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IMPACT OF MATERNAL ANEMIA ON UMBILICAL CORD HEMOGLOBIN LEVEL – PROSPECTIVE OBSERVATIONAL CROSS-SECTIONAL STUDY.

[1]Ritu Singh, [2]Meena Samant, [3]Swaroop Nanda, [4]Avinash Kumar Singh*

[1]Consultant, Department of Obs & Gyn, Kurji Holy Family Hospital, Patna, Bihar, India.
[2]HOD, Department of Obs and Gyn, Kurji Holy Family Hospital, Patna, Bihar, India.
[3]Resident, Department of Obs & Gyn, Kurji Holy Family Hospital, Patna, Bihar, India.
[4]Senior resident, Department of Radiodiagnosis, Indira Gandhi Institute of Medical Science, Patna, Bihar, India.

Abstract

Introduction

Anaemia is a prevalent condition in expecting mothers. Studies have shown that maternal anemia affects fetal growth and development which is evidenced by cord blood haemoglobin. The present study determines the effect of maternal anemia on fetal cord blood hemoglobin in the first and third trimesters.

Method

This study was conducted in a rural tertiary hospital in Eastern India in the department of obstetrics and gynecology. Women were recruited for 6 months and the follow-up analysis was conducted for up to 9 months. Women who delivered their babies at our institute were included in the study. Maternal hemoglobin in the first and third trimesters and cord blood hemoglobin after birth were measured to examine the impact of the former on the latter.

Result

Among 500 participants, the mean maternal hemoglobin was 11.51 ± 7.94 g/dl in the 1st trimester and 10.21 ± 1.52 g/dl in the 3rd trimester. Cord hemoglobin levels were 14.28 ± 2.08 g/dl. In the 3rd trimester, 342 (68.4%) women were anemic: 190 (55.56%) with mild, 137 (40%) with moderate, and 15 (4.3%) with severe anemia. Cord blood hemoglobin correlated positively with maternal hemoglobin in both trimesters (1st: F=5.55, p=0.001; 3rd: F=8.55, p=0.000). The 9-month follow-up showed that maternal anemia, especially in the 3rd trimester, was significantly associated with lower cord blood hemoglobin.

Conclusion

This study found a significant association between maternal hemoglobin and cord blood hemoglobin in the participants both in the 1st trimester and third trimester, and the association was identified to be linear.

Recommendations

Preventing neonatal complications requires early detection and treatment of anemia in pregnant women, especially in the third trimester. To protect maternal and fetal health, doctors should check hemoglobin levels throughout pregnancy.

Keywords: *Anemia, Cord Blood Haemoglobin, Maternal hemoglobin, Fatal development.*
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Corresponding Author*: Avinash Kumar Singh**
Email: ***avinash.8744@gmail.com***
Senior resident, Department of Radiodiagnosis, Indira Gandhi Institute of Medical Science, Patna, Bihar, India.

Introduction

Anaemia occurring during pregnancy is a notable concern for public health since it has consequences for the well-being of both the mother and the developing fetus. Based on the 2021 statistics from the World Health Organisation (WHO), the worldwide occurrence of anemia in pregnant women was approximately 36.5% in 2019 [1]. The National Family Health Survey (NFHS-5) conducted in India from 2019 to 2021 revealed that 52.2% of women between the ages of 15 and 49 experienced anemia during pregnancy. While the prevalence recorded in NFHS-4 (2015-16) has somewhat increased from the 50.4% seen, it still reflects a drop from the 57.9% prevalence reported in NFHS-3 (2005-2006) [2].

Anemia during pregnancy is characterized by the World Health Organisation (WHO) as having a hemoglobin (Hb) level below 11 g/dl. Anaemia is classified according to its severity into three categories: mild (10 to 10.9 g/dl), moderate (7 to 9.9 g/dl), and severe (<7 g/dl) [3]. Maternal anemia presents significant hazards to the development of the fetus, mainly because it affects the delivery of oxygen and nutrients, which are essential for fetal growth. Optimal fetal development is dependent on sufficient amounts of maternal hemoglobin, as the fetus relies on it for oxygen transport.

