Original Article

Effect Of Donor And Red Blood Cells Concentrate Characteristics On Recipient Hemoglobin Increment Following Red Blood Cells Transfusion In Pediatric Patients

[1]Dr. Muhammad Rizwan , [2] Dr. Amanullah Bhutto , [3] Dr. Urooj Yahya , [4] Dr. Jaweria Yousfani , [5]Gul Hassan Mahar , [6] Dr. Hira Naeem

[1]Associate Professor, Department of Pathology, Baqai Medical University Karachi
[2]Assistant Professor , Ghulam Mohammad Mahar Medical College Sukkur
[3]Assistant Professor, Department of Physiology, Swat Medical College, Khyber Medical University Peshawar, Pakistan Email: uroojyahya@yahoo.com
[4]Assistant Professor, Department of Dental Materials, Bhitai Dental and Medical College, Mirpurkhas, Pakistan
Email: Jaweriayousfani@gmail.com
[5]Medical Technologist, Liaqat Universty of Medical Health Science Jamshoro
[6]Assistant Professor, Baqai Institute of Pharmaceutical Sciences, Department of Pharmacology, Baqai Medical University, Karachi, Pakistan
Email: dr.hiranaeem@gmail.com
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Abstract

Introduction: Red blood cell (RBC) transfusion is a crucial and life-saving intervention for pediatric patients with anemia or other conditions that require rapid restoration of hemoglobin levels.

Objectives: The main objective of the study is to find the effect of donor and red blood cells concentrate characteristics on recipient hemoglobin increment following red blood cells transfusion in pediatric patients.

Material and methods: This retrospective observational study was conducted in one of the public hospitals of Karachi from 1st June 2022 till 1st June 2023. Demographic information, including age, sex, and weight, was recorded. Additionally, details about the primary diagnosis that led to the RBC transfusion was noted to account for differences in underlying medical conditions among the participants.

Results: Data was collected from 150 patients of both genders and the mean age was 8.5±3.2 years. The patients' primary diagnoses varied, with the most common indications for RBC transfusion being anemia due to chronic illnesses (45%), acute blood loss (30%), and surgical procedures (25%). The study found that the average pre-transfusion hemoglobin level among the participants was 8.0 g/dL (± 1.2 g/dL). After RBC transfusion, the post-transfusion hemoglobin level increased to an average of 9.2 g/dL (± 1.1 g/dL).

Conclusion: It is concluded that donor age and Rh blood group are essential determinants of Hb increment in recipients. Pediatric patients receiving blood from younger donors and Rh-positive donors showed significantly higher mean Hb increments compared to those from older donors and Rh-negative donors, respectively.

Keywords: RBC, Life-saving, Transfusion, Hemoglobin

Introduction

Red blood cell (RBC) transfusion is a crucial and life-saving intervention for pediatric patients with anemia or other conditions that require rapid restoration of hemoglobin levels. The success of this transfusion therapy depends not only on the availability of compatible blood products but also on various characteristics of the donor and the red blood cell concentrate [1]. Understanding the impact of these factors on recipient hemoglobin increment is vital in optimizing transfusion strategies and ensuring positive patient outcomes. Red blood cell

(RBC) concentrate transfusion is a potentially lifesaving intervention, yet the harms, benefits and scarcity of blood have to be balanced [2]. The transfusion of RBC concentrate is indicated in order to achieve a fast increase in supply of oxygen to the tissues, when the concentration of hemoglobin is low or oxygen carrying capacity is reduced and in the presence of inadequate physiological mechanisms of compensation. In pediatric patients, hemoglobin trigger demanding RBC transfusions varies according to the condition. Clinical assessment is vital. The usual dose of RBCs administered is 10-15 mL/kg leading to hemoglobin (Hb) increment of 2- 3 g/dL [3]. The selection of healthy blood donors becomes more important in this regard to prevent alloimmunization and other adverse reactions. In Pakistan, a huge chunk of children suffers from inherited disorders like Thalassemia, hemophilia, rare bleeding disorders (deficiencies of coagulation factors as fibrinogen, Factor (F) FII, FV, FVII, combined FV/FVIII, FX, FXI, and FXIII) and Platelet function defects (Glanzmann Thrombasthenia, Bernard Soulier syndrome, Storage pool defects etc.) who require frequent transfusions as a part of their therapy [4]. The quality and efficacy of RBC transfusions can be influenced by multiple factors, including the donor's age, sex, and health status, as well as the processing and storage conditions of the blood product. Furthermore, the recipient's age, weight, and underlying medical condition can also play a significant role in determining the response to transfusion [5]. Exploring the interplay between these variables and their effect on recipient hemoglobin increment is an essential step towards enhancing transfusion practices and minimizing adverse events in pediatric patients. Over the years, research in this area has shed light on several critical aspects of RBC transfusions. For instance, studies have shown that the length of storage and the method of preservation of RBCs can impact their functionality and survival after transfusion [6]. Additionally, investigations into the immunological compatibility between donor and recipient have highlighted the importance of considering minor blood group antigens to prevent adverse reactions and improve hemoglobin response. Moreover, emerging evidence suggests that certain characteristics of the donor, such as genetic polymorphisms related to oxygen-carrying capacity or red cell deformability, might influence the efficacy of the transfusion and the overall clinical outcome. Furthermore, recent advances in technology and our understanding of cellular biology have enabled researchers to delve deeper into the molecular mechanisms behind these observations, bringing us closer to personalized and targeted transfusion strategies [7].

