

Post-transfusion Haemoglobin Increment Following Packed Red Blood Cell Transfusion and Associated factors Among Children With Sickle Cell Anemia At Tertiary hospital in Tanzania: A Retrospective Observational Study

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Research Article

Keywords:

Posted Date: October 21st, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11184271/v1>

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Additional Declarations: No competing interests reported.

Abstract

Sickle cell anemia is an inherited hemoglobin disorder caused by a point mutation in the β -globin gene, resulting in the substitution of valine for glutamic acid at position 6. Blood transfusion is a cornerstone in managing selected complications of sickle cell anemia. However, evidence on post-transfusion hemoglobin increment among children with sickle cell anemia in resource-limited settings remains limited.

This retrospective study was conducted from 2024 to 2026 among children with sickle cell anaemia diagnosed by Hemoglobin Electrophoresis aged < 14 years who received packed red blood cell (PRBC) transfusion at 10 mL/kg. The mean difference between pre- and post-transfusion hemoglobin concentrations was assessed using a paired t-test, while Spearman's correlation was used to assess associations between hemoglobin increment and selected characteristics.

A total of 100 children were included. Following PRBC transfusion, the mean hemoglobin increment was 2.86 ± 1.6 g/dL. Hemoglobin increment was significantly negatively correlated with pre-transfusion hemoglobin concentration (Spearman's $r = -0.476$, $p < 0.0001$). Age ($r = -0.206$, $p = 0.324$) and body weight ($r = -0.153$, $p = 0.998$) were negatively correlated with hemoglobin increment, but these associations were not statistically significant.

Children with sickle cell anemia demonstrated a substantial but variable hemoglobin increment following 10 mL/kg PRBC transfusion. Post-transfusion hemoglobin monitoring may help assess transfusion response and guide subsequent transfusion decisions.

Background

Sickle cell anemia (SCD) is an inherited hemoglobin disorder caused by a point mutation in the β -globin gene, resulting in the substitution of valine for glutamic acid at position 6 of the beta-globin chain(1, 2). This leads to the production of sickle hemoglobin (HbS), this promotes red blood cell sickling, chronic hemolysis, and vaso-occlusive complications.(3, 4) As a consequence, affected children may develop moderate to severe anemia among other sickle cell related complications which may require blood transfusion(5–9). Blood transfusion remains a cornerstone of sickle cell anemia management, particularly in many developing countries. In sickle cell anemia patients, blood transfusions can be given for various indications including acute severe anemia, acute chest syndrome, splenic sequestration, and during top-up transfusions.(6, 10–12)

In high-income countries (HICs), transfusion of 5 mL/kg of packed red blood cells (PRBCs) has been reported to result in a mean hemoglobin increment of approximately 1 g/dL in the general pediatric population(13). These observations have contributed to the development of pediatric transfusion guidelines aimed at optimizing transfusion practices while minimizing complications such as transfusion-associated circulatory overload.(14, 15) However, in many developing countries, pediatric PRBC transfusion is commonly guided by a dose of 10 mL/kg however the post transfusion increment

hemoglobin based on this dose in pediatric sickle cell patient si still uncertain due to limited study which have evaluated its impact following transfusion .(12, 16)

Sickle cell anemia patients, however, demonstrate different physiological characteristics compared to the general pediatric population, including chronic hemolysis, reduced survival of transfused red blood cells and lower baseline hemoglobin concentrations, which could affect the post-transfusion hemoglobin increment following PRBC transfusion in this population.(17, 18) Owing to these features, the accuracy of post-transfusion hemoglobin estimation in this population with a dose of 10 mL/kg remains uncertain.

Despite the widespread use of blood transfusion in pediatric sickle cell patients for various indications, there is still paucity of published evidence regarding expected post-transfusion hemoglobin increments in this population particularly in low- and middle-income countries (LMICs),this highlights the need for studies evaluating hemoglobin responses following PRBC transfusions. This will improve our understanding of post-transfusion hemoglobin changes, assist clinicians in assessing transfusion effectiveness and optimizing transfusion decisions. Thus, this study aimed to determine the mean increment in hemoglobin concentration and its associated factors following PRBC transfusion among children with sickle cell disease younger than 14 years at Mbeya Zonal Regional Referral Hospital .

Methods

Study design and setting

This was a hospital-based retrospective observational study conducted at Mbeya Zonal Referral Hospital (MZRH), Tanzania. Mbeya Zonal Referral Hospital a tertiary referral hospital located in Mbeya City in the Southern Highlands of Tanzania. The hospital serves as a referral center for Mbeya, Songwe, Katavi, Rukwa, Njombe, Iringa, and Ruvuma regions and provides specialized medical services, including pediatric hematology care and blood transfusion services.

Study population and sampling method.