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Although fetal hemoglobin levels can offer valuable information about the health of the fetus, directly measuring fetal hemoglobin is both difficult and dangerous. Umbilical cord blood hemoglobin levels are frequently employed as a substitute to estimate fetal hemoglobin levels [4]. Nevertheless, there is ongoing controversy over the association between maternal anemia and cord blood hemoglobin. Recent investigations exhibit divergent results: certain studies demonstrate no link [5], while others propose a correlation [6], and some indicate a linear relationship [7]. However, there is a lack of data on the specific effects of maternal anemia, as determined in the first trimester, on cord blood hemoglobin levels.

The time of measuring maternal hemoglobin levels can impact the apparent relationship between maternal anemia and birth weight [8]. Considering the range of differences, conducting a prospective observational study to evaluate maternal anemia during the first and third trimesters and its impact on cord blood hemoglobin levels should yield valuable findings. This study seeks to address the current knowledge gap by investigating the impact of maternal anemia at various stages of pregnancy on fetal cord blood hemoglobin. This research will provide valuable insights into the consequences of anemia on fetal well-being.

Aim of the study

This study aims to examine the effect of maternal anemia on fetal cord blood hemoglobin levels by assessing the maternal hemoglobin status during the first and third trimesters of pregnancy. This study aims to elucidate the correlation between maternal anemia and cord blood hemoglobin during various stages of pregnancy to better understand the impact of anemia severity on neonatal outcomes. The objective of the research is to gain a deeper understanding of the impact of different levels of maternal hemoglobin on the health of the fetus. The purpose is to enhance knowledge about the consequences of anemia for both the mother and the newborn and to use this information to develop better methods for prenatal care.

Material and Methods

Study Design

Hospital-based Prospective Observational Cross-sectional Study.

Study Setting

Department of Radiodiagnosis, Indira Gandhi Institute of Medical Science, Patna, Bihar, India, spanning from February 2023 to June 2024.

Study Population

Pregnant women visiting the Department of Obstetrics and Gynecology outpatient unit.

Sample size

The hospital oversees and provides care for around 4,800 women annually. Based on a projected 15% occurrence of adverse outcomes in fetuses [9], a group of 500 women was selected to participate in this research project. The recruitment process spanned 6 months, and the participants were then monitored for a duration of 8 to 9 months.

Inclusion Criteria

All consecutive pregnant women, regardless of age and parity, with a single pregnancy in the first trimester, were enrolled in the study. This study comprised neonates born at 37-41 weeks of gestation (full-term) and neonates born before 34 weeks of gestation (preterm). This study included newborn infants delivered via both vaginal delivery and cesarean section.

Exclusion Criteria

Women who refused to continue participating in the study during the second and third trimesters of pregnancy were excluded from this study. This study did not include women who had fetuses with congenital malformations, cases of birth asphyxia, mothers with Rh incompatibility with their babies, women with gestational diabetes, or pregnancy-induced hypertension.

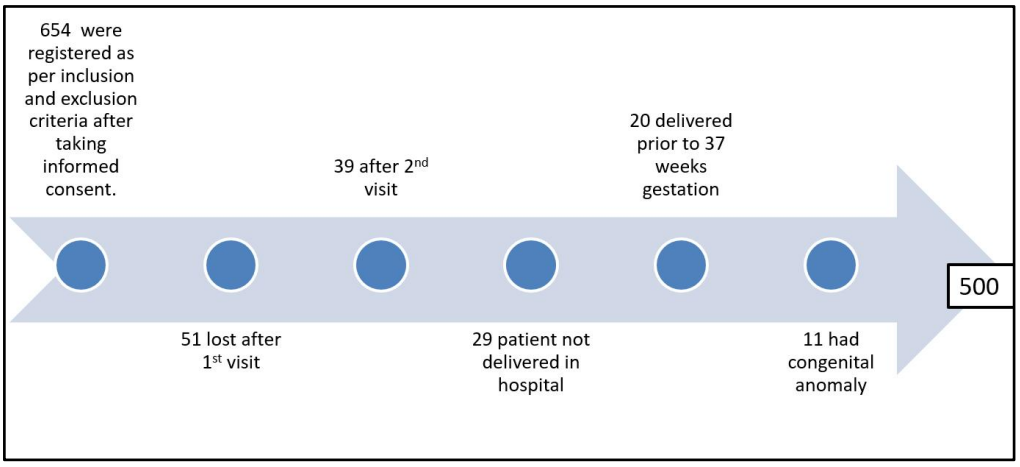

Figure 1: Flow chart depicting patient screening.

