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Original Research Article

The Correlation between Maternal Hemoglobin and Iron Levels with That of Newborns: A Cross-Sectional Study

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Abstract:

Background: Anemia is a common entity in the developing world. In particular female gender is more of a sufferer owing to the indispensable physiological conditions like menstruation and child birth. According to data from the World Health Statistics, 40.1 % of pregnant women worldwide were anemic in 2016. In India, the prevalence of anemia in pregnant women aged 15-49 years has decreased from 57.9 % in the NFHS-3 (National Family Health Survey-2005-06) to 52.2 % in NFHS-5 (2019-21). Various studies have found a link between maternal anemia and negative pregnancy outcomes such as Low birth weight (LBW), preterm birth, Small-for-gestational-age (SGA), postpartum hemorrhage, and eclampsia.

Aim: To study the impact of maternal hemoglobin on cord blood hemoglobin of newborn and correlation between maternal and newborn iron levels.

Methods: A cross sectional study conducted at a teaching hospital of Bihar, India for a period of one year. After ethical approval and obtained written consent from all participants, 200 mother-newborn pairs were enrolled in the study. Blood sample from mother was collected during routine investigation. Cord blood was collected after delivery of the newborn and also prior to expulsion of the placenta. Data was entered and analysed using statistical software Epi Info and Microsoft Excel.

Results: The Mean age of mothers was – 27.80 years SD- 4.23, Range – 19-43 years. Majority of the mothers (63%) were multi gravida whereas only 37% mothers were primi gravida. The mean maternal hemoglobin level was 10.52±1.74, for anemic mother it was 9.18±1.34, and for non-anemic mothers it was 11.89±0.76. The mean serum iron in mothers was 108.06±37.19. 31.68% mothers had mild anemia, 58.42% mothers had moderate anemia whereas only 9.90% study mothers had severe anemia. The mean cord blood hemoglobin were 15.55±1.35 and mean cord blood iron level was 148.69, SD- 36.00. Mean cord hemoglobin between anemic and non-anemic mothers were compared and the difference between them was statistically significant with $p<0.01$. There was statistically significant difference between mean cord hemoglobin among anemic compared with mean cord hemoglobin of the non-anemic group.

Conclusion: Iron deficiency in mothers may affect the haemoglobin and iron status of their babies. Timely intervention is needed to check this commonly prevalent problem.

Keywords: Anemia, cord haemoglobin, newborn, serum iron.

Introduction

Iron deficiency anemia is a common problem especially in developing countries. Anemia affects nearly half of all pregnant women in the world: 52% in developing countries compared with 23% in the developed world. The most common causes of anemia are poor nutrition, deficiencies of iron and other micronutrients, malaria, hookworm disease, and schistosomiasis; HIV infection and haemoglobinopathies are additional factors [1]. WHO defines maternal anaemia as haemoglobin level less than 11 gm/dl during pregnancy. It is further classified as mild (Hb levels: 10-10.9gm/dl), moderate (Hb: 7- 9.9gm/dl) and severe (Hb<7 gm/dl) [2]. Iron deficiency anemia is the most common micronutrient deficiency with a prevalence of 70% in pregnant women and 55%–60% in children [1]. It is generally agreed that the most common forms of nutritional disorder during pregnancy in developing & developed country are iron deficiency anaemia (IDA) and folic acid deficiency. During pregnancy, significant physiological changes occur in maternal

hematological parameters. Blood and plasma volume increase by 40-50%, leading to hemodilution and a decrease in hematocrit levels. This adaptation is crucial to support the growing fetus and prepare for labor and delivery.

Maternal hemoglobin levels are monitored closely due to their impact on fetal development and birth outcomes. Maternal iron deficiency during pregnancy may hamper the development of foetal iron stores prior to birth, and perhaps well into the first year of life also and therefore increasing the risk of anemia during infancy. This has adverse consequences on the neurological development of these infants.

