Rise of Haemoglobin after Blood Transfusion in Children Without Active Bleeding

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ABSTRACT

Introduction: Blood transfusion is a common practice among children with severe anaemia. A common assumption among physician is that transfusion of 5 ml/kg packed red cell will increase the haemoglobin of the recipient by 1 gm/dl. This study was aimed at assessing the effect of volume of blood product and hematocrit of donor blood in the rise of haemoglobin concentration after transfusion in children without active bleeding.

Methods: A prospective observational study was conducted in 32 children aged between one to 15 years without active bleeding who received blood transfusion in Paediatric ward and Paediatric Intensive Care Unit of a tertiary care hospital in Nepal from December 2013 to November 2014. Haemoglobin levels before and after transfusion were compared and any adverse reactions that occurred during transfusion were recorded. Hematocrit of each donor blood was measured.

Results: The overall rise of haemoglobin after transfusion of blood product with hematocrit of 53 $\pm$ 8.9 % at the rate 14.5 $\pm$ 6.0 ml/kg was 2.7 $\pm$ 1.4 gm/dl. The rise of haemoglobin after transfusion of whole blood with hematocrit of 38.8 $\pm$ 4.4% at the rate 15.5 $\pm$ 6.9 ml/kg was 1.8 $\pm$ 1.2 gm/dl. The rise of haemoglobin after transfusion of packed cell with hematocrit 57.0 $\pm$ 4.8 % at the rate 14.2 $\pm$ 5.8 ml/kg was 2.9 $\pm$ 1.4 gm/dl.

Conclusion: This study supports the general consensus of 1 gm/dl rise of haemoglobin after transfusion of packed red cell at 5 ml/kg.

Keywords: haematocrit; packed red cell; transfusion reaction; whole blood

INTRODUCTION

Blood transfusion, the transference of blood from the circulation of one individual to that of another for practical and therapeutic purposes,[1] is an integral part of the treatment of many infants and children.[2] In low-income countries, up to 52% of blood transfusions are given to children below five years of age.[3] Blood transfusions are frequently lifesaving but not without risks, and they should be given only when true benefits are likely.[4]

It is common assumption among paediatricians that the transfusion of 5 ml/kg of packed red blood cell increases the haemoglobin (Hb) concentration by about 1 g/dL.[5] However, such assumption does not take into account the variances in the hematocrit of the packed red blood cell. Moreover, the transfusion of calculated volume of blood 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. There is limited research done among paediatric population regarding blood transfusion. Therefore, this study presents an effort to correlate the effect of transfusion volume and hematocrit of blood products with haemoglobin increment after transfusion.

METHODS

A prospective observational study was conducted among children aged between one to 15 years admitted to Paediatric ward and Paediatric Intensive Care Unit of a tertiary hospital from December 2013 to November 2014. Patients who received blood transfusion either whole blood or packed red cell were enrolled. All the patients with active bleeding were excluded from the study.

Patient demographics recorded were age, sex, and weight (Table 1). Volume of blood to be transfused was calculated based on the patient's weight. Venous blood sample was drawn from patient just prior to blood product transfusion for estimation of haemoglobin level. Transfusion was completed over four to six hours and any transfusion reaction that occurred was recorded. Then venous blood sample was drawn from the patient within six to 12 hours of the completion of blood transfusion and post transfusion haemoglobin level was determined.

Hematocrit of the donor blood was determined by capillary centrifugation method in Micro Haematocrit Centrifuge (KUBOTA 3100, Japan) and then reading off the level of the red cell sediment on a microhematocrit scale (Microhaematocrit Capillary PCV Lineal Reader, China) and value of hematocrit of donor blood was recorded.

Paired t-test was used to correlate the association between the pre- and post- transfusion haemoglobin levels. Associations between variables (volume of the blood product transfused and hematocrit of the donor blood with the rise of haemoglobin) were calculated with Pearson's correlation coefficient. Multiple linear regression model was used to quantify their association in which rise in Hb was used as the dependent variable, and volume of transfusion per kg of body weight and hematocrit of the donor blood were used as the independent variable. Data was analysed using SPSS version 20.

RESULTS

A total of 54 patients received blood transfusion during the study period. Nineteen patients were excluded because of evidence of active bleeding. Of the remaining 35 patients, one patient's parent denied consent and two patients were unable to complete transfusion due to transfusion reaction. A total of 32 patients completed the study.

