



Original Article

Association Between Maternal Hemoglobin Levels, Umbilical Cord Hemoglobin, and Neonatal Anthropometric Parameters

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ABSTRACT

Background: Maternal anemia is a major public health issue that can negatively impact both maternal and neonatal health. This study aimed to explore the association between maternal hemoglobin levels, umbilical cord hemoglobin, and neonatal anthropometric parameters in term neonates.

Methods: A hospital-based, cross-sectional observational study was conducted at tertiary care centre enrolling 30 term pregnant women and their neonates. Maternal hemoglobin was measured within 24 hours of delivery, and umbilical cord blood hemoglobin was obtained immediately after birth. Neonatal anthropometric parameters, including birth weight, length, and head circumference, were recorded. Pearson's correlation coefficient was used to assess associations between maternal hemoglobin, cord blood hemoglobin, and neonatal anthropometric parameters.

Results: A significant positive correlation was found between maternal hemoglobin and umbilical cord hemoglobin ($r = 0.712$ to 0.824 , $p < 0.001$). Maternal hemoglobin levels were significantly positively correlated with neonatal birth weight ($r = 0.32$, $p < 0.01$) and neonatal length ($r = 0.28$, $p < 0.05$). However, no significant association was observed between maternal hemoglobin and neonatal head circumference ($p > 0.05$).

Conclusion: This study highlights the importance of maternal hemoglobin levels in influencing neonatal health outcomes. Higher maternal hemoglobin was associated with better neonatal birth weight and length, emphasizing the need for effective management of maternal anemia during pregnancy to improve fetal growth. Further studies are needed to explore long-term effects and other contributing factors.

Keywords: Maternal anemia, hemoglobin, umbilical cord blood, neonatal anthropometry, birth weight, neonatal length, term neonates.

INTRODUCTION

Maternal health plays a pivotal role in ensuring the optimal growth and development of the fetus during pregnancy. Among the various factors that influence fetal well-being, hemoglobin levels—both maternal and fetal are of significant importance. Hemoglobin is crucial for oxygen transport, and adequate maternal hemoglobin levels are necessary for maintaining sufficient oxygen supply to the developing fetus[1]. Any deviations from the normal hemoglobin range may result in complications such as intrauterine growth restriction (IUGR), low birth weight (LBW), and even preterm birth. Understanding the impact of maternal hemoglobin levels on fetal development can provide insights into potential pregnancy complications and guide clinical interventions. Umbilical cord hemoglobin levels serve as an important marker of the fetus's oxygenation status and nutritional supply during pregnancy[2]. Several studies have demonstrated that maternal hemoglobin levels directly affect the umbilical cord hemoglobin concentration, which in turn correlates with neonatal anthropometric parameters such as birth weight, head circumference, and length. These neonatal parameters are essential indicators of fetal growth and are closely linked to perinatal outcomes. Infants born to mothers with anemia are at increased risk for adverse outcomes such as low birth weight, preterm birth, and developmental delays, underscoring the importance of early detection and management of maternal anemia[1]. Anaemia during pregnancy is a widespread global

health concern, with the World Health Organization (WHO) estimating that 14% of pregnant women in developed countries experience anemia. However, the prevalence of anemia during pregnancy in India is considerably higher, ranging from 65% to 75%[1]. Nutritional deficiencies, especially iron deficiency, are the leading cause of anemia, accounting for more than 90% of cases. Other contributing factors include chronic blood loss due to infections, pre-existing anemia, early and recurrent pregnancies, and socio-economic status [2]. The impact of maternal anemia extends beyond pregnancy. Neonates born to anemic mothers are at a higher risk for poor perinatal outcomes, including increased rates of preterm birth, small for gestational age (SGA), intrauterine growth restriction (IUGR), and intrauterine death (IUD), all of which are associated with placental insufficiency. These infants also tend to have low iron reserves, which increases their susceptibility to infections and growth issues [3,4]. The long-term effects on these children can be severe, with studies indicating that they are more likely to experience cognitive deficits, reduced academic performance, behavioral issues, and a higher incidence of hypertension and cardiovascular diseases in adulthood[5]. These issues are compounded in preterm infants, further emphasizing the need for effective management of maternal anemia[6]. Given the high prevalence of maternal anemia and its associated complications, this study aims to investigate the association between maternal hemoglobin levels, umbilical cord hemoglobin levels, and neonatal anthropometric parameters such as birth weight, length, and head circumference. By exploring these relationships, this study seeks to contribute valuable insights into the early identification of at-risk pregnancies and the development of strategies to mitigate the impact of maternal anemia on both maternal and fetal health outcomes.