Iron deficiency anemia in pregnancy leads to decreased placental weight and significantly reduced number of placental cotyledons and thus is a risk factor for preterm delivery, intra uterine growth retardation and low birth weight and neonatal mortality. However mounting evidences suggest that even though infants of anemic mothers are born with adequate birth weight, they have low iron stores and are more likely to develop anemia. Infants have low haemoglobin when their birth weight was normal (>2500g) but mother was anemic (<11gm/dl) [4]. Iron required for pregnancy (3–4 mg/d) is substantial and thus, risk of iron deficiency and IDA increases with gestation, particularly among the poor. During pregnancy, anemia increases_4-fold from the 1st to the 3rd trimester in the low-income women monitored as part of pregnancy nutritional surveillance by the CDC [5].

Iron is actively transported from mother to foetus. In the iron deficiency state, there is up regulation of iron transport protein in the placenta, which ensures the adequate iron supply to the growing foetus. But this protective mechanism might fail in severe maternal anaemia leading to an insufficient iron supply to the foetus & breast milk. Women who do not take iron supplements frequently deplete their iron stores during the second and third trimesters of pregnancy and haemoglobin concentration is low than supplemented women [6].

Umbilical cord haemoglobin is an important haematological parameter which though promising, is very much underutilized. It can be utilized for early diagnosis of anaemia in new born babies [7]. Cord serum iron, transferrin saturation and total iron binding capacity have significant correlation with maternal haemoglobin. Several studies have reported a normal range of umbilical cord blood Hb values taken from healthy term infants.

Overall, average Hb concentration at term is 16.8 g/dl, with a range of 13.7-20.1 g/dl. With this high incidence, it is necessary to find out the prevalence of iron deficiency in infants, and its detrimental effects later in life. The main source of iron for the fetus in utero is from the mother.

Clinical management of maternal anemia involves early detection through routine screening and subsequent treatment with iron supplements. Monitoring fetal hematological parameters through cord blood analysis provides critical information for managing neonatal health post-delivery. Strategies such as delayed umbilical cord clamping have shown benefits in improving neonatal iron status and overall health outcomes [11, 12]. Recent studies highlight the impact of maternal anemia on fetal and neonatal outcomes, suggesting the need for tailored interventions to address regional disparities and improve maternal-fetal health outcomes. Further research is necessary to elucidate the mechanisms underlying maternal-fetal iron transfer and optimize strategies for preventing and managing maternal anemia and IDA [13, 14].

Maternal hematological changes during pregnancy, particularly related to anemia and iron deficiency, have profound implications for both maternal and fetal health [6]. Understanding these dynamics is crucial for implementing effective public health strategies aimed at reducing the global burden of maternal anemia and improving neonatal outcomes. Ongoing research and policy initiatives are essential to address these challenges comprehensively and ensure better maternal and child health outcomes worldwide [8].

Methodology

Study Site: Study was carried out at Nalanda Medical College & Hospital, Patna, Bihar.

Study Population: Pregnant mothers attending the labour room at Nalanda Medical College & Hospital and their babies delivered were included in the study.

Study Design: Cross sectional study

Study period: One year (May 2023 to April 2024)

Sample size with Justification: Sample size was calculated depending upon the prevalence of anemia in antenatal mothers in previous studies. Prevalence of anemia in the previous study was around 47%. As per study by Agrawal R.et al[7] the maximum error in the estimate we were willing to tolerate, say ± 7%, at 2-sided test with 95% confidence level (α=5%) and design effect =1, expected sample size was 196 patients.so total 200 sample size was taken.

Inclusion Criteria:

- Full-term neonates [37-41weeks]
- Preterm neonates > 34 weeks
- Women with singleton pregnancies
- Babies born with birth weight of 2 kg to 4 kg

Exclusion Criteria:

- Newborns with congenital malformations
- Birth asphyxia
- Twins
- Rh incompatibility
- Maternal risk factors like Gestational diabetes mellitus, Pregnancy induced hypertension, placenta previa and abruptio placenta.

