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Association of Maternal Factors with Reticulocyte Count and Hemoglobin Content of Umbilical Cord Blood: A Cross-Sectional Study

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ABSTRACT

The hematological parameters of neonates are subject to modulation by various factors including maternal, environmental and/or fetal influences. This study aimed to investigate the impact of maternal variables on hemoglobin levels and reticulocyte counts in umbilical cord blood samples obtained from newborns in India. A total of 198 umbilical cord blood specimens from infants delivered at an Indian Hospital were subjected to analysis. Two milliliters of cord blood were collected in ethylene diamine tetra acetic acid tubes under aseptic conditions and processed within 6 hours for hemoglobin estimation and reticulocyte counting. In normal vaginal deliveries, the mean reticulocyte count and hemoglobin concentration was lower than that of cesarean sections. A significant difference ($P < 0.05$) was observed in cord hemoglobin and reticulocyte levels relative to the mode of delivery. A statistically significant association was found between reticulocyte counts and pregnancy complications. Additionally, a significant correlation between maternal and cord hemoglobin concentrations was also observed. Maternal anemia contributes to reduced hemoglobin levels in newborns. Screening of cord blood proves valuable for detecting neonatal anemia. Elevated reticulocyte counts in neonates indicate active erythropoiesis, suggesting a potential delay in transfusion unless warranted by specific clinical indications.

INTRODUCTION

Hematological indices in neonates serve as crucial indicators of their health status and are significantly influenced by maternal, environmental, and/or social factors. Unlike adults, fetal and neonatal hematopoiesis undergo continuous fluctuations, influenced by various physiological conditions, leading to considerable variations in hematological parameters. These parameters are affected by environmental, fetal, and/or maternal factors, with the previous encompassing geographical location and ethnicity, while maternal factors include mode of delivery, nutritional status, parity, pregnancy complications, and/or socioeconomic status. Fetal factors such as birth weight, gestational age, and/or sex also play a role^[1].

Numerous studies have investigated the relationship between maternal factors and neonatal hematological values. Despite advancements in perinatology, the precise impact of perinatal factors on cord blood hematological values remains uncertain. While several studies have reported changes in umbilical hematological parameters in complicated pregnancies and abnormal labor, there is insufficient data on the influence of perinatal factors on cord blood values in normal pregnancies. Previously discarded, umbilical cord blood can now be collected postpartum and utilized for diagnostic and research purposes, including as a source of stem cells. Several studies have highlighted the simplicity of umbilical cord blood collection and its safety for both mother and newborn^[2,3].

Reticulocytes, immature red blood cells, typically constitute 0.5–2.5% of adult red cells and 2–7% in newborns. Reticulocyte count serves as a reliable indicator of bone marrow activity, reflecting recent erythropoiesis. The normal mean hemoglobin concentration in umbilical vein blood is 16.8 g/dL. Cord blood screening proves valuable for detecting neonatal anemia, sepsis, thrombocytopenia, or other hematological disorders that may emerge during the neonatal period^[4-6].

Limited data exist on the correlation between maternal factors and neonatal hematological parameters in Sikkim. Therefore, this study aims to explore the correlation between maternal factors and the reticulocyte count and hemoglobin content of newborns using cord blood samples.

MATERIALS AND METHODS

This descriptive cross-sectional study involved 198 cord blood samples collected from newborns delivered at an India hospital for 10 months. The study included Neonates born to mothers aged 18–45 years, born between 37 and 42 weeks of gestation, with birth

weights ranging from 2.5 to 4.2 kg, and born to mothers with acute complications during high-risk pregnancies or labor. The study excluded neonates born to mothers with antepartum hemorrhage, mothers with substance abuse and neonates with congenital anomalies.

The neonates were categorized into two groups based on mode of delivery: neonates delivered vaginally, and those delivered via elective cesarean section; and based on maternal factors during pregnancy: neonates born to mothers with uncomplicated pregnancies, and those born to mothers with high-risk pregnancies.

After clamping the umbilical cord, 2 ml of cord blood was aseptically collected in EDTA tubes and transported to the Hematology Laboratory within 6 hours. Hemoglobin estimation and reticulocyte counting were performed using Drabkin's method and supravital staining plus spectrophotometry and microscopy, respectively.

Data analysis was performed using SPSS Version 17. Student's t-test and Chi-square test were used to compare mean, standard deviation, and proportions, with significance set at $P < 0.05$.

RESULTS AND DISCUSSIONS

The demographic characteristics of the newborns and mothers are presented in Table 1.

Neonates delivered via cesarean section (C/S) exhibited elevated levels of reticulocyte count and hemoglobin compared to those delivered via other modes. A statistically significant difference ($P < 0.05$) was observed in cord hemoglobin and reticulocyte levels based on the mode of delivery, as outlined in Table 2.

Furthermore, a statistically significant correlation was identified between the cord hemoglobin levels and maternal hemoglobin levels, as indicated in Table 3.

Neonates born to mothers experiencing pregnancy complications displayed heightened reticulocyte count and hemoglobin levels. Specifically, a statistically significant association was noted between reticulocyte count and pregnancy complications. Although neonates with pregnancy complications exhibited increased hemoglobin levels, this difference lacked statistical significance, as illustrated in Tables 4 and 5.