MATERIALS AND METHODS

This hospital-based, cross-sectional observational study was conducted at a tertiary care hospital, after receiving approval from the Institutional Ethics Committee. The study aimed to investigate the association between maternal hemoglobin levels, umbilical cord hemoglobin levels, and neonatal anthropometric parameters in term neonates. The study population consisted of term pregnant women who delivered at the study center and their neonates. A total of 30 pregnant women and their neonates were included in the study based on sample size calculations, ensuring adequate power for the statistical analysis

Inclusion Criteria

- Singleton pregnancies at 37–42 weeks of gestation
- Vaginal or cesarean delivery
- Term neonates (without congenital anomalies)

Exclusion Criteria

- Mothers with chronic medical disorders (hypertension, diabetes) or hemoglobinopathies
- Multiple pregnancies
- Pregnancies with intrauterine growth restriction (IUGR), major fetal anomalies, or severe perinatal complications

Data Collection

1. Maternal Hemoglobin Measurement

Maternal hemoglobin levels were measured within 24 hours of delivery using an automated hematology analyzer. Venous blood samples were collected from the mothers at the time of admission or during the immediate postpartum period.

2. Umbilical Cord Hemoglobin Measurement

Umbilical cord blood was collected immediately after delivery from the placental-end of the cord. Hemoglobin concentration was measured using the same automated hematology analyzer used for maternal blood samples.

3. Neonatal Anthropometric Measurements

Neonatal anthropometric parameters, including birth weight (kg), crown-to-heel length (cm), and head circumference (cm), were recorded within 24 hours of birth using standard techniques. Birth weight was measured using an electronic digital scale, and length and head circumference were measured using a standard length board and a non-stretchable measuring tape, respectively.

Statistical Analysis

The data were analyzed using SPSS software (version 25). Descriptive statistics were used to summarize maternal and neonatal characteristics, including means, standard deviations (SD), and medians with interquartile ranges (IQR) for continuous variables. Categorical variables were expressed as frequencies and percentages. The correlation between maternal hemoglobin levels, umbilical cord hemoglobin levels, and neonatal anthropometric parameters was assessed using Pearson's correlation coefficient for normally distributed continuous data. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 30 term pregnant women and their neonates were enrolled in the study. The baseline characteristics of the study population are presented in Table 1. The mean maternal age was 27.36 ± 4.16 years, with a median of 27 years (IQR: 24–

30). The mean gestational age was 37.62 ± 2.36 weeks (median: 38 weeks, IQR: 37–39). Neonates had a mean birth weight of 2.56 ± 0.39 kg (median: 2.55 kg, IQR: 2.30–2.80), a mean neonatal length of 49.37 ± 3.41 cm (median: 49 cm, IQR: 47–52), and a mean head circumference of 34.29 ± 1.28 cm (median: 34 cm, IQR: 33–35) (Table 1).

The distribution of maternal hemoglobin levels and corresponding umbilical cord hemoglobin levels is shown in Table 2. A significant positive correlation was found between maternal hemoglobin and umbilical cord hemoglobin levels across all categories of maternal anemia. Specifically, in the non-anemic group (maternal hemoglobin > 11 g/dL), the mean maternal hemoglobin was 12.17 ± 0.81 g/dL, and the mean cord blood hemoglobin was 15.36 ± 1.24 g/dL, with a correlation coefficient of 0.712 ($p < 0.001$). Similar positive correlations were observed in the mild, moderate, and severe anemia groups, with the highest correlation found in the moderate anemia category ($r = 0.824$, $p < 0.001$) (Table 2).

