RESEARCH ARTICLE

Maternal Haemoglobin, Cord Blood Haemoglobin and Neonatal Anthropometry: A Prospective Observational Study

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ABSTRACT

Background: Maternal anaemia remains an important public-health problem and may influence neonatal haematological status and growth. Cord blood haemoglobin reflects neonatal haematological status, while anthropometric measurements provide an immediate assessment of fetal growth. The current study shows the relationship between third-trimester maternal haemoglobin, cord blood haemoglobin and neonatal anthropometric parameters.

Methods: A prospective observational study was conducted over 18 months in a tertiary care hospital at Puducherry; 40 mother and neonate pairs fulfilling the study criteria were enrolled by convenience sampling. Maternal third-trimester haemoglobin and cord blood haemoglobin were recorded. Neonatal birth weight, length, head circumference, chest circumference, abdominal circumference and neonatal ponderal index (NPI) were assessed. Data were analysed using SPSS version 23. Pearson correlation, independent-samples t-test and one-way ANOVA were used as appropriate, with $p<0.05$ considered statistically significant.

Results: Among 40 neonates, 22 (55.0%) were male and 18 (45.0%) were female. The mean maternal haemoglobin was 11.49±1.15 g/dL; 18 (45.0%) mothers had haemoglobin <11 g/dL. Mean cord blood haemoglobin was 14.79±1.40 g/dL and mean birth weight was 2.80±0.36 kg. Maternal haemoglobin was not significantly correlated with cord blood haemoglobin (r=-0.027, p=0.869), birth weight (r=0.297, p=0.063), length (r=-0.087, p=0.592), head circumference (r=0.272, p=0.089), chest circumference (r=0.268, p=0.095) or abdominal circumference (r=-0.021, p=0.899). A significant positive correlation was observed between maternal haemoglobin and NPI (r=0.376, p=0.017). Neonates of primigravidae had significantly higher birth weight, head and chest circumference and NPI than neonates of multigravidae. Significant differences were also observed across gestational-age and mode-of-delivery categories.

Conclusion: In this cohort, maternal third-trimester haemoglobin showed no significant association with cord blood haemoglobin or most neonatal anthropometric parameters. NPI showed a modest but statistically significant positive correlation with maternal haemoglobin. Larger multicentre studies incorporating maternal iron stores and neonatal ferritin are warranted.

Keywords: maternal anaemia; haemoglobin; cord blood; neonatal anthropometry; birth weight; ponderal index; pregnancy

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INTRODUCTION

Pregnancy-related anemia is a serious nutritional and public health issue, especially in low- and middle-income nations. Pregnant women in India have a significant prevalence of anemia, which is defined by the World Health Organization as having hemoglobin levels below 11 g/dL.[1,2] While the

third trimester is a time of fast fetal iron acquisition and growth, maternal hemoglobin is essential for oxygen transport and placental function.[3, 4]

Maternal-fetal iron transfer and cumulative fetal erythropoiesis may be reflected in cord blood hemoglobin, a readily accessible biomarker of neonatal hematological health. Maternal anemia and cord blood hemoglobin have been linked in earlier research, however the strength and direction of this relationship vary.[5-7] Despite maternal iron deficit, placental iron transfer can maintain the fetal iron supply, especially in mild-to-moderate anemia.[8,9]

Neonatal anthropometric measurements, which include birth weight, length, head circumference, chest circumference, belly circumference, and the neonatal ponderal index, provide further information about fetal growth and nutritional health. Some studies have found a weak or inconsistent correlation between maternal hemoglobin and fetal growth.[10–13] Therefore, in a tertiary-care setting in Puducherry, the current study was conducted in maternal third-trimester hemoglobin in relation to cord blood hemoglobin and infant anthropometric characteristics.

AIM AND OBJECTIVES

The aim was to evaluate the relationship between maternal haemoglobin, cord blood haemoglobin and neonatal anthropometry, to determine maternal and cord blood haemoglobin levels at birth, to assess neonatal birth weight, length, head circumference, chest circumference, abdominal circumference and neonatal ponderal index. To study the correlation between maternal haemoglobin and cord blood haemoglobin, to determine the correlation between maternal haemoglobin and neonatal anthropometric measurements and to correlate cord blood haemoglobin with neonatal anthropometric parameters.

MATERIALS AND METHODS

A prospective observational hospital-based study was conducted in the neonatal care unit and relevant obstetric/post-operative wards in a tertiary care centre at Ariyur, Puducherry for a period of 18 months following institutional ethical approval (Ref no: 119/SVMCH/IEC-Cert/February24). Mother-neonate pairs fulfilling the predefined eligibility criteria were considered as the study participants. Term and preterm neonates born by vaginal or caesarean delivery were eligible. Mothers with severe anaemia (Hb <7 g/dL), diabetes mellitus, pregnancy-induced hypertension, cardiovascular disease and twin pregnancies were excluded. Unregistered/uninvestigated mothers were also excluded. Convenience sampling was used and the study comprised 40 neonates.

