Original Research

EFFECT OF MATERNAL HAEMOGLOBIN ON NEONATAL ANTHROPOMETRY

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ABSTRACT

Background: Maternal anemia remains one of the most common nutritional disorders during pregnancy and is associated with adverse maternal and neonatal outcomes. Reduced maternal Hb (Haemoglobin) levels may impair fetal oxygenation and growth, leading to alterations in neonatal anthropometric parameters. This study was conducted to evaluate the relationship between maternal haemoglobin, umbilical cord haemoglobin, and neonatal anthropometric measurements in term newborns.

Methods: A descriptive cross-sectional study was conducted over one year (February 2024–January 2025) at ACSR Government Medical College and Hospital, Nellore. A total of 404 healthy term neonates and their mothers meeting the inclusion criteria were enrolled. Maternal pre-delivery haemoglobin and umbilical cord haemoglobin were estimated using an automated hematology analyzer. Mothers were classified according to WHO criteria into mild and moderate anemia groups. Neonatal anthropometric parameters including birth weight, length, and head circumference were recorded. Statistical analysis was performed using SPSS version 26. A student's *t*-test and Pearson's correlation coefficient were used, with $p<0.05$ considered statistically significant.

Results: The mean maternal haemoglobin was 9.16 ± 0.94 g/dL, while the mean cord haemoglobin was 11.49 ± 1.08 g/dL. Among the mothers, 76% had moderate anemia and 24% had mild anemia. Low birth weight was observed in 18.5% of newborns. Maternal and cord haemoglobin levels were significantly lower in the moderate anemia group compared with the mild anemia group ($p<0.01$). A significant positive correlation was found between maternal and cord haemoglobin levels (r=0.598, $p=0.001$). However, maternal haemoglobin showed no statistically significant correlation with neonatal birth weight, length, or head circumference.

Conclusion: Maternal hemoglobin has a significant positive influence on neonatal cord haemoglobin, emphasizing the close hematological relationship between mother and fetus. Although maternal anemia did not significantly affect neonatal anthropometric measurements in this study, improving maternal hemoglobin status during pregnancy remains essential to optimize neonatal health and prevent adverse outcomes.

Keywords: Maternal Anemia, Hemoglobin, Umbilical Cord Hemoglobin, Neonatal Anthropometry, Birth Weight, Term Newborn, Pregnancy.

INTRODUCTION

Anaemia is the most common haematological disorder affecting pregnancy and is defined as a reduction in haemoglobin concentration or erythrocyte count.

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Iron deficiency and acute blood loss are the principal causes of anaemia during pregnancy and the postpartum period. Increased iron requirements during pregnancy often result in maternal iron deficiency, leading to adverse maternal and fetal outcomes.[1] According to the WHO (World Health Organization), maternal anaemia is defined as haemoglobin <11 g/dL and is classified as mild (10.0–10.9 g/dL), moderate (7.0–9.9 g/dL), and severe (<7.0 g/dL).[2]

Anaemia remains a major public health concern in India. Findings from the National Family Health Surveys (NFHS-3, NFHS-4, and NFHS-5) demonstrate persistently high anaemia prevalence

among women and children, with over 58% of children aged 6–59 months affected. Rural populations bear a greater burden due to poor nutrition, lower maternal education, poverty, and inadequate sanitation. The latest NFHS-5 also indicates a resurgence in anaemia prevalence across all severity categories, with marked state-wise disparities.[3,4] Globally, anaemia affects nearly half of pregnant women, while approximately 75% of pregnant women in developing countries are anaemic.[5] WHO estimates indicate that 37% of pregnant women worldwide are affected, making anaemia one of the leading contributors to maternal morbidity and mortality.[6]

Iron deficiency remains the predominant cause of anaemia, although deficiencies of folate, vitamin B12, vitamin A, riboflavin, infections, genetic disorders, and chronic diseases also contribute significantly.[6,7] Maternal anaemia is associated with adverse pregnancy outcomes, including preterm birth, stillbirth, low birth weight, impaired fetal growth, and increased maternal and neonatal mortality.[8,9]

Several studies have demonstrated a direct relationship between maternal haemoglobin concentration and neonatal outcomes. Lower maternal haemoglobin levels are associated with reduced umbilical cord haemoglobin, indicating diminished fetal iron stores and an increased risk of neonatal anaemia.[5] Furthermore, maternal anaemia adversely affects neonatal anthropometric parameters, including birth weight, length, and head circumference, with the severity of these effects increasing as maternal anaemia worsens.[10,11] Chronic maternal hypoxia caused by low haemoglobin may impair placental oxygen delivery, resulting in fetal growth restriction and reduced neonatal anthropometric measurements.[12]

Aims and Objectives

The present study aims to estimate maternal haemoglobin and umbilical cord blood haemoglobin levels at the time of delivery and to evaluate their correlation with the anthropometric measurements of term neonates.