Association Between Maternal Hemoglobin and Neonatal Anthropometric Parameters

The relationship between maternal hemoglobin levels and neonatal anthropometric parameters was assessed using Pearson's correlation. Table 3 presents the correlation coefficients between maternal hemoglobin levels and neonatal birth weight, length, and head circumference. A significant positive correlation was observed between maternal hemoglobin levels and neonatal birth weight ($r = 0.32$, $p < 0.01$) and neonatal length ($r = 0.28$, $p < 0.05$). However, no significant association was found between maternal hemoglobin and neonatal head circumference ($p > 0.05$) (Figure 1).

Table 1: Baseline Maternal and Neonatal Characteristics (n = 30)

Variable	Mean \pm SD	Median (IQR)
Maternal age (years)	27.36 ± 4.16	27 (24–30)
Gestational age (weeks)	37.62 ± 2.36	38 (37–39)
Birth weight (kg)	2.56 ± 0.39	2.55 (2.30–2.80)
Neonatal length (cm)	49.37 ± 3.41	49 (47–52)
Head circumference (cm)	34.29 ± 1.28	34 (33–35)

Table 2: Distribution of Maternal Hemoglobin and Corresponding Cord Blood Hemoglobin Levels

Maternal anemia category	Maternal Hb (g/dL) Mean \pm SD	Cord blood Hb (g/dL) Mean \pm SD	Pearson r	p-value
Non-anemic (>11)	12.17 ± 0.81	15.36 ± 1.24	0.712	<0.001
Mild anemia (10–10.9)	10.21 ± 0.98	14.36 ± 0.82	0.785	<0.001
Moderate anemia (7–9.9)	9.46 ± 0.94	14.62 ± 0.91	0.824	<0.001
Severe anemia (<7)	7.62 ± 0.81	13.76 ± 0.43	0.681	<0.001

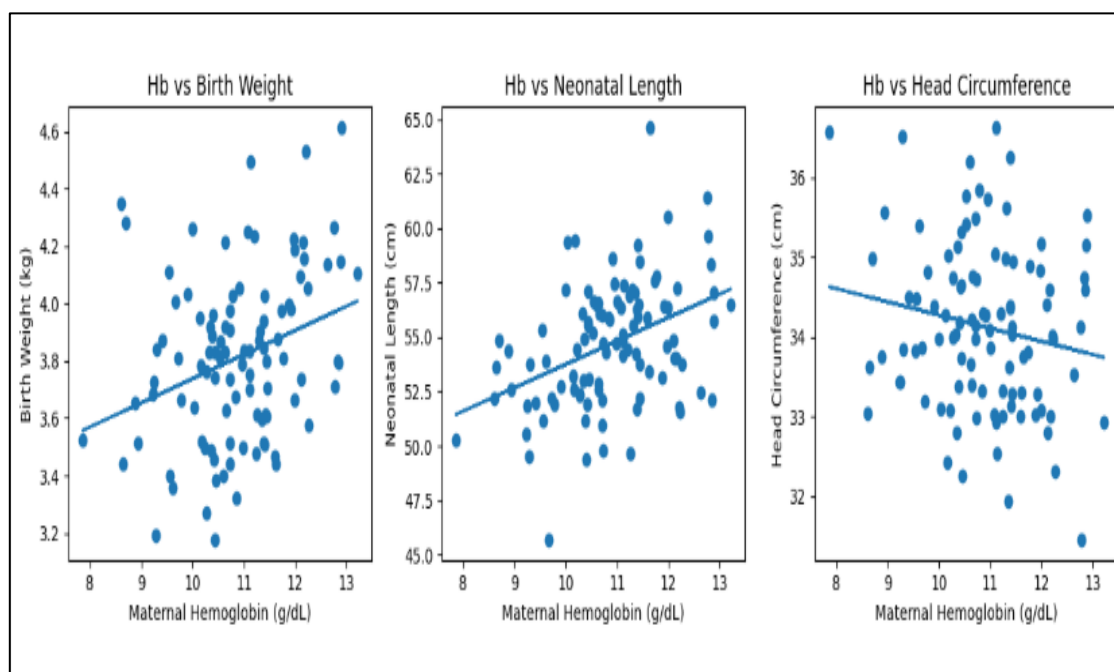


Figure 1: Association Between Maternal Hemoglobin and Neonatal Anthropometric Parameters