The study included children aged less than 14 years with confirmed sickle cell anemia diagnosed by Hb-Electrophoresis who were admitted to MZRH during the study period and received PRBC transfusion at a dose of 10 ml/kg. Eligible participants had documented pre and post-transfusion hemoglobin measurements obtained within 72 hours after transfusion and with complete clinical and laboratory records for review. Participants were enrolled using a consecutive enrollment approach.Participants with missing pre- or post-transfusion hemoglobin measurements and incomplete medical records were excluded from the study.

Data collection

Data were retrospectively extracted from the hospital electronic medical record system using a standardized data extraction form. Information collected included demographic characteristics (age, sex, and body weight), pre-transfusion hemoglobin concentration and post-transfusion hemoglobin concentration measured within 72 hours after transfusion. Ethical approval was obtained from Mbeya Medical Research and Ethic Committee (Ref No:SZEC-2439/R.A/24/01) and permission from Mbeya Zonal Referral Hospital administration. Informed consent was obtained from parents care givers before the start of the study, researchers ensured confidentiality and privacy by excluding patient's name and identifying information. Analyzed data are not publicly available as they contain potential patient information and are subject to institutional and ethical restrictions. These data may be obtained from the corresponding author on reasonable request subject to approval by relevant institution ethics and Mbeya Zonal Referral Hospital.

Study variables

The primary outcome variable was post-transfusion hemoglobin increment, calculated as the difference between post-transfusion and pre-transfusion hemoglobin concentrations measured in g/dl. Independent variables included age, sex, body weight, and baseline pre-transfusion hemoglobin concentration.

Statistical analysis

Data were entered into Microsoft Excel for cleaning and exported to IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA) for analysis. Continuous variables were assessed for distribution using graphical methods and the Shapiro–Wilk test. Normally distributed variables were summarized using means and standard deviations, while categorical variables were presented using frequencies and percentages. The mean difference between pre-transfusion and post-transfusion hemoglobin concentrations was assessed using a paired t-test. Associations between continuous variables and hemoglobin increment were evaluated using Spearman correlation analysis. Factors independently associated with post-transfusion hemoglobin increment were assessed using multivariable linear regression analysis. Regression coefficients (β), 95% confidence intervals (CIs), and p-values were reported. Statistical significance was defined as a two-sided p-value of < 0.05 .

Results

A total of 100 children with sickle cell disease aged < 14 years who received packed red blood cell (PRBC) transfusion and had post-transfusion hemoglobin measurements within 72 hours were included in the study. Among the participants, 46% were male, and 54% were female. The mean age of participants was 6 ± 4 years, with a mean body weight of 19.4 ± 8 kg. A detailed summary of sociodemographic characteristics is presented in Table 1.

Table 1
Social demographic characteristic of study participants.

Characteristics	Category	Frequency(n)	Percentage(%)
Age groups	10–13 years	21	21
	5–9 years	33	33
	< 5 years	46	46
Sex	Male	46	46
	Female	54	54
Weight groups	≥ 30	9	9
	20-29.9 kg	35	35
	10-19.9	47	47
	< 10 kg	9	9

Pre-transfusion and post-transfusion hemoglobin concentration measurements

The mean pre-transfusion hemoglobin concentration was 5.7 ± 1.2 g/dL. Following transfusion with packed red blood cells at a dose of 10 mL/kg, the mean post-transfusion hemoglobin increment was 2.86 ± 1.6 g/dL. A detailed summary of of post transfusion hemoglobin increament following transfusion of PRBC by dose of 10mL/kg is presented in Table 2.

Table 2
Distribution of transfusion characteristics and post-transfusion hemoglobin response following PRBC transfusion at approximately 10 mL/kg.

Characteristics	Category	Frequency	Percentage
Number of Blood transfusion	1	66	66
	2	29	29
	3	5	5
Standardized Hb response	0.8–1.4 g/dl	9	9
	> 1.4 g/dl	85	85
	< 0.8 g/dl	6	6
Footnote: Category 1 ,2 and 3 represents frequency of PRBC transfused by dose of 10mL/kg.			

Factors associated with post-transfusion hemoglobin increment

In this study, post-transfusion hemoglobin increment was significantly associated with pre-transfusion hemoglobin concentration, demonstrating a significant negative correlation (Spearman’s $r = -0.476$, $p < 0.0001$). Age and body weight were also negatively correlated with post-transfusion hemoglobin increment, with correlation coefficients of -0.206 and -0.153 , respectively. However, after adjusting for other factors in the multivariable linear regression model, neither age nor body weight showed a significant independent association with post-transfusion hemoglobin increment. A detailed results of multi-variate linear regression and spearman correlation are presented in Table 3.

Table 3
Factors associated with post-transfusion hemoglobin increment among children with sickle disease.

Factors	Spearman r	Adjusted β coefficient	95% CI	p-value
Pre-transfusion Hb (g/dL)	-0.476	-0.453	-0.696 to -0.210	< 0.0001
Age (years)	-0.206	-0.081	-0.243 to 0.081	0.324
Weight (kg)	-0.153	-0.0001	-0.069 to 0.069	0.998

Footnote

The dependent variable was post-transfusion hemoglobin increment. Adjusted β coefficients were derived from multivariable linear regression.

