Assessing Hematologic Response to Cord Blood Transfusion in Severe Acute Malnutrition: A Comparison with Adult Blood Transfusion

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ABSTRACT

Introduction: The pediatric population frequently necessitates blood transfusions for a variety of indications. However, in developing countries, there is often a shortage of available blood due to several factors, including a lack of donors, insufficient awareness, irrational demand, and inadequate supply chain management systems. This study aimed to evaluate hematologic response to umbilical cord blood (UCB) transfusion in cases of severe acute malnutrition (SAM) as compared to adult blood (AB) transfusion.
Methods: This prospective interventional study involved UCB transfusions administered to children with SAM in need of blood transfusion. UCB was collected under sterile conditions in the labor room and pretested in the blood bank. Children meeting the inclusion criteria were enrolled in the study. Transfusions of UCB or AB were administered based on availability and consent. Hematological parameters were assessed the day following the transfusion, and any reactions were monitored. A total of 90 transfusions were carried out, with 40 patients receiving UCB and 50 receiving AB.
Results: Out of 50 UCB units collected from healthy placentas, 40 were suitable for transfusion (6 not used), while 10 were unsuitable. The baseline characteristics of the study participants were comparable with no significant difference between the two groups. The hematological parameters showed significant improvement after UCB transfusion (Table 2). The mean hemoglobin (HB) levels increased from 3.605 ± 0.3658 g/dL to 5.007 ± 0.4221 g/dL ($p<0.01$). Similarly, significant improvements were observed in the hematological parameters following AB transfusion. The mean HB levels increased from 3.488 ± 0.5393 g/dL to 4.666 ± 0.5840 g/dL ($p<0.01$).
Conclusion: UCB is a viable and safe alternative to AB for blood transfusions in children with severe acute malnutrition as it results in similar improvement in hematological parameters post transfusion.
Key Words: Severe acute malnutrition; Umbilical cord blood; Placental blood; Blood Transfusion

INTRODUCTION

The pediatric population frequently necessitates blood transfusions for various medical reasons; however, a significant shortage of available blood persists due to donor scarcity, lack of awareness, irrational demand, and inefficiencies in supply chain management, particularly in developing countries. In India, the annual requirement for neonatal care alone is approximately one million units of blood, yet a considerable gap exists between the demand and the supply [1]. Despite all efforts to promote voluntary blood donation and the use of blood component therapy, no viable substitute for human blood has been identified. Placental blood, which is typically discarded after childbirth, contains 80 ml to 150 ml of whole human blood that could be collected, stored, and used as a replacement for adult whole blood [2–4].

Anemia leads to various health issues, including heart failure, impaired cognitive function, and deficiencies in macro- and micronutrients [2]. Severe anemia is a leading cause of mortality, hospitalization, and death in children suffering from severe acute malnutrition (SAM) and is a frequent co-morbidity. Children with SAM and anemia have a mortality rate that is 2.62 times higher than those with SAM alone [3]. Annually, around 100 million deliveries occur globally, offering a substantial opportunity to collect this blood and save numerous lives [4,5]. Consequently, this study was conducted to evaluate hematologic response to umbilical cord blood (UCB) transfusion in cases of severe acute malnutrition (SAM) as compared to adult blood (AB) transfusion.

MATERIAL AND METHODS

This prospective interventional study was conducted at a level III neonatal care unit in a central Indian institutional hospital from January 2020 to June 2021. Ethical approval was granted by the institutional ethical committee. The primary objective was tto evaluate hematologic response to UCB transfusion in cases of SAM admitted within the first 24 hours as compared to AB transfusion [6]. Exclusions from the study included parents who declined participation, children with prior transfusions, those with clinically diagnosed syndromic conditions, and individuals with primary hematological disorders.

Cord blood was collected in the labor room following strict aseptic protocols from healthy mothers and placentas. The collection was performed in citrate phosphate dextrose (CPD) bags with a 100 ml capacity [7]. Healthy mothers were defined as those without antenatal complications such as preeclampsia, sepsis, or abnormal amniotic fluid. The placenta was examined post-delivery for abnormalities; any abnormal findings led to discarding the sample. Cord blood was collected from healthy placentas of normal vaginal deliveries. Informed consent was obtained from the patient or guardian. Delayed cord clamping was performed according to the Neonatal Resuscitation Program (NRP) guidelines, after which the placenta was placed in a sterile tray. The distal end of the cord was sterilized with betadine and spirit, and the umbilical vein was punctured to collect 80 to 120 ml of blood via gravity into the CPD bag. Aseptic techniques were strictly observed. Samples with less than 60 ml of blood, or those positive for infections or immunologically unsuitable (defined by the presence of anti-AB antibodies leading to ABO Hemolytic Disease of the Newborn), were discarded. Pre-testing for ABO and Rh typing, HIV, Hepatitis B, Hepatitis C, malaria, and syphilis was conducted at the blood bank. Suitable blood units were stored and transfused to SAM children under 6 kg with severe anemia (hemoglobin <4 g/dl or packed-cell volume <12%) within 24 hours of admission.