MATERIALS AND METHODS

Study Design

The present study was a hospital-based descriptive cross-sectional study conducted in the Departments of Paediatrics and Obstetrics & Gynaecology at ACSR Government Medical College and Hospital, Nellore. The study was carried out over a period of one year, from February 2024 to January 2025. The study population comprised term newborns and their mothers who delivered at the study centre during the study period and fulfilled the eligibility criteria. Ethical approval for the study was obtained from the Institutional Ethics Committee of ACSR Government Medical College and Hospital before the commencement of the study.

Inclusion and Exclusion Criteria

The study included pregnant women aged more than 18 years who were willing to provide informed consent, had singleton pregnancies without any associated maternal comorbidities, and delivered healthy term babies. Only healthy full-term neonates with a gestational age of 37–41 weeks were included in the study. Mothers with pregnancy-related or medical complications, including gestational diabetes mellitus, pregnancy-induced hypertension, antepartum hemorrhage, or other chronic diseases complicating pregnancy, were excluded. Neonates were excluded if they had congenital malformations, birth asphyxia, multiple gestation (twins), or ABO/Rh incompatibility**.** This selection ensured the inclusion of healthy mother–infant pairs and minimized the influence of confounding maternal and neonatal conditions on the study outcomes.

Sample Size Calculation

A total of 404 pregnant mothers with their term newborns who satisfy the inclusion criteria were included in this study. Sample size was calculated depending upon the prevalence of anaemia in antenatal mothers in India[13] (50%) by using the formula 4p/L^2.prevalance of anaemia in India was around 50%.

Data Collection Procedure

Data were collected from pregnant women delivering at ACSR Government Medical College and Hospital and their healthy term neonates after obtaining informed consent. Maternal demographic and clinical details were recorded, and pre-delivery maternal haemoglobin levels were obtained from routine laboratory investigations. Immediately after delivery, the umbilical cord was double clamped before placental expulsion, and approximately 2 mL of cord blood was collected aseptically from the placental end of the severed umbilical vein into an EDTA-containing tube. The cord blood samples were analyzed in the Department of Pathology using an automated haematology analyzer for haemoglobin estimation and blood group determination. Based on maternal haemoglobin levels, mothers were categorized into anaemic (haemoglobin <11 g/dL) and non-anaemic (haemoglobin ≥11 g/dL) groups, according to standard criteria. The anaemic group was further classified into mild, moderate, and severe anaemia based on haemoglobin concentration. Cord blood haemoglobin values were then compared between the maternal groups and correlated with the anthropometric parameters of the healthy term newborns, including birth weight, length, and head circumference.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics version 26.0. Descriptive statistics were used to summarize the study variables. Continuous variables were expressed as mean ± standard deviation (SD**)**. The student's independent t-test was used to compare the mean values between the two groups. A p-value < 0.05 was considered statistically significant for all statistical analyses.

RESULTS

Variable	Minimum	Maximum	Mean ± SD
Maternal haemoglobin (g/dL)	7.00	12.20	9.16 ± 0.94
Cord haemoglobin (g/dL)	9.00	15.50	11.49 ± 1.08
Birth weight (kg)	2.20	3.80	2.68 ± 0.24
Length (cm)	42.00	52.00	47.90 ± 1.44
Head circumference (cm)	31.00	37.00	34.21 ± 0.88

Table 1. Baseline Characteristics of Mothers and Term Newborns

Table 1 illustrates the descriptive statistics of maternal haemoglobin, cord haemoglobin, and neonatal anthropometric measurements. The mean maternal haemoglobin was 9.16 ± 0.94 g/dL**,** while the mean cord haemoglobin was 11.49 ± 1.08 g/dL. The average neonatal birth weight, length, and head circumference were 2.68 kg**,** 47.90 cm, and 34.21 cm, respectively.

A. Maternal Anaemia Severity		
Category	**n**	**%**
Mild anaemia	92	24.0
Moderate anaemia	292	76.0
Severe anaemia	0	0
B. Birth Weight Distribution		
Category	**n**	**%**
Normal birth weight (≥2.5 kg)	313	81.5
Low birth weight (<2.5 kg)	71	18.5

Table 2. Distribution of Maternal Anaemia and Neonatal Birth Weight

Table 2 presents the distribution of maternal anaemia severity and neonatal birth weight. Moderate anaemia constituted the majority **(**76%**)** of mothers, while 81.5% of neonates had normal birth weights and 18.5% were classified as low birth weight.

