRBC stored between 5-7days. A total of 39 participants (36.1%) received PRBC <150 ml, 64 participants (59.2%) received PRBC between 151-250 ml while 5 participants (4.6%) received PRBC >250 ml. Blood donors with Hb concentration between 12-13 g/dl were 24 (22.2%), 66 donors (61.1%) had Hb concentration between 13.1-14g/dl while 18 (16.7%) donors had Hb concentration of >14g/dl. Participants with pre-transfusion Hb concentration of ≤ 5g/dl were 57(52.8 %) while 51 participants (47.2 %) had pre-transfusion Hb concentration of >5g/dl [Table 3].

Table 1: Distribution of the diagnosis of participants, donor Hb concentration, duration of storage of PRBC, volume of PRBC transfused and the pre-transfusion Hb concentration of participants.

Variable	Values
Diagnosis of participants, n (%)	
Severe Malaria anaemia	83(76.9)
Sepsis	30(23.1)
Donor blood group, n (%)	
O-	9(8.3)
O+	58(53.7)
A+	26(24.1)
B-	4(3.7)
B+	11(10.2)
Duration of storage of PRBC (days), n (%)	
1-4	68(63.0)
5-7 >7	40(37.0) 0(0.0)
Volume of PRBC transfused (ml), n (%)	
<150	39(36.1)
151-250	64(59.2)
>250	5(4.6)
Volume of PRBC transfused (ml), Mean (SD)	183.3(65.4)
Volume of PRBC transfused (ml), (min, max)	(,80, 360)
Donor Hb concentration (g/dl), n (%)	
12-13	24(22.2)
13.1-14 >14	66(61.1) 18(16.7)
Donor Hb concentration, Mean (SD)	13.5(0.7)
Donor Hb concentration, (min, max)	(,11.0, 15.3)
Pre-Transfusion Hb (g/dl), n (%)	
≤5	57(52.8)
>5	51(47.2)
Pre-Transfusion Hb, mean (SD)	5.1(1.4)
Pre-Transfusion Hb, (min, max)	(,2.3, 8.7)

SD-standard deviation, n=frequency, %=percent, min=minimum, max=maximum

Table 2: Socio-demographics and basic health information of study participants.

Variables	Frequency (%)
Age group (in years)	
1-5	70(64.8)
6-10	38(35.2)
Gender	
Male	65(60.2)
Female	43(39.8)
Socio-economic class	
Lower class	57(52.8)
Middle class	21(19.4)
Upper class	30(27.8)

Changes in Haemoglobin Concentration and Haemoglobin Concentration Increment over Time

A repeated sample ANOVA was adopted to analyze the mean Hb concentration at different post-transfusion time points with Duncan post-hoc test. The mean pre-transfusion Hb concentration was significantly different ($p<0.05$) from the mean post-transfusion Hb concentrations at all-time points. The mean 6-hour post-transfusion Hb concentration was significantly ($p<0.05$) higher than the mean 1-hour post-transfusion Hb concentration. However, there was no statistically significant ($p>0.05$) difference between the mean 6-hour post-transfusion Hb concentration and the 12th, 24th and 48 hours. The increments in Hb concentration from baseline at 1, 6, 12, 24 and 48 hours after-transfusion were 1.7, 5.1, 5.3, 5.3 and 5.3g/dl respectively. The peak percentage increment in Hb concentration (from baseline) occurred at 12 hours post-transfusion (50.9%) as shown in Table 4.

Table 3: Distribution of the pre-transfusion Hb of participants, duration of storage of PRBC, volume of PRBC of participants and donors' Hb

Variable	Frequency (%)
Pre-transfusion Hb of participants ≤ 5g/dl	57(52.8)
>5g/dl	51(47.2)
Duration of storage of PRBC (days)	
1-4	68(63.0)
5-7 >7	40(37.0) 0(0.0)
Volume of PRBC transfused (ml)	
<150	39(36.1)
150-250	64(59.2)
>250	5(4.6)
Donor Hb concentration (g/dl)	
12-13	24(22.2)
13.1-14 >14	66(61.1) 18(16.7)

A multivariate regression model was adopted to examine the relationship between the changes in the Hb concentration and age of the recipient, gender, body mass index, pre-transfusion Hb concentration, Hb concentration of donor blood, volume of packed red blood cell transfused and duration of storage of packed red blood cell. The univariate aspect shows the relationship between the variables aforementioned and an observed change in Hb concentration at each time point. A significant relationship was observed between changes in haemoglobin concentration, pre-transfusion Hb concentration ($p=<0.001$) and donor's haemoglobin concentration ($p=0.008$), as shown in Table 5.

DISCUSSION

After red cell transfusion, a rise in Hb concentration occurred over time until a final level of Hb concentration (equilibration) was reached. This study showed the expected immediate rise in Hb concentration after PRBC transfusion as documented by previous studies [6-8,13-15]. There was a significant difference between the pre-transfusion Hb concentration (baseline) and the post-transfusion Hb concentration at 1, 6, 12, 24 and 48 hours after transfusion and this is in agreement with the findings of other studies [1,7,16-22]. The 6th-hour post-transfusion Hb concentration was significantly higher than the pre-

Table 4: Hb concentration increment with time.