Children meeting the inclusion criteria received cord blood based on availability, while adult blood was used as per institutional protocols. Prior to transfusion, a pre-transfusion blood sample was taken for CBC, and vital signs including temperature, heart rate, respiratory rate, oxygen saturation, and random blood sugar were monitored. Vital signs were recorded at 10 minutes, 30 minutes, 1 hour, 2 hours, and upon completion of the transfusion. Significant changes in vital signs were documented. Blood was administered at a rate of 10 ml/kg over 5 hours using an infusion pump. Feeding was halted during and for at least 3 hours post-transfusion. Six hours after transfusion, a post-transfusion CBC was performed, with routine monitoring continuing until discharge. The cohort was divided into two groups: Group 1 (UCB) and Group 2 (AB), based on the type of blood received. Hematological parameters, such as hemoglobin, mean corpuscular volume (MCV), packed cell volume (PCV), and total red blood cell count (TRBC), were compared between the two groups.

Data were analyzed using SPSS version 20. Normality was assessed, and categorical variables were analyzed using chi-square and Fisher's exact tests. Continuous variables were compared using independent t-tests as appropriate. A p-value of <0.05 was considered statistically significant, with all tests being two-tailed.

RESULTS

A total of 50 UCB units were collected from healthy placentas following normal deliveries. Of these, 40 units were deemed suitable for transfusion (with 6 units not utilized during the study period), while 10 units were found unsuitable. Among the 10 unsuitable units, 4 were rejected due to insufficient volume (< 60 ml), 2 due to technical issues such as clot formation, 1 unit tested positive for Hepatitis B, and 3 units were discarded based on immunological criteria.

The baseline characteristics of the study participants are summarized in Table 1. The mean age of participants in the UCB group (N=40) was 7.19 ± 5.343 years, while the AB group (N=50) had a mean age of 7.96 ± 7.259 years, with no significant difference between the two groups (p=0.576). Gender distribution was similar across groups, with 57.50% males in the UCB group and 44% in the AB group (p=0.20). The distribution of blood groups among the participants did not show a statistically significant difference (p=0.17). Specifically, the UCB group had 20% A+, 15% AB+, 45% B+, and 20% O+ blood types, while the AB group had 10% A+, 8% AB+, 68% B+, and 14% O+ blood types.

Table 1: Baseline parameters of study participants

Parameter	UCB (N=40)	AB (N=50)	p Value
Age (years); Mean ± SD	7.19 ± 5.343	7.96 ± 7.259	0.576
Gender; n (%)			
Male	23 (57.50)	22 (44)	0.20
Female	17 (42.50)	28 (56)	
Blood Group; n (%)			
A+	8 (20)	5 (10)	0.17
AB+	6 (15)	4 (8)	
B+	18 (45)	34 (68)	
O+	8 (20)	7 (14)	

The hematological parameters showed significant improvement after UCB transfusion (Table 2). The mean hemoglobin (HB) levels increased from 3.605 ± 0.3658 g/dL to 5.007 ± 0.4221 g/dL (p<0.01). Hematocrit (PCV) improved from 10.975 ± 1.2707% to 15.200 ± 1.5884% (p<0.01). The total red blood cell count (TRBC) rose from 1.366 ± 0.1556 million/µL to 1.822 ± 0.3017 million/µL (p<0.01). Mean corpuscular volume (MCV) increased from 77.225 ± 14.4692 fL to 84.025 ± 14.6559 fL (p<0.01), and mean corpuscular hemoglobin (MCH) from 23.825 ± 4.645 pg to 27.750 ± 4.2108 pg (p<0.01). Mean corpuscular hemoglobin concentration (MCHC) also showed an improvement from 30.925 ± 3.8122 g/dL to 32.675 ± 2.5256 g/dL (p<0.05). There was a notable decrease in total white blood cell count (TWBC) from 9321.250 ± 3917.13 cells/µL to 8437.5 ± 2655.39 cells/µL (p<0.05). Platelet count increased from 2.1102 ± 1.09 lakh/µL to 2.3855 ± 0.9339 lakh/µL (p<0.05).

Table 2: Hematological parameters improvement after UCB transfusion

Parameter	Pre BT (Mean ± SD)	Post BT (Mean ± SD)	P value
HB	3.605 ± 0.3658	5.007 ± 0.4221	<0.01
PCV	10.975 ± 1.2707	15.200 ± 1.5884	<0.01
TRBC	1.366 ± 0.1556	1.822 ± 0.3017	<0.01
MCV	77.225 ± 14.4692	84.025 ± 14.6559	<0.01
MCH	23.825 ± 4.645	27.750 ± 4.2108	<0.01
MCHC	30.925 ± 3.8122	32.675 ± 2.5256	<0.05
TWBC	9321.250 ± 3917.13	8437.5 ± 2655.39	<0.05
PLATELET	2.1102 ± 1.09	2.3855 ± 0.9339	<0.05