Objectives

The main objective of the study is to find the effect of donor and red blood cells concentrate characteristics on recipient hemoglobin increment following red blood cells transfusion in pediatric patients.

Material and methods

This retrospective observational study was conducted in public hospitals of Karachi from 1st June 2022 till 1st June 2023.

Inclusion Criteria:

- Pediatric patients aged 0 to 18 years.
- Patients who received at least one red blood cell (RBC) transfusion during the study period.
- Patients undergoing RBC transfusions for various clinical indications, including but not limited to anemia due to chronic illnesses, acute blood loss, or as part of a surgical procedure.

Exclusion Criteria:

- Patients with incomplete or insufficient data in their electronic health records, which hinders the accurate calculation of hemoglobin increment following transfusion.
- Patients with known hematological disorders (e.g., sickle cell disease, thalassemia) that might confound the analysis of hemoglobin response to transfusion.

Data collection

For this retrospective observational study, data was collected from electronic health records (EHRs) of 150 pediatric patients who underwent red blood cell (RBC) transfusions. The data collection process was involving

the extraction of relevant variables from the EHR system for each patient. Demographic information, including age, sex, and weight, was recorded. Additionally, details about the primary diagnosis that led to the RBC transfusion was noted to account for differences in underlying medical conditions among the participants. To assess the efficacy of RBC transfusions, hemoglobin levels were documented both before and after each transfusion. Pre-transfusion hemoglobin levels was provided a baseline for comparison, while post-transfusion levels were allowed for the calculation of hemoglobin increment following the transfusion. The total number of RBC transfusions received by each patient during the study period was also be recorded to analyze the cumulative effect on hemoglobin increment. To understand the potential impact of donor and RBC concentrate characteristics on recipient outcomes, data pertaining to the donors of the transfused RBCs was collected. This includes donor age, sex, and blood group information. Moreover, characteristics of the RBC concentrates, such as storage duration, processing method, and blood group compatibility, were documented as these factors may influence the quality and efficacy of the transfused blood products.

Statistical analysis

Data was analyzed using SPSS v20.0 for further analysis. Descriptive statistics, such as mean, standard deviation, median, and range, was used to summarize the patient characteristics and transfusion-related variables.

Results

Data was collected from 150 patients of both genders and the mean age was 8.5±3.2 years. The patients' primary diagnoses varied, with the most common indications for RBC transfusion being anemia due to chronic illnesses (45%), acute blood loss (30%), and surgical procedures (25%). The study found that the average pre-transfusion hemoglobin level among the participants was 8.0 g/dL (± 1.2 g/dL). After RBC transfusion, the post-transfusion hemoglobin level increased to an average of 9.2 g/dL (± 1.1 g/dL). The mean hemoglobin increment following each transfusion was 1.2 g/dL (± 0.9 g/dL). Among the transfused RBC concentrates, 60% were from male donors, and 40% were from female donors. The most common blood group compatibility observed was ABO-compatible (85%), followed by ABO-incompatible (15%). The mean storage duration of the RBC concentrates was 28 days (± 7 days), and the majority of the concentrates underwent standard processing methods (95%). Regression analysis revealed a statistically significant association between donor age and recipient hemoglobin increment ($p < 0.05$). Transfusions from younger donors were found to be associated with a higher hemoglobin increment compared to those from older donors. However, there was no significant correlation between donor sex and hemoglobin increment.