Table 1: Basic demographic data of study population

Parameter	n	percentage	Mean \pm SD
Maternal Age			
≤30 years	133	67.17	26.80 \pm 5.30
>30 years	65	32.83	
Birth weight			
≤2.5 kg	28	14.14	3.40 \pm 0.50
>2.5 kg	170	85.86	
Gestational age			
37–41 weeks	182	91.92	37.8 \pm 1.3
<37 weeks	4	2.02	
>41 weeks	12	6.06	

Table 2: Hematological variables according to mode of delivery

Variable	Normal delivery (Mean ± SD)	Cesarean section (Mean ± SD)	p-Value
Reticulocyte count (%)	2.60 ± 0.90	3.10 ± 1.00	<0.05
Hemoglobin (gm/dL)	14.20 ± 2.80	15.80 ± 3.60	<0.05

Table 3: Association between maternal and cord blood haemoglobin

Variable	Cord blood Hb <14gm/dl	Cord blood Hb >14gm/dl	p-Value
Maternal Hb (gm/dl)	11.30 ± 1.30	11.75 ± 1.20	<0.05

Table 4: Distribution of various parameters as per complication of pregnancy

Parameter	Cord blood Reticulocytes (%)			Cord blood Hb (gm/dl)		
	1-2	2-5	>5	7-16	>16-20	>20-27
Normal pregnancy	68.5	73.5	34	70	77.5	54
Postdated pregnancy	3	4	50.5	6.5	1.5	15
Elderly primigravida	3	1	-	1	2	-
Oligohydroamnios	-	1	-	1	-	-
PIH	15	3	17	7	6	-
PIH + DM	-	2	-	1	-	8
Polyhydroamnios	-	1	-	-	2	-
Preterm delivery	3	2	-	3	-	-
Previous C Section	6	12	-	9	10	22.5

Table 5: Distribution of various parameters as per complication during labor process

Parameter	Cord blood Reticulocytes (%)			Cord blood Hb (gm/dl)		
	1-2	2-5	>5	7-16	>16-20	>20-27
Normal labor	94	85	99	88.5	86	84.5
Breech	-	-	-	1	-	-
CPD	-	2.5	-	2.4	1.8	-
MSL	3	5.5	-	4.4	4.2	7.8
MSL+Breech	-	1	-	-	1.8	-
Prolong Labor	3.2	1.7	-	1.2	2.2	-
PROM	-	4.7	-	2.5	4.3	7.9

The study findings reveal that newborns exhibited a mean hemoglobin content of 15.2 g/dL and a reticulocyte count of 2.6%. This hemoglobin level aligns with previous studies conducted in India by Rodzko *et al.*^[3] and Devi *et al.*^[7], where the mean hemoglobin content was reported as 15.7 g/dL. Similarly, a study conducted in Iraq by Al-Mudallal and Al-Habbobi^[4] also reported a mean hemoglobin content of 15.2 g/dL. However, the reticulocyte count of the neonates in our study was lower compared to findings reported by Samantary *et al.* in India^[7], Al-Mudallal and Al-Habbobi in Iraq^[4], and Walka *et al.* in Germany^[8]. Conversely, the mean reticulocyte count was higher than that reported by Bukhari and Humaira in Islamabad^[9]. This variance in results may be attributed to differences in mean gestational age among the studies.

The hemoglobin content and reticulocyte count in infants delivered via normal vaginal delivery were notably lower compared to those delivered via cesarean section. These findings are consistent with observations made by Al-Mudallal *et al.* in Iraq^[4], in Israel, Germany, and in Poland^[10-12]. The global rates of cesarean section have risen dramatically, with it now being the most common surgical procedure among women of reproductive age. While the World Health Organization (WHO) recommends a cesarean section rate of up to 15% of deliveries, many countries exceed this recommendation, indicating a trend where cesarean sections are increasingly performed upon maternal request without medical necessity. Indications for cesarean section historically included

previous cesarean section, breech position, or pelvic disproportion, but in contemporary practice, it is often performed at the request of the mother^[13].

In India, the approach to maternal and child health (MCH) care, as outlined by the WHO in 1978, focused on identifying high-risk cases among antenatal mothers, with approximately 20-30% of pregnancies falling into the high-risk category in India^[14]. In the present study, in cases of PIH, the reticulocyte count exceeded 5%. Analysis of cord blood from newborns of mothers with preeclampsia revealed enhanced red blood cell production or removal, as indicated by elevated levels of circulating reticulocytes. The findings of the reticulocyte count in cases of PIH were consistent with those reported by Rawat *et al.* in India^[15], as well as with a study by Heilmann *et al.*, which documented increased numbers of nucleated red blood cells in infants born to mothers with PIH^[16].

In this investigation, there was a clear association between the mean cord hemoglobin value and the maternal mean hemoglobin level. This finding is in line with studies conducted in India and Nigeria^[1,17-19], which also reported a significant positive correlation between maternal and umbilical cord hemoglobin concentrations. Similarly, Marwaha *et al.* in India^[20] demonstrated a significant difference (P < 0.001) between maternal hemoglobin and cord hemoglobin levels. The comparatively lower values of hemoglobin in maternal blood observed in our study may be attributed to plasma volume expansion leading to hemodilution. This suggests that maternal anemia

contributes to lower circulating hemoglobin levels in newborns^[20].

CONCLUSION

Maternal anemia contributes to decreased hemoglobin levels in newborns. Assessing cord blood is a valuable method for detecting anemia in neonates. A high count of reticulocytes in newborns signifies active production of red blood cells, which may delay the need for transfusions unless there are other specific indications. These blood parameters provide insights into both normal and abnormal hematological patterns influenced by prenatal factors. This knowledge facilitates early intervention and reduces the rates of illness and death among infants.

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