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Transfusion Associated Hematological Modulation in Beta Thalassemia Major: A Comparative Clinical Evaluation

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ABSTRACT

Beta thalassemia major is a severe inherited condition of blood, where the production of the hemoglobin can no longer take place correctly, resulting in the incurable persistent anemia and the need of regular transfusions with blood. The purpose of the study was to compare transfusion associated hematological parameters in pediatric patients beta thalassemia major through a comparative analysis of before and after blood transfusion.

A prospective observational paired study was conducted in Sundus Foundation Thalassemia Centre in Lahore and was conducted over a four-month period. They involved 121 beta thalassemia major patients in the ages of 3-12 years who were

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selected through repeating sampling techniques. The blood samples were taken, one hour before transfusion and 24 hours after transfusion. Complete blood count, Hemoglobin (Hb), Red blood cell count, MCV, and MCH factors were analyzed using automated hematology analyzer.

Data analysis was performed using SPSS, and a paired samples t-test was used to determine statistical significance. The current research has indicated that, following transfusion, all the hematologic parameters have greatly improved. Mean hemoglobin increased from 7.3 ± 0.9 g/dL to 10.6 ± 0.9 g/dL following transfusion. The red blood cell (RBC) counts also showed a significant improvement, rising from 3.08 ± 0.40 to 3.92 ± 0.42. Red cell indices, including MCV and MCH, improved significantly ($p < 0.05$).

These findings indicate effective correction of anemia and partial improvement in RBC morphology after transfusion. Blood transfusion therapy is essential and life saving in the management of patients with major β-thalassemia. Overall, the results suggest that transfusion is an effective intervention for improving key hematological parameters and enhancing physiological stability.

Key words: Hematology parameter, Pediatric Patients, Blood Transfusion, Beta Thalassemia Major

Introduction

Beta thalassemia is one of the common inherited hemoglobin disorders in all over world and show a major public health concern particularly in developing countries. It is caused by decreased or no longer synthesis of the goblin chains of hemoglobin because of mutations in the goblin chains of hemoglobin gene, resulting in an ineffective erythropoiesis and chronic hemolytic anemia.[1]

Worldwide, it is estimated that 1.5 percent of the population are carriers of either beta thalassemia or other hemoglobinopathies. Although in Pakistan alone has an estimated prevalence of 5-8% carries a relatively high national burden because there is also an undertly high prevalence.[2] The molecular pathogenesis of beta thalassemia is quantitative defects in production of beta globin due to more than two hundred known mutations including deletions or splices of the globin cross bridges or deletions or splices of the beta globin intermolecular interactions section. The decrease in the production of beta- globin chain leads to the unregulated synthesis of the alpha-chain, resulting in damage to the membrane inefficient erythropoiesis and the pre premature destruction of erythroid precursors.[3]

The hyper transfusion have turned the deadly childhood disease β-thalassemia into a chronic disease, which can be controlled. Though having these advantages, transfusion has quantifiable influences on the hematologic parameters that may be different between pre and post transfusion, and this can and should be evaluated comparatively before and after transfusion.[4] The values of pre transfusion hemoglobin models tend to reflect the level of chronic anemia and the sufficiency of the timing schedule of transfusion, and post transfusion hemoglobin shows immediate correction and oxygen carrying restoration. Comparative evaluation of the pre and post transfusion hemoglobin could therefore give some meaningful evidence as far as hematological modulation is concerned as relates to transfusion support.[5]

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Beyond hemoglobin correction, transfusion might also affect the red blood cell indices such as mean corpuscular volume, mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration. The indices indicate erythrocyte morphology and hemoglobinization of red cells that can be affected by poor erythropoiesis, chronic erythrolysis and red cell transfusion with donors. Observing the variation in these aspects prior to and following transfusion can provide a further understanding of the pattern of hematologic responses and the modulation by the diseases.