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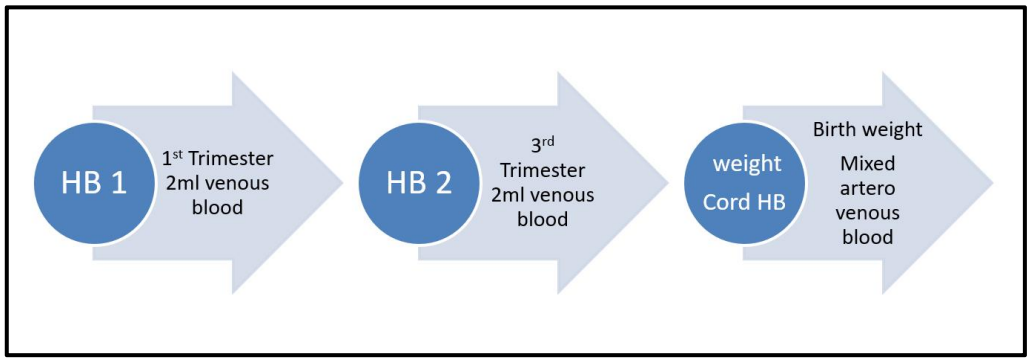

Figure 2: Study procedure following in the patients.

Procedure

For this study, a total of 2 ml of venous blood was obtained from pregnant women at two different stages of pregnancy: the first trimester and the third trimester, before giving birth. Following the delivery, the average birth weight and the combined arteriovenous blood of the newborn were documented. Maternal hemoglobin levels were assessed before birth, and mothers were classified into two groups based on these values: anemic and non-anemic. Anemia during pregnancy is categorized into three levels: mild (10-10.9 g/dl), moderate (7-9.9 g/dl), or severe (<7 g/dl). Subsequently, the hemoglobin levels in the cord blood of newborns born to women with anemia (including mild, moderate, and severe cases) were compared to those of newborns born to mothers without anemia.

Statistical analysis

The data was entered into a spreadsheet using Excel. The statistical study was conducted using the Jamovi 2.3.28 stable version. Descriptive statistics, including the mean and standard deviation, were computed for all numerical variables in the study, such as age, maternal hemoglobin, and neonatal cord blood hemoglobin. The process of inferential statistics was employed to analyze the relationship between maternal hemoglobin and cord blood hemoglobin using a one-way ANOVA. A p-value less than 0.05 was deemed statistically significant.

Ethical considerations

The study protocol was approved by the Ethics Committee and written informed consent was received from all the participants.

Results

Table 1: Descriptive statistics for various parameters in the study population:

Parameters	N	Minimum	Maximum	Mean	Std. Deviation
Age (years)	500	18.00	35.00	23.52	3.03
1st-trimester Maternal Hemoglobin (g/dl)	500	4.70	14.05	11.51	7.94
3rd trimester Maternal Hemoglobin(g/dl)	500	4.30	13.70	10.21	1.52
Cord Hemoglobin(g/dl)	500	8.00	19.50	14.28	2.08

The study encompassed a sample of 500 pregnant women, with the average age of participants being 23.52 ± 3.03 years, ranging from 18 to 35 years. The average maternal hemoglobin levels recorded in the first trimester were 11.51 g/dl, with a minimum of 4.70 g/dl and a maximum of 14.05 g/dl. During the third trimester, the average maternal hemoglobin level dropped to 10.21 g/dl, ranging from 4.30 to 13.70 g/dl. The average hemoglobin level in the cord blood of the newborns was 14.28 g/dl, with recorded values ranging from a minimum of 8.00 g/dl to a maximum of 19.50 g/dl as shown in Table 1.