DATA COLLECTION

Parents and guardians provided written informed consent. As soon as the baby was delivered, around 5 mL of cord blood was drawn from the placental end of the umbilical cord and placed in a clot-activator tube. After allowing the sample to clot, the serum was separated and kept at -20°C until analysis after being centrifuged at 400×g for 10 minutes. Gestational age, parity, third-trimester hemoglobin, and maternal background data were noted. The Ballard score was used to determine gestational age. An infantometer was used to measure the newborn's length, an electronic scale was used to determine its weight, and a non-stretchable measuring tape was used to measure its head, chest, and abdomen circumferences.

STATISTICAL ANALYSIS

Maternal hemoglobin from the third trimester was the main exposure. Cord blood hemoglobin was the main newborn hematological result. Birth weight, length, head circumference, chest circumference, belly circumference, and NPI were the anthropometric results. NPI was computed by dividing length in centimeters cubed by weight in grams and then multiplying the result by 100.

Microsoft Excel 2010 was used to enter the data, while SPSS version 23 was used for analysis. Frequencies and percentages were used to summarize categorical variables, while mean±standard deviation and range were used to convey continuous variables. Relationships between continuous variables were evaluated using Pearson correlation. When comparing two groups, the independent-samples t-test was employed, and when comparing more than two groups, the one-way ANOVA was utilized. Statistical significance was defined as a p-value of less than 0.05.

RESULTS

The results of the study were presented in tables 1-4. In forty neonates there were 22 (55.0%) males and 18 (45.0%) females. Twenty-two mothers (55.0%) were primigravidae and 18 (45.0%) were multigravidae. Thirty-two neonates (80.0%) were term, six (15.0%) were late preterm and two (5.0%) were preterm. Twenty neonates (50.0%) delivered vaginally, 11 (27.5%) by elective LSCS and nine (22.5%) by emergency LSCS.

Table 1: Baseline characteristics of the study population (N=40)

Characteristic	n	%
Male neonates	22	55.0
Female neonates	18	45.0
Primigravida	22	55.0
Multigravida	18	45.0

Normal birth weight (≥2.5 kg)	34	85.0
Low birth weight (1.5–<2.5 kg)	6	15.0
SVD	20	50.0
Elective LSCS	11	27.5
Emergency LSCS	9	22.5
Term (37–42 weeks)	32	80.0
Late preterm (35–37 weeks)	6	15.0
Preterm (32–34 weeks)	2	5.0
Maternal Hb ≥11 g/dL	22	55.0
Maternal Hb <11 g/dL	18	45.0

Table 2: Maternal and Neonatal Descriptive Statistics

Variable	Mean±SD	Range
Maternal haemoglobin (g/dL)	11.49±1.15	9.3–13.7
Cord blood haemoglobin (g/dL)	14.79±1.40	10.5–17.4
Birth weight (kg)	2.80±0.36	2.02–3.47
Length (cm)	49.65±4.46	41–65
Head circumference (cm)	33.20±2.66	22–35
Chest circumference (cm)	31.68±2.12	20–34
Abdominal circumference (cm)	29.77±0.83	28–31
Neonatal ponderal index	2.30±0.21	1.90–2.86

Table 3: Comparison of neonatal parameters by sex.

Neonatal parameter	Male (n=22) Mean±SD	Female (n=18) Mean±SD	p-value
Birth weight (kg)	2.79±0.37	2.82±0.36	0.764
Cord blood Hb (g/dL)	14.81±1.39	14.76±1.46	0.916
Length (cm)	49.68±5.46	49.61±2.97	0.961
Head circumference (cm)	32.86±3.50	33.61±0.92	0.384
Chest circumference (cm)	31.45±2.74	31.94±0.94	0.474
Abdominal circumference (cm)	29.77±0.92	29.78±0.73	0.985
Neonatal ponderal index	2.31±0.24	2.28±0.19	0.680

Table 4: Pearson correlation between maternal haemoglobin and neonatal parameters (N=40)

Parameter	Pearson r	p-value	Interpretation
Birth weight	0.297	0.063	Not significant
Cord blood Hb	−0.027	0.869	Not significant
Length	−0.087	0.592	Not significant
Head circumference	0.272	0.089	Not significant
Chest circumference	0.268	0.095	Not significant
Abdominal circumference	−0.021	0.899	Not significant
Neonatal ponderal index	0.376	0.017	Significant

The mother's haemoglobin showed no significant correlation with the cord blood haemoglobin (r=0.027, p=0.869). There was also no statistical significance between these measurements baby's birth weight, length, head

circumference, chest circumference, or abdominal circumference. Mild, but positive correlation was found between the mother's haemoglobin level and the NPI score (r=0.376, p=0.017), which accounts for about 14.1% of the changes seen.

When compared the neonatal parameters based on the mother's haemoglobin levels, the only important difference was in the NPI score. Babies born to mothers with haemoglobin levels of 11 g/dL or higher had a higher average NPI compared to babies born to mothers who were anaemic. The average NPI was 2.36 ± 0.23 for the higher haemoglobin group and 2.22 ± 0.17 for the anaemic group, and this difference was statistically significant (p=0.038). Birth weight, cord blood haemoglobin levels, length, and circumferences were all similar and did not show any major differences. Primigravida mothers had neonates with higher birth weight (2.96±0.29 vs 2.61±0.35 kg; p=0.001), head circumference (34.00±0.69 vs 32.22±3.72 cm; p=0.034), chest circumference (32.27±0.83 vs 30.94±2.90 cm; p=0.047) and NPI (2.40±0.19 vs 2.17±0.17; p=0.047) and and NPI (2.40±0.19 vs 2.17±0.17; p<0.001) than multigravida mothers.