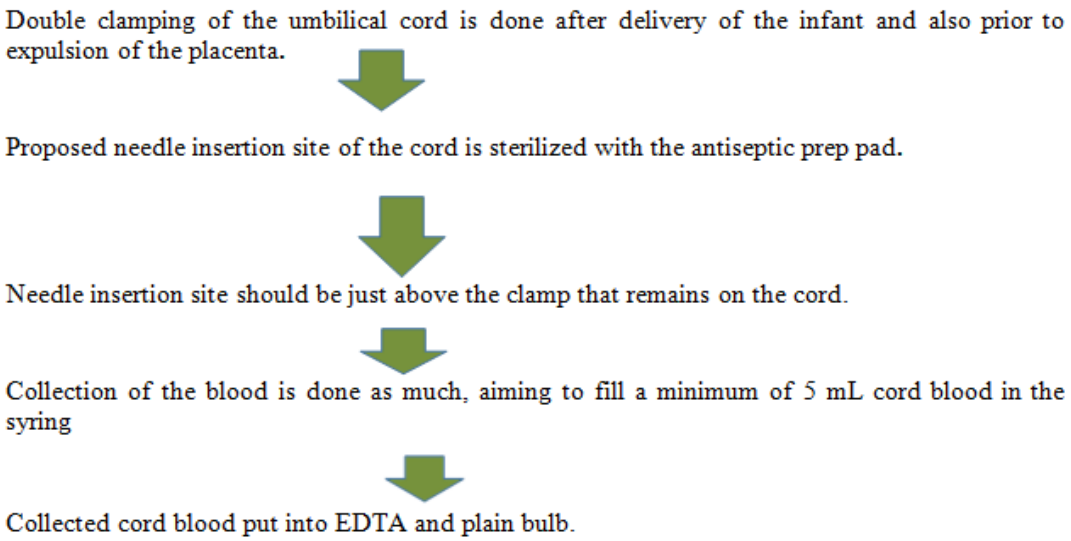
All post-partum women and their newborns, fulfilling the inclusion criteria was selected. A total of 200 mother-newborn pairs was enrolled over a period of one year.

- Blood sample from mother was collected during routine investigation.
- Cord blood was collected after delivery of the newborn and also prior to expulsion of the placenta.
- Umbilical vein was identified and needle insertion was done under all aseptic precautions.
- Cord blood sample was collected from the placental end of severed cord.
- About 5 ml of blood was aspirated from the umbilical vein.
- EDTA blood samples was analyzed in the pathology lab in automated analyzer for hemoglobin estimation.
- Plain sample of cord blood was used for iron study.

Equipment required for cord blood sampling

- Gloves
- Syringes 5 ml
- Needles 21g
- Plain bulb
- EDTA bulb
- Face shield
- Clamps
- Optional (ice and water)

Instructions for Collection of cord blood prior to Expulsion of Placenta



Statistical methods:

Data was analysed using statistical software Epi Info and calculations and entries done in Microsoft Excel. The description of the data was done in form of arithmetic mean +/- SD (or median [25 to 75 % quartiles]) for quantitative data while in the form of frequencies (%) for qualitative (categorical) data. P-values of < 0.05 was considered significant. For comparison of categorical variables (to examine the associations between qualitative/quantitative variables), the chi-square test was used.

Observations and Results

This was a cross sectional study, in which we have compared the maternal hemoglobin and serum iron levels, with cord blood hemoglobin and cord blood iron levels respectively. The Mean age of mothers was 27.80 years SD- 4.23, Range – 19-43 years. Seventy-four (37%) mothers were primi gravida while 126 (63%) mothers were multi gravida. The mean maternal hemoglobin level was 10.52±1.74, for anemic mothers it was 9.18±1.34, and for non-anemic mothers it was 11.89±0.76. Thirty-two (31.68%) mothers had mild anemia, whereas 59 (58.42%) mothers had moderate anemia and only 10 (9.90%) studied mothers had severe anemia. The mean serum iron in mothers was 108.06±37.19. Ninety (45 %) mothers were delivered by normal vaginal delivery whereas 110 (55 %) mothers were delivered by LSCS. 57.5% babies delivered were male whereas rest 42.5% were female. 85% babies were of more than 2.5 kg, whereas only 15% babies were of less than 2.5 kg. The mean cord blood hemoglobin were 15.55±1.35. Mean cord blood iron level was 148.69, SD- 36.00.