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Table 2: Effect of maternal anemia on cord blood Hemoglobin

Maternal anemia	Mean cord Hb (n=500)	F-value	p-value
First Trimester			
Normal- 251(≥11g/dl)	14.65±2.18	5.55	0.001 S,p<0.05
Mild -154(10-10.9g/dl)	13.89±1.76		
Moderate- 86(7-9.9g/dl)	13.92±1.95		
Severe- 9(<7g/dl)	13.90±3.60		
Pre-delivery			
Normal-158(≥11g/dl)	14.79±2.22	8.55	0.000 S,p<0.05
Mild- 190(10-10.9g/dl)	14.32±2.00		
Moderate-137(7-9.9g/dl)	13.80±1.58		
Severe-15(<7g/dl)	12.80±3.68		

Significant variations were observed in cord blood hemoglobin levels when analyzing the impact of maternal anemia at different levels. During the initial trimester, the average cord hemoglobin level was highest among mothers with normal hemoglobin levels (≥11 g/dl), with an average of 14.65 ± 2.18 g/dl. Subsequently, those with mild (10-10.9 g/dl), moderate (7-9.9 g/dl), and severe (<7 g/dl) anemia had average cord hemoglobin levels of 13.89 ± 1.76 g/dl, 13.92 ± 1.95 g/dl, and 13.90 ± 3.60 g/dl, respectively. The disparity in cord hemoglobin levels between these groups was statistically significant, as indicated by an F-value of 5.55 and a p-value of 0.001. Similarly, the levels of hemoglobin in expectant mothers before delivery had a notable effect on the amounts of hemoglobin in the cord blood. Mothers who had normal levels of hemoglobin before giving birth had the highest average cord hemoglobin level of 14.79 ± 2.22 g/dl. In comparison, mothers with mild, moderate, and severe anemia had average cord hemoglobin levels of 14.32 ± 2.00 g/dl, 13.80 ± 1.58 g/dl, and 12.80 ± 3.68 g/dl, respectively. The observed difference was statistically significant, as evidenced by an F-value of 8.55 and a p-value of 0.000. This suggests that maternal anemia, namely during the third trimester, is linked to reduced amounts of hemoglobin in the cord blood of newborns (Table 2).

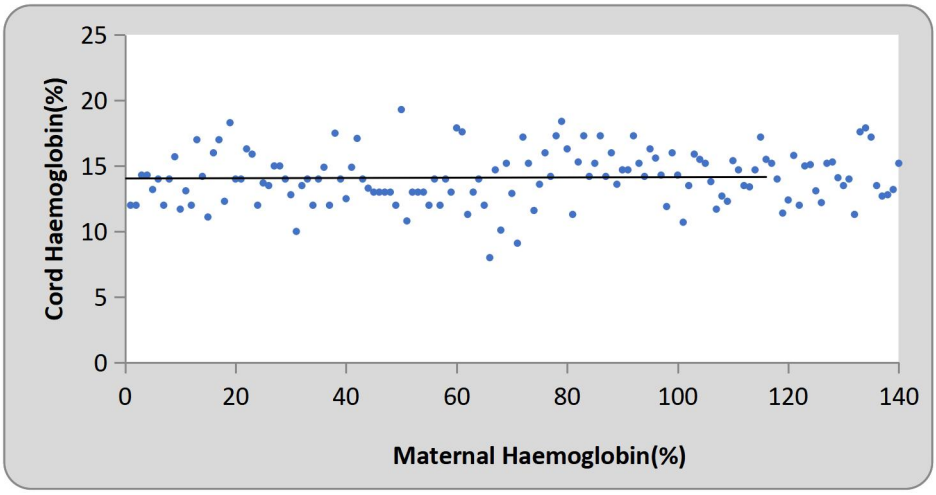

Figure 3: Correlation of maternal hemoglobin and cord blood hemoglobin.