Post transfusion time (hours)	Pre-transfusion Mean Hb concentration	Post-transfusion Mean Hb concentration ±SD	p*	Increment in Hb	% Increment in Hb
1 hour	5.1±1.4	6.8±1.5	<0.001	1.7	32.9
6 hours	5.1±1.4	10.2 ±1.5	<0.001	5.1	50.0
12 hours	5.1±1.4	10.4±1.4	0.493	5.3	50.9
24 hours	5.1±1.4	10.5±1.4	0.742	5.3	50.5
48 hours	5.1±1.4	10.5±1.7	0.371	5.3	50.5
	F	265.249			
	p-value	<0.001			

Table 5: Multivariate Regression of the changes in Hb concentration with variables

Variable	Multivariate Test		
	Δ	F	P
Intercept	0.806	4.611	0.001
Sex	0.917	1.734	0.134
Age	0.969	0.605	0.696
BMI	0.945	1.128	0.351
Pre-transfusion Hb concentration	0.357	34.55	<0.001
Donors' Hb concentration	0.851	3.355	0.008
Volume of PRBC transfused	0.926	1.540	0.185
Duration of storage of PRBC	0.973	0.541	0.745

Δ-Wilks' Lamda statistic value, p<0.05 indicates significance.

transfusion (baseline) and the 1-hour post-transfusion Hb concentration, but similar to the 12th, 24th and 48th- hour post-transfusion Hb concentration.

The increment in Hb concentration from the baseline following transfusion of 10 ml/kg body weight of PRBC as observed in this study at the 6th-hour post-transfusion time was 5.1g/dl. This implies that at the 6th-hour post-transfusion time (equilibration time), transfusion of 10 ml/kg body weight of PRBC increased the Hb concentration from its baseline value by approximately 5g/dl. This finding is similar to that of Audu et al. [7], in Abuja, Nigeria who reported haematocrit increment of 14.7 % (approximately Hb concentration of 4.9g/dl) at the equilibration time following transfusion of PRBC. However, Oseni et al. [8], in Owo, South-west Nigeria reported a haematocrit increment of 11.5% (approximately Hb concentration of 3.8 g/dl) following transfusion of 15ml/kg body weight of sedimented red cells. The difference in Hb concentration or haematocrit increment from baseline between this study and that by Oseni et al. [8], may be due to the difference in blood products used, Hb concentration of donor blood and volume of the blood product transfused.

In this index study, there was a significant difference between the changes in Hb concentrations at different time points and the pre-transfusion Hb concentration of participants. As expected, the mean post-transfusion Hb value of participants with pre-transfusion Hb value of ≤5g/dl was consistently lower than those of participants with pre-transfusion Hb value of > 5g/dl at all time points since participants were transfused with similar volumes of packed red blood cells per kg body weight.

Also, the linear regression analysis showed that the pre-transfusion Hb concentration, donor Hb concentration and the duration of storage of PRBC accounted for 65% of the changes seen in Hb concentration at 6 hours post-transfusion with the pre-transfusion Hb concentration responsible for 56.1% of these changes suggesting a significant positive relationship between the pre-transfusion Hb concentration and the changes in Hb concentration. This implies that the lower the pre-transfusion Hb concentration, the lower the post-transfusion Hb concentration, signifying that participants with very low pre-transfusion Hb concentration are most likely to require additional blood transfusion in the correction of severe anaemia.

The increment in Hb concentration from the baseline following transfusion of 10 ml/kg body weight of PRBC as observed to peak at 12th hour post-transfusion with a value of 5.3g/dl, suggesting that transfusion of 10 ml/kg body weight of PRBC increased the Hb concentration from its baseline value by approximately 5g/dl. This finding is similar to that of Audu et al. [7], in Abuja, Nigeria who reported haematocrit increment of 14.7 % (approximately Hb concentration of 4.9g/dl) at the equilibration time following transfusion of PRBC.

However, Shrestha et al. [23], reported a Hb increment of 2.9g/dl after transfusion of 14.2ml/kg body weight of packed red blood cells with a mean haematocrit of 57%. However, patients with significant haemolysis were not excluded in their study and that may have affected the result.

Oseni et al. [8], in Owo, South-west Nigeria reported a haematocrit increment of 11.5% (approximately Hb concentration of 3.8 g/dl) following transfusion of 15ml/kg body weight of sedimented red cells. The difference in Hb concentration or haematocrit increment from baseline between this study and that by Oseni et al. [8], may be due to the difference in blood products used, Hb concentration of donor blood and volume of the blood product transfused.

This study showed a relationship between donors Hb and changes in Hb concentration implying that the higher the donors Hb, the higher the rate of rise of Hb concentration. This is similar to the findings of Pilania et al. [21], who reported that the volume of PRBC transfused, baseline haematocrit of the neonate, and haematocrit of donor blood independently determined the rise in post-transfusion haematocrit. This study, did not however,

show any relationship between the age of recipient, gender, body mass index, volume of PRBC transfused, duration of storage of PRBC and changes in Hb concentration. Transfusion of 10 ml/kg body weight of PRBC increased the Hb concentration from its baseline value by approximately 5g/dl.

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