Red cell index comparative evaluation has thus come into significance in measuring the overall hematological effects of transfusing therapy in major patients of beta thalassemia.[6] High reticulocyte counts could be linked with a compensatory marrow stimulation in response to chronic anemia and hemolysis with transfusion potentially temporarily altering these reactions through inhibition of natural erythropoietic drive. Post and pre-transfusion analysis of reticulocytes can thus help to interpret the dynamic nature of the relationship between the support given by transfusion and the activity of reticulocytes in the bone marrow.[7]

The other significant complication proposed with chronic transfusion is a condition known as all immunization; an outcome of exposure to foreign red cell antigens and subsequent antibody production. Increased hemolytic risk, and possibly transfusion response may arise due to development of all antibodies to complicate future hemoglobin transfusion compatibility, development of all antibodies, and the occurrence of hemolytic reaction.[8] Another complication of repeated blood transfusion is transfusion reactions that may be mild, febrile reactions, or severe hemolytic or allergic reactions. Such reactions may negatively impact patient safety, break transfusion procedures and, possibly impact post-transfusion hematological reactions. Diagnosis of transfusion reactions is especially crucial when dealing with populations that are chronically transfused in which cumulative exposure increases the risk.[9]

The purpose of this comparative cross-sectional study is therefore to assess the transfusion associated changes after blood transfusion in pre and post transfusion a period of 200 patients of age group 18-30 years suffering from β thalassemia major representing the different variants of representative alleles of β thalassemia. The findings of this study might assist in narrowing the current gap of knowledge and aid in developing more effective monitoring and management strategies for patients with β-thalassemia major.

METHODOLOGY

This Comparative study was carried out in Sundas Foundation of Thalassemia Centre, Shadman Lahore. Group 1 was Beta Thalassemia Patients (Before Blood Transfusion) and Group 2 was Beta Thalassemia Patients (After Blood Transfusion). The sample size was calculated using the Cochran formula for estimating a mean/proportion in health research, which is widely accepted for observational and hematological studies. Sample size calculated was 121 participants, which were included in the study. The sampling technique used was Consecutive (Not Probability) Sampling. All eligible participants were included after obtaining informed consent.

Two venous blood samples were taken for each patient, while the blood transfusion was still taking place, one before and the other after transfusion within the specified

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time frame. Blood (around 3 to 5 mL) was collected under aseptic conditions, collecting in a sterile disposable syringe. The collected blood was placed in anti-coagulated tubes of EDTA for hematological analysis. All samples were appropriately labelled, and patient identification and time of sampling recorded to facilitate accurate comparison with pre/post transfusion values. Immediately after collecting the samples, they were sent to the laboratory for analysis using the automated hematology analyzer. The samples were collected, handled and processed as per the standard operating procedure to ensure accuracy and reliability. Clotted/ hemolyzed samples were discarded and re-collected to insure accurate results.

RESULTS

The comparative clinical evaluation revealed that after the transfusion process there was a significant positive change in all hematological parameters. The blood profile was successfully modulated as evidenced by the marked increase in the counts of Hemoglobin (Hb) and Red Blood Cell (RBC) and immediate correction of the anemic status. Besides this, the improvement of indices like MCV and MCH showed that the transfusion successfully kept the patient's hematological environment stable and better oxygenating and physiologically stable.

Table 1 showed the demographic distribution of the study population. Most patients belonged to the 3–6 years age group (36.4%), followed by 7–9 years (32.2%) and 10–12 years (31.4%). This indicated that more patients of Beta thalassemia Major were seen in early childhood.

Table 1: Demographic Characteristics of Study Participants (n = 121)

Variable	Category	Frequency (n)	Percentage (%)
Age Group (Years)	3 – 6	44	36.40%
	7 – 9	39	32.20%
	10 – 12	38	31.40%
	Total	**121**	**100%**

Table 2 showed by the descriptive statistics of hematological parameters before and after transfusion. A definite rise was noted after the transfusion. The hemoglobin levels showed a significant rise, as did the RBC count. The red cell indices (MCV, MCH) also showed mild to moderate improvement, reflecting improved red cell morphology after transfusion.

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Table 2: Comparison of Hematological parameters (Pre & Post Transfusion)

Parameter	Pre-Transfusion (Mean ± SD)	Post-Transfusion (Mean ± SD)
Hemoglobin (Hb) (g/dL)	7.3 ± 0.9	10.6 ± 0.9
RBC Count ($\times 10^{12}$/L)	3.08 ± 0.40	3.92 ± 0.42
MCV (fL)	63.5 ± 5.8	65.2 ± 6.0
MCH (pg)	19.0 ± 2.1	20.4 ± 2.2

Table 3 Presented the results of paired sample t-test for hematological parameters before and after transfusion. A significant increase was seen in the case of hemoglobin and RBC count ($p<0.001$). Further, there was also a statistically significant improvement in MCV, MCH. The results of this study revealed that transfusion of blood was statistically significant in improving haematological parameters in patients suffering from Beta-Thalassemia Major.