Mean cord hemoglobin between anemic and non-anemic mothers were compared and the difference between them was statistically significant with p<0.01. The mean cord hemoglobin among the three groups (mild, moderate, severe) were compared with mean cord hemoglobin of the non-anemic group. The difference between the groups were statistically significant with P values <0.01, <0.01 and <0.01 respectively. Mean cord blood iron level between anemic and non-anemic mothers was not associated. We compared cord blood iron of babies born to severe anemic mothers with non-anemic mothers then difference was significant with p value <0.05, however it was non-significant with mild and moderate anemic mothers. The mean maternal hemoglobin level was 10.52±1.74 gm/dl, for anemic mother it was 9.18±1.34 gm/dl, and for non-anemic mothers it was 11.89±0.76. The mean cord blood haemoglobin was 15.55±1.35 gm/dl. Mean cord hemoglobin between anemic and non-anemic mothers were compared and the difference between them was statistically significant with p<0.01. The mean cord hemoglobin among the three groups (mild, moderate, severe) were compared with mean cord hemoglobin of the non-anemic group. The difference between the groups were statistically significant with P values <0.01, <0.01 and <0.01 respectively. Cord blood iron of babies born to severely anemic mothers when compared to non-anemic mothers was found to be significant with p value <0.05, however it was non-significant with mild and moderate anemic mothers.

Table 1: Distribution of study subjects as per the age of mothers.

Age Group (in years)	Number of Subjects	Percentage of subjects
<20	1	0.5
20-25	47	23.5
25-30	**88**	**44.0**
30-35	53	26.5
35-40	11	5.5
>40	1	0.5
Total	200	100