A substantial correlation between maternal hemoglobin levels and cord blood hemoglobin was found using one-way ANOVA. The association between the first trimester and pre-delivery hemoglobin groups was observed, as indicated by F-values of 5.55 and 8.55, and corresponding p-values of 0.001 and 0.000, respectively. The results suggest that fluctuations in maternal hemoglobin levels have a consistent and significant effect on the hemoglobin levels in the umbilical cord blood of newborns. Furthermore, there is a direct relationship between the levels of hemoglobin in mothers and the levels of hemoglobin in cord blood. This indicates that greater levels of hemoglobin in mothers are linked to higher levels of hemoglobin in cord blood. The linear relationship is visually depicted in Figure 3, which demonstrates the direct link between the two variables throughout the entire research population. This link emphasizes the significance of maintaining normal maternal hemoglobin levels during pregnancy to

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guarantee improved neonatal outcomes regarding hemoglobin levels.

Discussion

The study involved 500 pregnant women, with an average age of 23.52 ± 3.03 years. Maternal hemoglobin levels averaged 11.51 g/dl in the first trimester, dropping to 10.21 g/dl by the third trimester. Newborn cord blood hemoglobin levels averaged 14.28 g/dl. These findings indicate a decline in maternal hemoglobin as pregnancy progresses, while cord blood hemoglobin remains relatively higher.

The study found significant variations in cord blood hemoglobin levels based on maternal anemia status. In the first trimester, mothers with normal hemoglobin (≥11 g/dl) had the highest average cord hemoglobin (14.65 ± 2.18 g/dl), while those with mild, moderate, and severe anemia had slightly lower levels. A similar trend was observed pre-delivery, where mothers with normal hemoglobin had the highest cord blood hemoglobin (14.79 ± 2.22 g/dl). The differences in cord blood hemoglobin across anemia levels were statistically significant, with lower maternal hemoglobin associated with lower cord blood hemoglobin. This highlights that maternal anemia, particularly in the third trimester, adversely affects newborn hemoglobin levels.

The study identified a significant positive correlation between maternal hemoglobin levels and cord blood hemoglobin. This correlation was consistent across both the first trimester and pre-delivery, with higher maternal hemoglobin levels associated with higher cord blood hemoglobin. The results suggest that maintaining adequate maternal hemoglobin throughout pregnancy is crucial for ensuring optimal hemoglobin levels in newborns, emphasizing the importance of maternal health for favorable neonatal outcomes.

Multiple cross-sectional studies conducted in different countries, such as Brazil [10], China [11], Jordan [12], Mexico [13], and Turkey [14], have found no correlation between maternal anemia and cord blood hemoglobin levels. These studies indicate that the occurrence of maternal anemia does not necessarily result in reduced amounts of hemoglobin in the cord blood. Mahajan S. et al. hypothesized that the discrepancy could be attributed to a compensatory rise in erythropoietin levels in newborns born to mothers with moderate anemia. This increase in erythropoietin levels improves the supply of oxygen to the fetus, even though the mother is anemic [15]. This compensatory mechanism is corroborated by evidence from other investigations, which have demonstrated increased levels of erythropoietin and hemoglobin in newborns born to women with mild anemia [14]. These data indicate that mild anemia may not negatively impact fetal hemoglobin levels because the body can adjust to the decreased ability to carry oxygen by increasing the production of erythropoietin.

However, the situation undergoes substantial alterations in instances of severe maternal anemia. Recent research suggests that severe anemia might overpower the body's compensatory systems, resulting in a breakdown of placental iron transport and a subsequent decrease in cord blood hemoglobin levels [16]. This is particularly alarming because iron is an essential ingredient for the development of a fetus, and a lack of it can have enduring consequences on the health of a newborn. The current study's results are consistent with four separate investigations conducted in India, which indicated a reduction of 2-6 g/dl in neonatal hemoglobin levels in babies born to severely anemic mothers compared to those born to non-anemic mothers [17,18,19,20]. The substantial decrease emphasizes the crucial influence of severe anemia on levels of fetal hemoglobin and emphasizes the significance of promptly identifying and treating anemia during pregnancy.

The inconsistencies identified in studies that did not distinguish between mild, moderate, and severe anemia [11,13,14] should clarify why certain research has not established a consistent link between maternal anemia and neonatal cord blood hemoglobin levels. The current study indicates that the degree of anemia plays a crucial role in deciding whether a correlation is detected. The primary factor contributing to the observed connection is severe anemia, as opposed to mild or moderate anemia. This emphasizes the importance of classifying anemia in depth when studying maternal and newborn health outcomes.