DISCUSSION

In this study assessing the association between maternal hemoglobin levels, umbilical cord hemoglobin, and neonatal anthropometric parameters, we found a significant positive correlation between maternal hemoglobin and umbilical cord

hemoglobin, and significant positive associations between maternal hemoglobin levels with neonatal birth weight and neonatal length, while the correlation with head circumference was not statistically significant. These findings provide important clinical insights into the impact of maternal hematological status on fetal growth at term. Our study demonstrated a direct maternal–fetal hematologic relationship: as maternal hemoglobin increased, umbilical cord hemoglobin levels also increased significantly across anemia severity categories (Table 2). This finding is consistent with previous research showing that maternal anemia negatively affects neonatal hemoglobin status. Studies have reported that anemic mothers tend to deliver neonates with lower cord blood hemoglobin concentrations compared to non-anemic mothers, underscoring the role of maternal hematological status in determining fetal hematologic reserves at birth[6].

In terms of neonatal growth outcomes, our results showed that maternal hemoglobin levels were significantly positively correlated with birth weight ($r = 0.32$, $p < 0.01$) and length ($r = 0.28$, $p < 0.05$) (Table 3). This aligns with several published studies that found positive relationships between maternal hemoglobin and neonatal anthropometry., *Kaur et al.* reported that maternal hemoglobin was significantly correlated with neonatal birth weight, length, and head circumference, and that increasing maternal hemoglobin was associated with improved anthropometric parameters of newborns[7]. Similarly, other observational studies have noted that neonates born to anemic mothers had significantly lower birth weights and reduced anthropometric measures compared to those born to non-anemic mothers.[7]

The positive association between maternal hemoglobin and birth weight in our study is corroborated by *Jo Haritash et al.* who reported that neonates born to mothers with moderate anemia had significantly lower birth weight, length, and head circumference. [8] Additionally, studies conducted in various Indian populations have consistently demonstrated that maternal anemia contributes to lower birth weight and other adverse neonatal outcomes, suggesting that this relationship persists across different settings and populations. [9]

Interestingly, while some studies reported significant correlations between maternal hemoglobin and all three anthropometric parameters, including head circumference, [10] our study did not find a statistically significant association between maternal hemoglobin and neonatal head circumference. This divergence could be due to differences in sample size, study population characteristics, or the categorization of anemia severity. Despite this, many studies have shown that severe maternal anemia is associated with smaller head circumference and overall reduced fetal growth, particularly in settings with high prevalence of iron deficiency anemia.[11] The findings of this study confirm the evidence that maternal hemoglobin concentration is an important determinant of fetal growth and that improving maternal anemia may have a beneficial impact on birth weight and length. Given that hemoglobin is a readily measurable and modifiable parameter in antenatal care, these results emphasize the need for continued efforts to prevent, detect, and treat maternal anemia through nutritional support and iron supplementation during pregnancy.

CONCLUSION

This study demonstrates a significant positive association between maternal hemoglobin levels and both umbilical cord hemoglobin and neonatal anthropometric parameters, including birth weight and neonatal length. Higher maternal hemoglobin levels were associated with better neonatal growth outcomes, suggesting that optimizing maternal hematological status during pregnancy may improve fetal growth and reduce the risk of complications such as low birth weight and intrauterine growth restriction. However, no significant association was observed between maternal hemoglobin and neonatal head circumference. These findings emphasize the importance of monitoring and managing maternal hemoglobin levels to promote optimal maternal and fetal health outcomes. Further longitudinal studies are needed to explore the long-term effects of maternal anemia on neonatal development and health.

Limitations

This study was conducted in a single-center setting with a relatively small sample size, which may limit the generalizability of the findings. Additionally, the cross-sectional design does not allow for causal inferences, and the study did not account for other potential confounders such as maternal diet or genetic factors that could influence neonatal outcomes.

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