Mean age of mothers were – 27.80 years, SD- 4.23, Range – 19-43 years

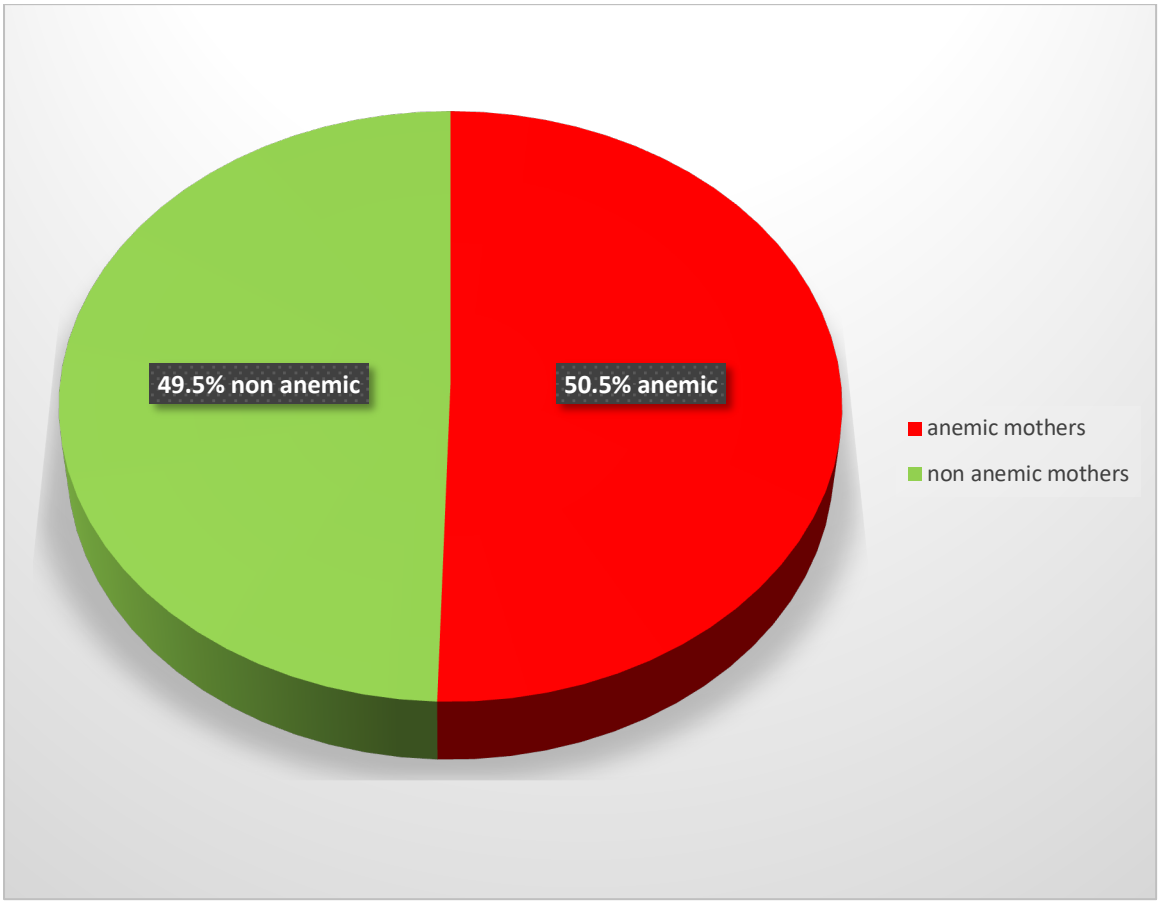


Figure 1: Pie Chart Showing Number of anemic and Non-anemic Mothers

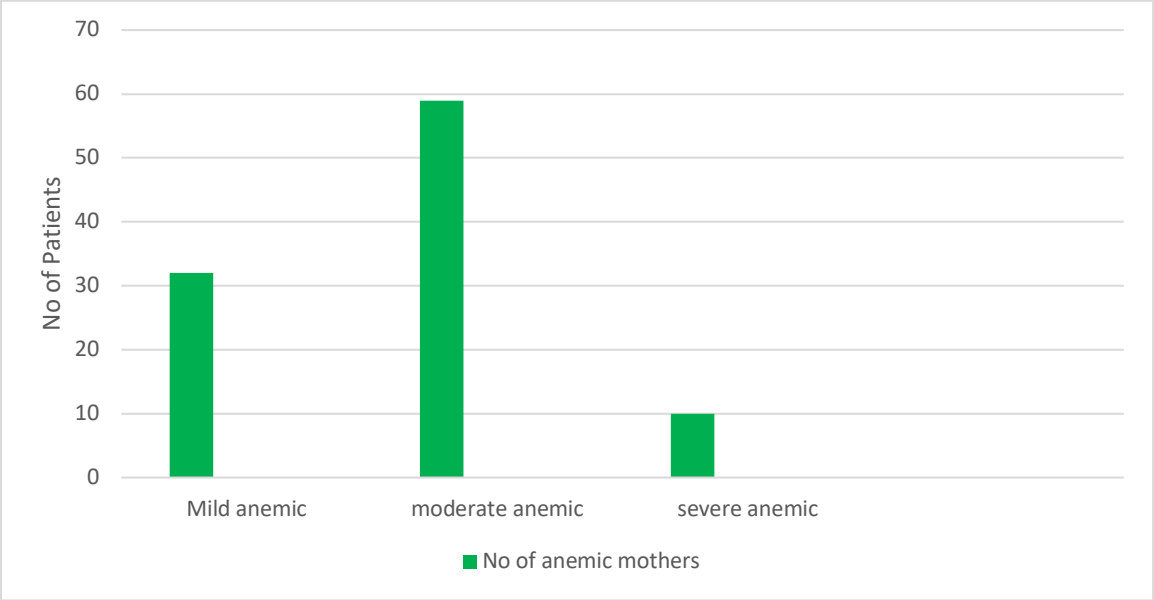


Figure 2: Bar Diagram Showing Number of Anemic Mothers Based On Its Severity

Distribution of mothers as per severity of anemia. Maximum 59 (58.42%) study subjects were moderately anemic.