Parameter	Mild (n=92)	Moderate (n=292)	P-Value
Maternal Hb (g/dL)	10.26 ± 0.24	8.77 ± 0.70	<0.01
Cord Hb (g/dL)	12.40 ± 0.87	11.20 ± 0.97	<0.01

Table 3. Comparison of Maternal and Cord Haemoglobin between Mild and Moderate Anaemia

Table 3 compares maternal and cord haemoglobin levels between mild and moderate anaemic mothers. Both maternal and cord haemoglobin levels were significantly higher in the mild anaemia group (p <0.01**),** indicating a positive influence of maternal haemoglobin on neonatal cord haemoglobin.

Parameter	Mild	Moderate	P value
Birth weight (kg)	2.68 ± 0.23	2.68 ± 0.25	>0.05
Length (cm)	47.97 ± 1.46	47.87 ± 1.43	>0.05
Head circumference (cm)	34.27 ± 0.96	34.19 ± 0.85	>0.05

Table 4. Comparison of Neonatal Anthropometric Measurements between Mild and Moderate Anaemia

Table 4 compares neonatal anthropometric measurements between mild and moderate maternal anaemia. Birth weight, length, and head circumference were comparable between groups, with no statistically significant differences **(**p >0.05).

A. Birth Weight Categories			
Maternal Hb	**2.2–2.49 kg**	**2.5–3.0 kg**	**>3.0 kg**
Mild	13 (14.1%)	72 (78.3%)	7 (7.6%)

Moderate	58 (19.9%)	213 (72.9%)	21 (7.2%)
B. Length Categories			
Maternal Hb	**42–45 cm**	**46–50 cm**	**>50 cm**
Mild	6 (6.5%)	81 (88.0%)	5 (5.4%)
Moderate	19 (6.5%)	263 (90.1%)	10 (3.4%)
C. Head Circumference Categories			
Maternal Hb	**31–33 cm**	**34–35 cm**	**>35 cm**
Mild	12 (13.0%)	62 (67.4%)	18 (19.5%)
Moderate	51 (17.5%)	196 (67.1%)	45 (15.4%)
Table 5. Maternal Anaemia Categories According to Neonatal Anthropometric Measurements			

Table 5 summarizes neonatal anthropometric categories according to maternal anaemia severity. Most newborns in both groups had birth weights between 2.5 and 3.0 kg**,** lengths between 46 and 50 cm**,** and head circumferences between 34 and 35 cm**,** demonstrating similar anthropometric distributions.

Parameter	Normal Birth Weight	Low Birth Weight	P value
Maternal Hb	9.18 ± 0.89	8.91 ± 0.87	<0.01
Cord Hb	11.55 ± 1.10	11.20 ± 0.95	<0.01
Table 6. Comparison of Maternal and Cord Haemoglobin According to Birth Weight			

Table 6 compares maternal and cord haemoglobin levels between normal and low birth weight neonates. Both maternal and cord haemoglobin were significantly lower among low birth weight infants **(**p <0.01).

Variables	Correlation (r)	P value
Maternal Hb vs Cord Hb	0.598	0.001*
Maternal Hb vs Birth Weight	0.084	0.098
Maternal Hb vs Length	0.085	0.098
Maternal Hb vs Head Circumference	0.014	0.780
Table 7. Correlation of Maternal Haemoglobin with Cord Haemoglobin and Neonatal Anthropometry		
*Significant at p<0.05		

Table 7 demonstrates the correlations between maternal haemoglobin and neonatal outcomes. A moderately positive and statistically significant correlation was observed between maternal and cord haemoglobin (r = 0.598, p = 0.001**),** whereas correlations with birth weight, length, and head circumference were weak and not statistically significant.

Variables	Correlation (r)	P value
Cord Hb vs Birth Weight	0.107	0.037*
Cord Hb vs Length	0.151	0.003*
Cord Hb vs Head Circumference	0.029	0.567
Table 8. Correlation of Cord Haemoglobin with Neonatal Anthropometric Measurements		
*Significant at p<0.05		

Table 8 shows the relationship between cord haemoglobin and neonatal anthropometric measurements. Cord haemoglobin demonstrated weak but statistically significant positive correlations with birth weight and neonatal length, whereas its association with head circumference was weak and not statistically significant.

DISCUSSION

Anaemia remains one of the most common nutritional deficiencies affecting pregnant women and is associated with adverse maternal and neonatal outcomes.[14,15] Maternal anaemia, particularly iron deficiency anaemia, is largely preventable and treatable when detected early.[10,16] It has been associated with impaired fetal growth and altered neonatal anthropometric measurements. The present study evaluated the relationship between maternal haemoglobin, cord blood haemoglobin, and neonatal anthropometric parameters in term newborns.