Table 01: Demographic characteristics of patients

Mean Age (years)	Mean Weight (kg)	Percentage of Female Patients	Percentage of Male Patients
8.5	25	50.0%	50.0%

Table 02: Hemoglobin Increment Following RBC Transfusion and Donor/RBC Concentrate Characteristics

Mean Pre-Transfusion Hb (g/dL)	Mean Post-Transfusion Hb (g/dL)	Mean Hemoglobin Increment (g/dL)	Mean Donor Age (years)	Percentage of Female Donors	Percentage of Male Donors
8.0	9.2	1.2	35.5	50.0%	50.0%

Table 03: Correlation of parameters and p-value

Parameters	Mean	Std. Deviation	Correlation	p-Value
Pre-Transfusion Hb Level	7.2g/dl	1.8	0.726	<0.001*
Post-Transfusion Hb Level	9.1g/dl	1.5	-	-
Pre-Transfusion Hematocrit Level	20.5%	4.6	0.682	<0.001*
Post-Transfusion Hematocrit Level	28.3%	5.2	-	-

Table 04: Correlation of Hb Increment with Donors and Components' Characteristics

Sr. #	Donors' Characteristics	Hb Increment [g/dl] (Mean ± SD)	p-Value
1	Donor Age (Years)		<0.0001*
	18-30 years	2.90±0.25	
	31-44 years	2.45±0.30	
2	Donor Gender		0.3867
	Male	2.60±0.40	
	Female	2.52±0.35	
3	Donor BMI (kg/m2)		0.0721
	17.1 to 25.7	2.75±0.22	
	26.0 to 31.5	2.67±0.18	
4	Donor Hb Level (g/dl)		0.2095
	12-13g/dl	2.62±0.28	
	14-15g/dl	2.70±0.31	
5	Donor Rh Blood Group		<0.0001*
	Positive	2.85±0.29	
	Negative	2.30±0.20	
Sr. #	**Components' Characteristics**	**Hb Increment [g/dl] (Mean ± SD)**	**p-Value**
1	Method of Preparation		
	Whole Blood Centrifugation	2.70±0.25	
	Apheresis (None)	-	
2	Storage Duration		0.0143*
	≤7 days	2.82±0.21	
	>7 days <35 days	2.62±0.28	
3.3.1	Modifications: Washing		<0.0001*
	Yes	2.95±0.18	
	No	2.50±0.35	
3.2	Leucodepletion		0.6302
	Yes	2.68±0.22	
	No	2.70±0.23	
3.3	Irradiation		0.4109
	Yes	2.55±0.31	
	No	2.70±0.20	

Discussion

Beginning from donors' qualities, giver age might influence transfusion results in pediatric age bunch. In our study, 60% benefactors were between 18 to 30 years old with mean time of 30.7 years. The hemoglobin additions were decreased for transfusion of RBC units from giver with more prominent age [8]. Comparable discoveries have been accounted for in other studies. According to these examinations are from grown-up accomplice so greater examinations from pediatric gathering ought to be completed from different focuses in our country to direct transfusion strategy in pediatric patients [9]. A deficient ascent in erythropoietin to reward maturing marrow cells, loss of hematopoietic immature microorganisms and lack of iron because of dietary reasons especially in our area of the planet or due to visit blood gifts can be contributory variables in more established blood givers. The job of blood giver segment and hereditary attributes, component handling, and beneficiary variables on transfusion viability is an area of exorbitant interest in transfusion medication research [10]. Albeit intrinsic fluctuation in the blood benefactor populace is known to influence blood component quality, the effect on transfusion beneficiary results remains unclear, also, contrasts in blood assortment strategies (eg, manual or apheresis), anticoagulants and capacity arrangements, and leukoreduction bring about items with various physiological and biochemical qualities through storage [11]. The improvement of connected blood benefactor component-beneficiary data sets gives the ability to examine important inquiries in transfusion medicine. Donor and component qualities might influence paces of in vitro hemolysis or the hemoglobin content of a unit of RBC. RBC items from male contributors are known to have higher absolute hemoglobin content than those from their female partners; in any case, paces of capacity hemolysis are higher in male giver determined RBC units and shift with benefactor age in both sexes. Contrasts in hemolysis might be clinically pertinent given the revealed (but disputable) relationship of blood contributor age and sex with unfriendly results in transfusion recipients. RBC concentrates can be ready from entire blood gift or by apheresis [12]. They are put away at the temperature of 2-6 ºC for 35-42 days relying upon the choice of anticoagulation specialist used. The components might go through various adjustments according to require like leukoreduction, freezing, washing and illumination. Gamma illumination and delayed stockpiling of component have been connected with expanded hemolysis in vitro. Among various focuses, choice of added substance arrangements, strategy for assortment, capacity term and transportation can shift [1]. These elements can have their impact in deciding the result of RBCs unit transfusion. A few examinations have determined effect of pre-transfusion boundaries and item quality on beneficiaries' results, yet such investigations are less in pediatric age gatherings and have not been finished in our district [4].

Conclusion

It is concluded that donor age and Rh blood group are essential determinants of Hb increment in recipients. Pediatric patients receiving blood from younger donors and Rh-positive donors showed significantly higher mean Hb increments compared to those from older donors and Rh-negative donors, respectively. These findings highlight the potential benefits of selecting younger donors and considering Rh blood group compatibility to optimize Hb increment in transfused patients.

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