Table 2: Distribution of study subjects as per the serum iron in mothers

Serum iron level	No of subjects	Percentage of subjects
<50	1	0.5
50-100	91	45.5
100-150	87	43.5
150-200	16	8
≥200	5	2.5

Distribution of study subjects as per the serum iron in mothers. Maximum 45.5% study subjects had serum iron in the range of 50-100. The mean serum iron in mothers was 109.18±36.27.

Table 3: Showing Distribution of study subjects as per cord blood hemoglobin

Cord blood HB	No	Percentage
11-14	12	6
14-17	**157**	**78.5**
17-20	30	15
20-23	1	0.5

Distribution of study subjects as per cord blood hemoglobin. The mean cord blood hemoglobin was 15.55±1.35.

Table 4: Study subjects as per cord blood iron level

Cord blood iron level	No	Percentage
<100	20	10
100-200	168	84
200-300	12	6

Distribution of study subjects as per cord blood iron level. Majority study subjects had cord blood iron level in the range of 100-200.Mean cord blood iron level was 148.69, SD- 36.00.

Table 5: Showing Mean Age, Mean maternal hemoglobin and mean cord hemoglobin among anemic and non-anemic Mothers

Group	Mean age	Mean maternal hemoglobin	Mean cord hemoglobin	P value
Anemic mothers	27.26±3.70	9.18±1.34	14.87±1.27	P<0.01
Non-anemic mothers	28.34± 4.67	11.89± 0.76	16.25 ± 1.04	

Table 6: Mean maternal hemoglobin among three groups (mild, moderate, severe) and mean cord blood hemoglobin of newborns respectively

Maternal Hemoglobin	Mean maternal hemoglobin gm/dl	No. of patients	Mean cord blood hemoglobin gm/dl	P value
Non anaemic (≥11gm/dl)	11.89 ± 0.76	99	16.25 ± 1.04	
Mild (10-10.9 gm/dl)	10.44±0.24	32	15.58±1.12	P<0.01
Moderate (9.9-7gm/dl)	8.98±0.87	59	14.75±1.12	P<0.01
Severe (<7gm/dl)	6.36 ±0.37	10	13.29±0.85	P<0.01

The mean cord hemoglobin among the three groups (mild, moderate, severe) were compared with mean cord hemoglobin of the non-anemic group. The difference between the groups were statistically significant with P values <0.01, <0.01 and <0.01 respectively.

Table 15: Mean cord blood iron level in anemic and non-anemic mother.

	No	Mean cord blood iron level	P value
Anemic mother	101	144.80±32.59	0.12
Non-anemic mother	99	152.65±38.94	

Mean cord blood iron level in anemic and non-anemic mother. When compared mean cord blood iron level between anemic and non-anemic mothers then association was not significant with p value- 0.12.

Table 7: Mean cord blood iron level among three groups (mild, moderate, severe) anemic mothers

Maternal Hemoglobin	No of Study subjects	Maternal serum iron	Cord blood iron levels	P value
Non anaemic (≥11gm/dl)	99	116.41±37.05	152.65±38.94	
Mild (10-10.9 gm/dl)	32	105.56±32.30	149.31 ±28.46	P=0.65
Moderate (9.9-7gm/dl)	59	102.76±32.30	145.83 ±35.88	P=0.27
Severe (<7gm/dl)	10	87.00±11.95	124.30 ±13.06	P<0.05

The mean cord iron among the three groups (mild, moderate, severe) were compared with mean cord iron of the non-anemic group. When compared cord blood iron of babies born to severe anemic mothers with non-anemic mothers then difference was significant with p value <0.05, however it was non-significant when mild and moderate anemic mothers compared with non-anemic mother with p=0.65 and p=0.27 respectively.