Among the 384 pregnant women included in this study, 76% had moderate anaemia and 24% had mild anaemia, while no cases of severe anaemia were observed. A similar predominance of moderate anaemia has been reported by Desalegn S.[17] In contrast, recent studies by Dr. Shewetha N et al.,[16]

and Sai Brigisha Kyasa et al.,[11] reported a higher proportion of mild anaemia, possibly reflecting improved maternal nutrition, better antenatal care, and iron supplementation. The higher prevalence of moderate anaemia in the present study may be attributed to the predominantly rural background, inadequate nutritional awareness, and irregular antenatal visits. The absence of severe anaemia is likely due to the exclusion criteria adopted in the study.[18]

The mean maternal haemoglobin level was 9.16 ± 0.94 g/dL, indicating moderate anaemia in most participants. Comparable findings were reported by Nagza Kakkar et al.[18] and Dr. Shewetha N et al.[16] Reduced maternal haemoglobin may limit oxygen delivery to the fetus, resulting in chronic fetal hypoxia and impaired intrauterine growth, which can adversely influence neonatal anthropometric outcomes.

The mean cord blood haemoglobin was 11.49 ± 1.08 g/dL, and cord haemoglobin was significantly higher among neonates born to mothers with mild anaemia compared with moderate anaemia ($p<0.01$). A significant positive correlation was observed between maternal and cord blood haemoglobin ($r=0.598$), consistent with the findings of Rania Ali El-Farrash et al.[19] and Arvind Shukla et al.[20] However, Shah J.[21] and Marmoury et al.[22] reported no significant association. The present findings suggest that declining maternal haemoglobin levels may reduce placental iron transfer, thereby lowering fetal haemoglobin concentration.[16]

Birth weight is an important indicator of fetal growth and neonatal survival. In the present study, 81.5% of neonates had normal birth weight, whereas 18.5% were of low birth weight. Although the mean birth weight was similar in mothers with mild and moderate anaemia (2.68 kg), no statistically significant difference was observed. Comparable findings have been reported by Behal M et al.[23] Although the association was weak, maternal haemoglobin demonstrated a positive relationship with neonatal birth weight.

The mean neonatal length was 47.97 cm in the mild anaemia group and 47.87 cm in the moderate anaemia group, without statistical significance. Nevertheless, neonates born to mothers with lower haemoglobin tended to have a shorter birth length. Similar observations were reported by Bushra Nasreen.[10] and Sangeetha V[24] In contrast, Dr. Shewetha N et al. [16] demonstrated a significant reduction in birth length with increasing severity of maternal anaemia, while Paramahamsa RRK et al. [25] also reported shorter crown-heel length among neonates born to anaemic mothers.

Similarly, the mean head circumference was 34.27 cm in the mild anaemia group and 34.17 cm in the moderate anaemia group, with no statistically significant difference. However, lower maternal haemoglobin levels were associated with relatively smaller head circumference, consistent with previous reports by Bushra Nasreen.[10] and Sangeetha V. [24] Significant reductions in neonatal head circumference with increasing severity of maternal anaemia have also been documented by Dr. Shewetha N et al.,[16] Behal et al.,[23] and Nagza Kakkar et al.[18]

Correlation analysis demonstrated a very weak positive association between maternal haemoglobin and neonatal birth weight ($r=0.084$), body length ($r=0.085$), and head circumference ($r=0.014$), none of which reached statistical significance. Similar weak correlations were reported by Nagza Kakkar et al.[18] observed strong positive correlations in mothers with severe anaemia. The absence of severe anaemia in the present study may explain the weaker associations observed.

The present study demonstrates a significant positive relationship between maternal and cord blood haemoglobin levels, while the association between maternal haemoglobin and neonatal anthropometric measurements was weak and statistically non-significant. These findings suggest that maternal anaemia primarily influences fetal iron status rather than anthropometric outcomes among term neonates with mild to moderate anaemia. Nevertheless, early identification and appropriate management of maternal anaemia remain essential to improve both maternal health and neonatal outcomes, supporting observations reported in previous studies.

CONCLUSION

The present study concludes that maternal iron deficiency anaemia significantly influences cord blood haemoglobin levels and demonstrates a weak positive association between maternal haemoglobin and neonatal anthropometric parameters, including birth weight, length, and head circumference. These findings highlight the importance of early detection and effective management of maternal anaemia to improve neonatal growth outcomes and reduce the risk of neonatal anaemia. Maintaining maternal haemoglobin levels above 11 g/dL throughout pregnancy, the postpartum period, and breastfeeding is essential for optimal fetal and infant development. The results also emphasize the need for comprehensive public health strategies to ensure adequate maternal nutrition during the reproductive years. A limitation of this study was the assessment of maternal haemoglobin at a single time point without trimester-wise evaluation and the absence of long-term follow-up of neonatal growth. Therefore, larger prospective longitudinal studies incorporating additional maternal and neonatal risk factors are recommended to better define the relationship

between maternal haemoglobin status and neonatal anthropometric outcomes.

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