Table 3: Paired Sample t-Test Analysis of Pre and Post Transfusion Values

Parameter	Mean Difference (Post–Pre)	t-value
Hemoglobin (Hb)	3.3	25.6
RBC Count	0.84	18.2
MCV	1.7	4.9
MCH	1.4	5.2

Figure 1 showed by indicated in the variation of hemoglobin levels before and after transfusion. A significant rise was found, indicating that transfusion of blood was an important part of therapy in correction of anemia in Beta Thalassemia Major patients.

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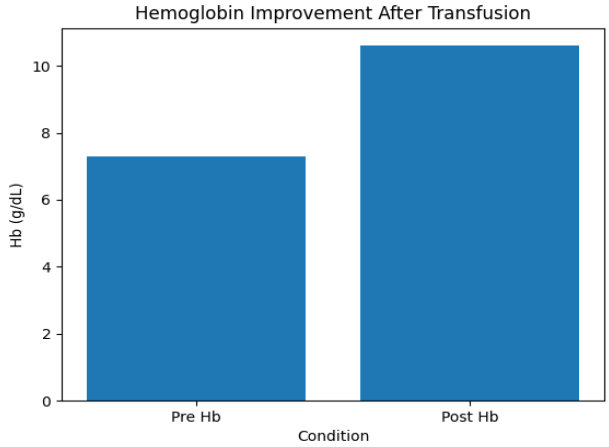


Figure 1: Hemoglobin Improvement After Transfusion

DISCUSSION

The clinical management of Beta Thalassemia Major is one of the most complex challenges in pediatric hematology due to its need for lifelong supportive therapy. The evaluation of 121 children, aged 3–12 years in this study, showed marked changes in hemoglobin levels from a pre-transfusion level of 7.3 g/dL to a post-transfusion mean of 10.6 g/dL. The 3.3 g/dL increase is significant, as 7.3 g/dL represents an "anemic stress" situation where the heart must work harder to supply oxygen to tissues.[10]

N. Osataphan studied the effects of splenectomy and found that while surgery may decrease transfusion needs and raise hematocrits, it also increases platelets and thromboembolism risk. Our study focuses on transfusion alone, which achieves stable hematological status without surgical complications. The large rise in red blood cell (RBC) count demonstrates transfusion effectiveness, as transfused erythrocytes are vigorous, physiologically mature, and have an average lifespan of 100–120 days.[11]

Our results are supported by the clinical caution of H. Ayyash and M. Sirdah (2018), who observed significantly higher ferritin and liver enzymes in transfused patients compared to healthy individuals, indicating iron overload and liver disease. While our study celebrates hematological achievements including increased RBCs and hemoglobin, each transfusion introduces about 1 mg of elemental iron.[12–14]

These findings concur with R. P. Ali and a 2024 study from Pakistan, which noted that patients on a regular transfusion schedule had much improved growth parameters and significant rises in hemoglobin and hematocrit compared to those receiving random transfusions.[15–16]

The present study supports that a well-controlled transfusion program is the cornerstone on which other treatments for thalassemia (iron chelation and/or bone marrow transplantation) should be built. While hematological benefits are immediate and life-saving, the care of a thalassemic child requires a multidisciplinary approach to improve their quality of life, ensuring they can dream, learn, and grow like every other child.[17]

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CONCLUSION

Blood transfusion therapy is an important therapy for patients with Beta Thalassemia Major which could help to enhance their hematological condition by increasing their Hb levels and stabilizing their blood cell counts, which helps to reduce the effects of chronic anemia. It also helps to improve blood indices like MCV and MCH, which show a better blood profile. This therapy does not cure the disease, however, it is supportive as the genetic disease is still present. Hence, well-organized and regular transfusion programs are fundamental for patient management and careful long-term follow-up is crucial to prevent complications and improve the overall quality of life.

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