Discussion

Anemia in pregnancy has several undesirable effects on maternal health and outcomes of the fetus. During pregnancy, maternal blood hemoglobin and hematocrit is reduced owing to the expansion of blood plasma volume and increased demand from the fetus. Physiological changes during pregnancy modify the chemical composition of blood, hematopoietic micronutrients transfer amplification, and as a defense mechanism to counter oxidative stress, few of this micronutrients are utilized more, which may lead to low hematological values during pregnancy. In our study mean age of mothers was 27.80 years, SD-4.23. Age at the time of delivery is one of the important factors affecting pregnancy outcome. Mean age of anemic mothers was 27.26±3.70 years and mean age of non-anemic mothers was 28.34± 4.67 years. Ramadoss D et al found mean age of anemic and non-anemic mothers were 25.79±2.22 and 25.72±2.46 respectively. Agrawal R. et al found that mean age of anemic and non-anemic mothers were 26.72± 1.34 and 25.82±2.32. These all studies had comparable mean maternal age to our study. In our study we found 63% mothers were multi gravida and 37% mothers were primi gravida. In other similar study they also found results which are almost comparable to our study, such as Timilisna S et al found 59.64% were multi gravida and 40.36% were primi gravida. Study by Shukla AK et al found 57.6% were primiparous whereas 42.4% were multiparous [11, 12]. Study by Terefe et al found that majority of mothers were primiparous (64.0%; n =57) [19].

Out of 200 mothers, 50.5% were anemic and 49.5% were non-anemic., Debbarma R et al found that 55% were anemic and 45% non-anemic [17]. Among the anemic mothers 31.68 % of them had mild anemia, 58.42% had moderate anemia and 9.90% severe anemia. In similar studies conducted by Timilisna et al and Agrawal R. et al it was found that 46.49% and 47% of the participants were anemic respectively. Some studies which shows very low prevalence of anemic mothers was found in study by Rusia U et al and Paiva et al [26]. This variation of maternal hemoglobin depends on many factors including age, parity, socioeconomic conditions, education etc.

We found mean maternal hemoglobin in our study to be 10.52±1.74gm/dl. Other studies by Timilisna et al and Qaiser DH et al also had similar findings

such as 11.14 ± 1.39 g/dL and 11.5 ± 1.1g/dl respectively [12, 35]. In this study mean maternal hemoglobin among non-anemic and anemic mothers were 11.89 ± 0.76 gm/dl and 9.18±1.34 gm/dl. Other studies also have comparable findings such as Agrawal R et al who found mean maternal hemoglobin in non-anemic mothers was 11.23±0.34 gm/dl whereas 8.67±0.5 gm/dl in anemic mothers. Ramadoss D et al, Hokama T et al, Sareen A et al have also found similar results [10, 33]. Hemoglobin level in pregnant mothers is one of very important predicting factors of outcome of pregnancy. In our study the mean serum iron in mothers was 108.06±37.19.

In other study done in maharajah institute of medical scinces, Andhra Pradesh government hospital by Swetha K et al median maternal iron was 85, which is lower than our observations. We found 55 % mothers were delivered by LSCS, whereas only 45 % mothers were delivered by normal vaginal delivery. Study by Qaiser DH et al found that 67.08% were delivered by spontaneous vaginal delivery and 32.92% by elective caesarean section [35]. Study by Terefe et al found Most of the babies were delivered through vaginal delivery 78.7% [19].

These results are different than our results, because our hospital being a tertiary care center, more patients with difficult pregnancies and complications are referred from other centers. Among 200 babies delivered 181 were term babies (90.5%) and 19 were preterm babies (9.5%). Agrawal R. et al in their study found 90 % full term babies and 10% preterm babies, which is almost similar to our study [7]. Swetha K et al found among their study population, 72.7% term and 27.3% preterm babies, which is slightly different than our study [16].