In different modes of delivering babies, there were significant differences in birth weight, length, head size, chest size and NPI scores, but not in cord blood hemoglobin or abdominal size. When looking at different stages of pregnancy, there were clear differences in birth weight, length, head size, chest size, belly size, and the NPI score.However, the amount of oxygen-carrying protein in the blood from the umbilical cord did not show any major differences. The preterm group had just two babies. Compared with normal-birth-weight neonates, low-birth-weight neonates had significantly lower length (44.50±2.95 vs 50.56±4.07 cm; p=0.001), head circumference (30.33±4.08 vs 33.71±2.02 cm; p=0.003), chest circumference (28.67±4.27 vs 32.21±0.77 cm; p<0.001), abdominal circumference (28.50±0.55 vs 30.00±0.65 cm; p<0.001) and NPI (2.05±0.10 vs 2.34±0.20; p=0.001). No significant difference was observed between the maternal and cord blood haemoglobin between birth-weight categories.

DISCUSSION

This observational study aimed to assess whether the haemoglobin levels of mothers in their third trimester were associated with the haemoglobin levels in cord blood and the growth parameters of newborns. The study indicated that there was no notable correlation between maternal haemoglobin and cord blood haemoglobin. This result supports the idea that the mechanisms of placental iron transport and fetal regulation could protect the fetus from the effects of mild-to-moderate maternal iron deficiency.[8,9] However, earlier research has shown varying relationships between maternal and cord blood haemoglobin, highlighting the impact of different population characteristics, the severity and duration of maternal anaemia, the timing of haemoglobin measurements, and other maternal factors.[5,7,14-15]

The average maternal haemoglobin level recorded was 11.49 g/dL, with 45% of mothers classified as anaemic according to the study's criteria. This prevalence is particularly significant in India, where pregnancy-related anaemia remains widespread.[1,2]. The average cord blood hemoglobin level observed was 14.79 g/dL, which falls within the typical neonatal range for this group. The absence of a correlation between maternal and cord hemoglobin indicates that cord hemoglobin alone might not sufficiently reflect neonatal iron reserves, a concern also raised by research utilizing ferritin as a more accurate indicator of neonatal iron levels [9,6].

Maternal hemoglobin did not show a significance birth weight, length, or the circumferences of the head, chest, or abdomen. Although the association with birth weight was positive (r=0.297), it did not achieve statistical significance (p=0.063). Likewise, the correlation with head circumference was close to, but not quite at, conventional levels of significance (r=0.272, p=0.089). The relatively small sample size may have restricted the ability to identify clinically relevant associations.

The positive correlation between maternal haemoglobin levels and NPI (r=0.376, p=0.017) is significant. NPI accounts for the birth weight in relation to length and may offer insights into the proportionality of fetal growth that birth weight alone does not reveal. The reduced NPI in infants born to mothers with anemia suggests that the haemoglobin levels of the mother could impact fetal body composition or proportional growth, even in cases where traditional anthropometric measurements do not show significant differences.[10]

The present study also indicated substantial variations in neonatal anthropometry based on factors such as parity, gestational age, and the mode of delivery. These relationships should not be viewed as causal. Gestational age is inherently linked to the size of the newborn, while the method of delivery may indicate underlying obstetric reasons. The substantial differences between term and preterm groups reinforce the importance of considering gestational age when interpreting neonatal anthropometry.

Low-birth-weight neonates had substantial smaller length and circumferences and a lower NPI that is biologically coherent and consistent with relationship developed between birth weight and neonatal anthropometry.[16-18] No significant difference between maternal and cord haemoglobin among the normal and low-birth-weight groups that suggests heamoglobin concentration alone contributes the pathway linked with maternal nutritional status to fetal growth.

In the present study, the results indicate the maternal haemoglobin has relationship with neonatal growth than simple linear association with birth weight or cord haemoglobin. The study suggests maternal iron status, ferritin, dietary intake, iron–folic acid supplementation, socioeconomic factors and gestational-age-related processes which may all contribute to neonatal outcomes were similar with earlier studies.[19-21]

CONCLUSION

In this cohort of 40 mother–neonate pairs, maternal third-trimester haemoglobin was not significantly correlated with cord blood haemoglobin, birth weight, length, head circumference, chest circumference or abdominal circumference. Mild positive significant correlation was observed between maternal haemoglobin and neonatal ponderal index. Neonatal anthropometry varied significantly with parity, gestational age and mode of delivery. Larger multicentre prospective studies incorporating maternal ferritin and other iron-status measures, detailed nutritional information and longitudinal neonatal follow-up are needed to clarify the relationship between maternal iron status and neonatal growth and haematological status.

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