Table 1. Data of patients receiving transfusion

Variable	Number or range
Number of patients	32
Male : Female	3:1
Age (years)	1-15 (median:4)
Weight (kg)	6-38 (median:12)
Volume of blood transfused (ml/kg)	7.5-35(mean:14.5)
Hematocrit of transfused blood (%)	34-68 (mean:53)
Duration of transfusion (hours)	3-6 (mean:4.6)
Rise of hemoglobin (gm/dL)	0.4-7.4 (mean:2.7)

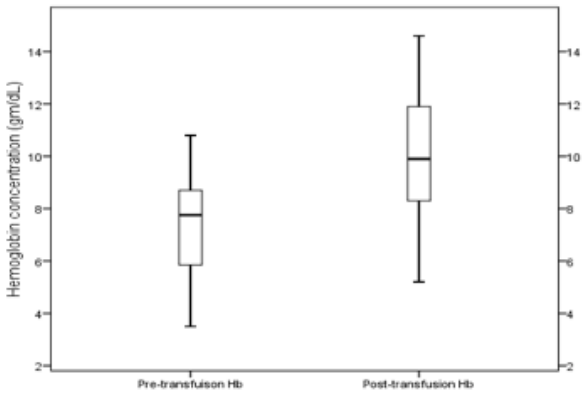

Figure 1. Hemoglobin level before and after transfusion. Box = interquartile range; line = median.

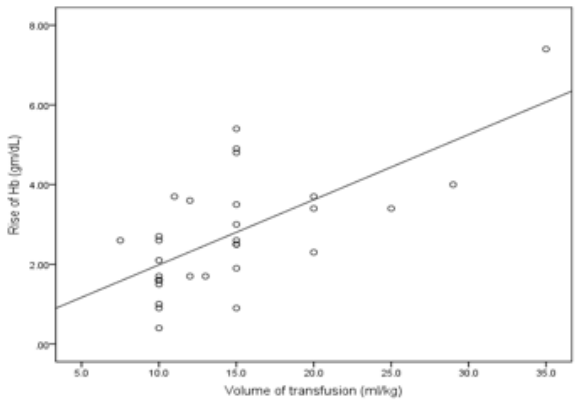

Figure 2. Scattered plot of volume of transfusion (ml/kg) versus rise of hemoglobin (gm/dL).

Demographic data of patients involved in the study is given in table 1.

The median age of patient included in the study was 12 years. Most patients, 21 out of 32 (25%), were in the age group of one to five years. Male to female ratio was 3:1. The weight of the patients varied from six to 38 kg, 12 kg being the median.

The mean volume of the blood product transfused was 14.5 ml/kg with standard deviation of 6.0, 7.5 - 35 ml/kg being the range. The haematocrit of the blood product varied from 34 - 68% with mean of 53.0 % and standard deviation of 8.9. The pre-transfusion haemoglobin range was 3.5 - 10.8 gm/dL (mean: 7.2 gm/dL; standard deviation: 2.0) whereas the post-transfusion haemoglobin ranged from 5.2 - 14.6 gm/dL (mean: 9.9 gm/dL; standard deviation: 2.3) [Fig. 1].

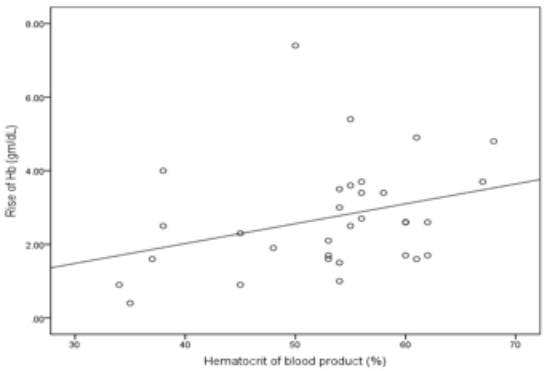

Figure 3. Scattered plot of haematocrit of blood product (%) versus rise of hemoglobin (gm/dL).

The rise of haemoglobin after transfusion of blood product with haematocrit of 53 ± 8.9% at the rate 14.5 ± 6.0 ml/kg was 2.7 ± 1.4 gm/dl. On sub-analysis of transfusion into whole and packed cell, it was found that increment in haemoglobin after transfusion of whole blood with haematocrit of 38.8 ± 4.4% at the rate 15.5 ± 6.9 ml/kg was 1.8 ± 1.2 gm/dL and after transfusion of packed cell with haematocrit 57.0 ± 4.8 % at the rate 14.2 ± 5.8 ml/kg was 2.9 ± 1.4 gm/dL. Transfusions were given over a mean duration of 4.6 hours with standard deviation of 0.8 hours.