We found 57.5% babies delivered were male whereas rest 42.5% were female. In the population census of 2011 it was revealed that Indian population had 51.43% males, and 48.53% females. In other studies such as Terefe et al 50.6% delivered were female whereas rest 49.4% were male [19]. Alizadeh L et al found 50.72% males whereas rest 49.28% were females [20]. We found that mean cord blood Hemoglobin was 15.55±1.35gm/dl. Studies showing almost similar results, such as Mamoury GH et al found the mean cord blood hemoglobin was 15.8 (range: 11-21.4) g/dl, Timilsina S et al found The mean cord blood haemoglobin was in same range [9,12].

Mean cord hemoglobin of babies among non-anemic and anemic mother it was 16.25± 1.04 gm/dl and 14.87±1.27 gm/dl respectively. Mean cord hemoglobin between anemic mothers and non-anemic mothers were compared and the difference between them was statistically significant with p < 0.01. This denotes that there is an impact of maternal anemia on cord hemoglobin. Our observation was similar to the study done by Nadia et al in Babylon University which showed a linear relationship between maternal hemoglobin and cord hemoglobin. Agrawal R. et al found that mean cord blood hemoglobin in non- anemic mothers was 16.22±0.45gm/dl, whereas 14.06±1.2gm/dl among anemic mothers.

Mean cord hemoglobin among the three maternal anemia groups (mild, moderate, severe) was 15.58± 1.12, 1.75± 1.12 and 13.29± 0.85 respectively. It was compared with mean cord hemoglobin of the non-anemic mothers group (16.37+_0.85) and the difference was statistically significant with P value less than 0.01 in all 3 groups. This denotes that there is an impact of maternal anemia on cord hemoglobin. Sweet et al in their study had shown that mothers with iron deficiency anemia gave birth to newborn with lower hemoglobin level [30]. Debbarma et al, Sareen A et al also showed a linear relationship between the cord and maternal hemoglobin similar to our study [1, 17]. Marmoury GH et al study differs from our study as they reported that there was no association between cord hemoglobin and maternal hemoglobin level [9].

In our study when we compared mean cord blood iron level between anemic mothers and non-anemic mothers we found non-significant association with p value- 0.16. It is reported that there is up regulation of iron transport proteins in the placenta in the iron deficiency state, this may result in increase in iron levels in newborn of anemic mothers [6]. Contrary to our results Terefe B et al in their study enrolled 21 anemic mothers and 78 non-anemic mothers and found lower level of iron in newborns delivered from Iron deficiency anemia (IDA) mothers compared to non-anemic mothers [19]. According to them iron supply to the placenta and the fetus is affected in maternal anemia and the fetus takes iron in direct proportion to the levels available in the mother.

When we compared cord blood iron of babies born to severely anemic mothers with non-anemic mothers it was found that cord blood iron level was directly proportionate to the maternal iron levels. This difference was significant with p value <0.05. Indicating neonatal iron stores are affected in case of severe maternal iron deficiency.

However it was non-significant when mild and moderate anemic mothers group was compared with non-anemic mothers with p=0.65 and p=0.27 respectively. It also indicates that upgradation of iron transport is seen only in mild and moderate anemia .In a study by Swetha k et al it was found that there was a positive correlation between maternal hemoglobin and neonatal iron [16]. Paiva

A et al found that iron status of pregnant women with mild anemia does not seem to have a significant impact on the iron levels of their children [26].

Conclusion

Maternal hematological changes during pregnancy profoundly influence fetal development and neonatal outcomes. Understanding these dynamics is crucial for improving prenatal care and implementing targeted interventions to mitigate the risks associated with maternal anemia. Continued research is essential to address remaining gaps in knowledge and enhance strategies for promoting maternal and child health globally.

Limitations of the study

- Iron status and maternal hemoglobin level was not determined in the first and second trimester. However, it is likely that mothers who were anemic in the third trimester had poor iron intake throughout their pregnancy and this may lead to decreased cord hemoglobin level.
- A major limitation of this study was that it has not taken into account influence of other maternal factors such as gestational diabetes on neonatal iron level.

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