Similarly, significant improvements were observed in the hematological parameters following AB transfusion (Table 3). The mean HB levels increased from 3.488 ± 0.5393 g/dL to 4.666 ± 0.5840 g/dL (p<0.01). PCV levels rose from 10.460 ± 1.7168% to 14.260 ± 2.0683% (p<0.01). TRBC count improved from 1.275 ± 0.3126 million/µL to 1.595 ± 0.3940 million/µL (p<0.01). The MCV increased from 86.940 ± 13.6208 fL to 93.080 ± 16.1850 fL (p<0.05), and MCH from 27.480 ± 3.7917 pg to 30.380 ± 5.2679 pg (p<0.01). MCHC decreased slightly from 33.760 ± 3.8309 g/dL to 32.460 ± 2.0123 g/dL (p<0.05). TWBC decreased from 9060.00 ± 4464.5 cells/µL to 8244.00 ± 2403.2 cells/µL (p<0.05), while the platelet count increased from 1.973 ± 1.1511 lakh/µL to 2.454 ± 0.8941 lakh/µL (p<0.01).

Table 3: Hematological parameters improvement after AB transfusion

Parameter	Pre BT (Mean ± SD)	Post BT (Mean ± SD)	P value
HB	3.488 ± 0.5393	4.666 ± 0.5840	<0.01

PCV	10.460 ± 1.7168	14.260 ± 2.0683	<0.01
TRBC	1.275 ± 0.3126	1.595 ± 0.3940	<0.01
MCV	86.940 ± 13.6208	93.080 ± 16.1850	<0.05
MCH	27.480 ± 3.7917	30.380 ± 5.2679	<0.01
MCHC	33.760 ± 3.8309	32.460 ± 2.0123	<0.05
TWBC	9060.00 ± 4464.5	8244.00 ± 2403.2	<0.05
PLATELET	1.973 ± 1.1511	2.454 ± 0.8941	<0.01

DISCUSSION

In this study, a total of 90 transfusions were administered, with 40 SAM patients receiving UCB and 50 receiving adult blood. Out of the 50 UCB units collected, 40 were deemed suitable for transfusion, representing an 80% suitability rate [7-9]. Of the remaining 10 units, 5 were rejected due to insufficient volume, and the other 5 were discarded because of clot formation and inadequate recovery. Thus, 40 units of UCB were transfused to SAM patients meeting the inclusion criteria [10].

We observed increases in hemoglobin, hematocrit, and total red blood cell counts in SAM patients who received UCB. The rise in hemoglobin was statistically significant, with a p-value of 0.005. In a similar study by Maria Bianchi et al. in 2015, 128 UCB units were collected, of which 16 were discarded, resulting in 112 units suitable for transfusion, or 87.5% [11]. Among these, 5 units tested positive for transfusion-transmitted infections (TTI), 5 units exhibited immunological reactions, and 6 units had technical issues such as clotting or inadequate recovery. In Bianchi et al.'s study, the packed cell volume (PCV) before transfusion was 31.6±12.55% in the UCB group and 31.6±3.4% in the adult blood group, compared to 11.575±1.90% and 10.460±1.71% respectively in the present study [12].

The change in PCV in the UCB group was 11.945%, while in the adult blood group it was 13+5%, compared to 3.625% and 3.8% in our study. This discrepancy may be attributed to multiple transfusions performed within 0-7 days, with 31 occurring beyond seven days. Hassall et al. [8] documented hemoglobin levels 24 hours and 28 days post-transfusion, noting an increase of 2.6 gm/dL at 24 hours and 5.0 gm/dL at 28 days, with minimal severe adverse effects. In a 2003 study, Hassall et al. transfused UCB to 131 children in a Ghanaian labor ward, observing a 3 gm/dL rise in hemoglobin, which was higher than our study's findings, potentially due to the broader pediatric age range used in their study compared to our focus on SAM patients [8].

Comparing our results with previous studies, we conclude that UCB can be a viable alternative for treating anemia in SAM patients. No transfusion reactions or adverse effects, such as fever, hemolysis, allergic reactions, or transfusion-related acute lung injury (TRALI), were observed. UCB demonstrated a significant increase in hemoglobin levels in these patients.

This study has several limitations. The sample size was relatively small, and larger multicentric studies are needed to better assess the utility of this intervention. Additionally, factors such as cytokine roles and cord blood oxygen-carrying capacity were not evaluated. The use of whole blood for transfusion, due to the lack of a component separator for small volumes, is another limitation. Furthermore, neonates were only followed until discharge.

CONCLUSION

From this study, it can be inferred that UCB represents a genuine, valuable, and safe alternative to AB for routine and emergency blood transfusions. In the present investigation, UCB demonstrated superior efficacy in enhancing hemoglobin levels compared to AB and equal efficacy in enhancing other hematological parameters. This suggests that UCB could bridge the gap between the demand and supply of blood in the PICU. However, further large-scale studies are needed to establish UCB as a reliable source for transfusions in neonates.

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