Discussion

This study evaluated post-transfusion hemoglobin increment among children with sickle cell disease receiving approximately 10 mL/kg of packed red blood cells. The mean hemoglobin increment observed was 2.86 ± 1.6 g/dL. This finding is comparable to that reported by Shrestha et al., who observed a mean hemoglobin increase of 2.9 ± 1.4 g/dL following PRBC transfusion at a mean volume of 14.2 ± 5.8 mL/kg among the general pediatric population. The similarity between these findings may be explained by the use of comparable weight-based transfusion volumes, which deliver similar amounts of red cell mass relative to body weight and consequently produce comparable haemoglobin increments.(13)

A contrary study by Ezra Enya et al. in Nigeria reported a greater post-transfusion hemoglobin increment following administration of 10 mL/kg of PRBCs(19).The higher hemoglobin increment observed compared with our study may be explained by differences in donor hemoglobin concentration and the storage duration of donor blood, both of which were not available in our retrospective dataset and have been shown to significantly influence post-transfusion hemoglobin increment.(20, 21)

Furthermore, these findings suggest that the commonly cited hemoglobin increment of approximately 1 g/dL, extrapolated from adult-based studies, may underestimate the expected hemoglobin response when a 10 mL/kg transfusion dose is administered in children. Consequently, reliance on this

assumption may increase the risk of exceeding recommended post-transfusion hemoglobin targets. In children with sickle cell disease this may result into increase blood viscosity and potentially predispose patients to complications associated with over-transfusion, including stroke.(5, 15).

Although age and body weight demonstrated weak negative correlations with hemoglobin increment in the unadjusted analysis, these associations were not significant after controlling for other factors. This has been similar to studies done in HICs.(22) This may be explained by the weight-based approach used in pediatric transfusion, as children with greater body weight have larger circulating blood volumes which necessitates proportionally larger transfusion volumes, resulting in comparable hemoglobin responses across different age and weight groups.

In this study, pre-transfusion hemoglobin concentration was the only factor independently associated with post-transfusion hemoglobin increment. A significant inverse relationship was observed, indicating that children with lower baseline hemoglobin concentrations experienced a greater hemoglobin increase following transfusion similar to study done by aidech et al.(17) This finding is biologically plausible because patients with lower baseline hemoglobin levels have a greater capacity for hemoglobin increment following replacement of circulating red cell mass

Similar observations have been reported in pediatric transfusion studies, where baseline hemoglobin concentration was a stronger predictor of hemoglobin increment than demographic characteristics such as age and weight. However, further multi-center prospective studies are required to confirm these findings among children with sickle cell anemia and determine whether they are generalization across different clinical settings and transfusion practices. Overall, our findings suggest that children with sickle cell anemia receiving approximately 10 mL/kg of packed red blood cells experience a greater hemoglobin increment than traditionally assumed, highlighting the need for evidence-based pediatric transfusion guidelines specific to this population and patients individualization.

Limitations

1. This study was conducted at a single tertiary referral hospital with limited number of participants, which may limit the generalizability of the findings.
2. Potential confounding factors, including red blood cell storage duration, hematocrit, and baseline medical conditions, were not evaluated and may have influenced the post-transfusion hemoglobin increment.

Conclusion

Our study demonstrated that children with sickle cell anemia receiving 10 mL/kg of packed red blood cells achieved a mean post-transfusion hemoglobin increment greater than that commonly expected from traditional transfusion estimates, which are largely extrapolated from adult populations. However, considerable inter-individual variability was observed, and lower pre-transfusion haemoglobin was independently associated with a greater haemoglobin increment.

Given the observed variability, clinicians in our setting and similar resource-limited centres individualize transfusions decisions based on the pre-transfusion hemoglobin concentration, recognize the substantial inter-individual variability in post-transfusion haemoglobin increment, and assess the post-transfusion haemoglobin response after each transfusion before deciding on subsequent transfusion. rather than assuming a uniform haemoglobin increment following a fixed 10 mL/kg dose. This will be crucial in avoiding unnecessary additional transfusion.

Declarations

Competing interest

The authors declare they have no conflict of interest.

Funding

No funding was received for the works.

Author Contribution

H.M- Conceptualisation of the research ,Data collection and report writing A.C- Conceptualisation and Discussion A.M-Conceptualisation and Discussion M.S-Discussion Y.K-Data analysis and interpretation

Acknowledgment

We would like to express our sincerely gratitude to the hospital administration, research department team , colleague at pediatric department , family and friends for their incredible support and dedication toward completion of this work I also would sincerely appreciate tremendous work done by Mr. Yusuph Kilanga on data analysis for this works. AI was used cautiously in language polishing in some paragraph.

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