Analysis of rise in haemoglobin after transfusion found a correlation of 0.77 ($p < 0.001$) using paired t-test. Rise in haemoglobin was strongly associated with volume of blood product transfused with a Pearson correlation coefficient of 0.66 whereas the haematocrit of the donor blood had Pearson correlation coefficient of 0.32 only. Scattered plots were drawn and regression lines fitted (Fig. 2 and 3). Multiple linear regression showed significant correlation of rise of haemoglobin with both volume of transfusion and haematocrit of blood product (p value: < 0.001, 0.001; standardised coefficient beta: 0.72, 0.42 respectively) with adjusted square R value of 0.61 and standard error of 0.95 i.e. 61% ± 0.95 variability in rise of haemoglobin was due to combined effect of volume of transfusion and haematocrit of donor blood, the volume of transfusion being the major contributor.

DISCUSSION

In this prospective, single - centre study the mean rise in haemoglobin concentration in children

without active bleeding was 2.9 g/dl after transfusion of average volume of 14.2 ml/kg of blood with mean haematocrit of 57%. The common assumption is that the transfusion of 5 ml/kg packed blood cells will result in a 1 gm/dl increase in the haemoglobin.[7,8] There is limited data from clinical trials comparing the increase in haemoglobin level pre- and post-transfusion in children. Statement available regarding the increase in haemoglobin in children after blood transfusion is also not uniform.

Chegondi et al. in their retrospective chart review study to evaluate the haemoglobin threshold for red cell transfusion in children admitted to a paediatric intensive care unit reported that the mean (± SD) pre-transfusion haemoglobin was 7.3 g/dl (± 1.20) and the mean post-transfusion haemoglobin was 9.83g/dl (± 1.97) after transfusing an average of 11.52 ml/kg (± 9.94) of packed red blood cells.[9] For the analysis, the patients were divided subdivided into four subgroups: acute blood loss, haematologic, unstable and stable groups. On subgroup analysis of patients, the mean rise of haemoglobin was similar for equal volume of blood transfused and comparable to our study. Giancarlo Liumbruno et al. concluded that transfusion of 10 ml/kg of red cell with haematocrit of 60% increases the Hb concentration by about 2 gm/dl in retrospective study done on paediatric intensive care charts of two years at Bristol Royal Hospital for Children.[5] Haematocrit of the donor blood was specified in this study and was comparable to our study. In the study conducted by Adedoyin OT et al. including a total of 172 patients admitted to the Emergency Children's Hospital of the University of Ilorin Teaching Hospital, the mean rise of haematocrit was 13.3% after transfusion of 15 ml/kg of packed red cell irrespective of pre-transfusion haematocrit.[10] The textbook of Paediatric Haematology states that in paediatric patients, a whole blood transfusion of 8 ml/kg will result in the increase in recipient haemoglobin (Hb) concentration by approximately 1 gm/dl and when packed cell with haematocrit 50% to 60% is used, 15 ml/kg is expected to raise the haemoglobin level by approximately 2 gm/dl.[11] Increment in post-transfusion haemoglobin stated is less compared to our study.

Patrik Davies et al. concluded that the equation, weight (kg) x increment in Hb (g/dL) x 3/ (haematocrit level of RBCs), should be used to calculate transfusion volumes.[12] The given equation makes the haematocrit of the donor blood as chief determinant of post transfusion haemoglobin level provided that there are no other confounding factors affecting the rise of haemoglobin. As haematocrit of the packed red cells can vary from 50% to 80% based on the preservative used for storage of blood, the post transfusion haemoglobin level can also vary even after transfusing same volume of blood if they have different haematocrit levels.[13,14] In order to address this issue, the haematocrit of individual donor blood was measured individually and to our knowledge, this is the first study in doing so. In addition, exact amount of weight-based volume of blood product was also guaranteed.

The possibility of ongoing intravascular haemolysis without external bleeding in patients with haemolytic anaemia was not evaluated in our study which might have reduced the extent of rise of post transfusion haemoglobin level. Use of intravenous fluids in addition to blood transfusion was not taken into account that might have affected the haemoglobin concentration. However, none of the patients had any drain losses including but not limited to chest drains and postoperative drains. The major limitation of our study is being a single centric with small sample size. However, it is expected that it shall definitely shed the light upon the subject of rise of haemoglobin post transfusion.

CONCLUSIONS

In our study, we found out that transfusion of 14.2 ml/kg of packed red blood cell with haematocrit of 57% will raise the haemoglobin level by 2.9 gm/dl. This is similar to the common assumption that the transfusion of 5 ml/kg of packed red cell with haematocrit of 60% will raise the haemoglobin concentration by 1 gm/dl.

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