The descriptive statistics obtained from the current investigation offer additional context for these findings. The average maternal hemoglobin level throughout the first trimester was 11.51 ± 7.94 g/dl, ranging from 4.70 to 14.05 g/dl. During the third trimester, the average maternal hemoglobin level declined to 10.21 ± 1.52 g/dl, with a range of values between 4.30 and 13.70 g/dl. The average hemoglobin concentration in cord blood was 14.28 ± 2.08 g/dl, ranging from 8.00 to 19.50 g/dl. The values published by [21] and [22] are similar to these. In Kohli et al.'s study, the average maternal hemoglobin level was 11.62 g/dl, while in the [22] study, it was 11 ± 1.46 g/dl. The mean cord blood hemoglobin level was 15.27 g/dl in [21] study and 16 ± 2.19 g/dl [16]. These comparisons indicate that the results of the current study align with previous research, providing additional confirmation of the identified connections.

During the third trimester, the present investigation identified anemia in 342 women, which accounted for 68.4% of the total. Out of these ladies, 190 (55.56%) had mild anemia, 137 (40%) had moderate anemia, and 15 (4.3%) had severe anemia. The numbers mentioned are comparable to the findings of [8]. In their study, 47% of the women examined were found to be anemic. Among them, 48.9% had mild anemia, 40.4% had moderate anemia, and 10.7% had severe anemia [8]. The consistent results across multiple research emphasize the widespread occurrence of anemia during pregnancy and its diverse levels of seriousness, which can have a substantial impact on the health of newborns.

The findings of this study add to the increasing amount of evidence that maternal anemia, especially when it is severe, is linked to decreased amounts of hemoglobin in the cord blood of newborns. These findings emphasize the need to identify and treat anemia during pregnancy at an early stage to reduce the possible negative impact it

may have on the development of the fetus. The study emphasizes the necessity for additional investigation into the processes via which maternal anemia impacts fetal hemoglobin levels, particularly in instances of mild and moderate anemia, where the connection seems to be less evident. Future research should also examine the impact of maternal diet, iron supplements, and other variables that may affect both maternal and newborn hemoglobin levels. This will help in the development of more precise therapies to enhance maternal and neonatal health outcomes.

Generalizability

The generalizability of this study may be limited by its specific population, which included 500 pregnant women within a defined age range and geographical location. While the findings offer valuable insights into the relationship between maternal anemia and newborn hemoglobin levels, variations in socioeconomic, nutritional, and healthcare access factors across different populations may affect the applicability of the results to broader, more diverse groups. Further studies in varied settings would help validate and extend these findings.

Conclusion

The current study establishes a notable linear link between the levels of hemoglobin in mothers and the levels of hemoglobin in cord blood. Maternal hemoglobin is statistically significant in both the first and third trimesters when considering cord blood hemoglobin. The importance of maternal hemoglobin levels in determining newborn outcomes is emphasized by this. The findings emphasize the significance of addressing and preventing maternal anemia, a condition that can be largely rectified by adequate management.

Limitation

The current study did not directly evaluate the iron levels of the mothers, and it was presumed that anemia was primarily caused by iron insufficiency. Ferritin levels, which serve as an indicator of iron storage, were not assessed in either the mothers or the neonates. Conducting future research in this field to assess the amounts of maternal iron and ferritin would offer a more precise comprehension of how iron accumulates in the fetus.

Recommendations

It is recommended that measures to prevent anemia should start before getting pregnant and be aggressively addressed throughout the initial stages of pregnancy, preferably in the period before conception or the first three months of pregnancy. Optimizing maternal hemoglobin levels not only benefits the mother's health but also promotes fetal development and lowers the likelihood of negative consequences for the newborn. Therefore, it is crucial to prioritize the implementation of specific approaches to prevent and manage anemia in maternal healthcare to improve health outcomes for both mothers and their newborns.

Acknowledgment

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List of abbreviations

Hb - Hemoglobin
WHO - World Health Organization
NFHS - National Family Health Survey

Source of funding

No funding was received.

Conflict of interest

The authors have no conflicting interests to declare.

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