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Original Research Article

Effects of maternal iron deficiency anemia on the iron stores of the new born- an analytical study

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ABSTRACT

Background: The aim of the study was to determine the effect of maternal iron deficiency anemia on neonatal iron stores.
Methods: This prospective study was conducted in the department of obstetrics and gynecology, Government Medical College, Amritsar from January 2023 to March 2024. A total of 200 antenatal patients at gestation ≥37 weeks were allotted to four groups: group A (included non-anemic cases), group B (included cases with mild to moderate anemia with hemoglobin 7-10.9 gm/dl), group C included cases with severe anemia with hemoglobin <7 gm/dl) and group D (included treated cases of iron deficiency anemia that had been corrected by therapeutic iron replacement) with 50 patients in each group after written informed consent. Cord hemoglobin and ferritin levels were taken at the time of delivery to see the effect of maternal anemia on neonatal iron stores.
Results: A positive correlation between maternal ferritin and neonatal ferritin levels (r^2=0.332, p=0.014) and positive correlation between maternal hemoglobin levels and neonatal hemoglobin levels (r^2=0.32, p=0.033) was seen indicating maternal anemia during pregnancy impacts the neonatal iron stores at birth.
Conclusions: Neonatal hemoglobin as well as iron stores have a positive correlation with maternal hemoglobin and iron stores thus appropriate management of maternal anemia can play a major role in reducing anemia in future generations.

Keywords: Anemia, Anemia in pregnancy, Cord hemoglobin and ferritin, Iron supplementation, Maternal-fetal iron transfer, Maternal hemoglobin, Maternal iron deficiency, Neonatal anemia, Neonatal outcomes in anemia, Newborn iron stores

INTRODUCTION

According to WHO, anemia amongst pregnant women is a hemoglobin concentration <11 gm/dl.[1] ICMR categorizes hemoglobin levels of 10.0 to 10.9 gm/dl as mild grade, 7.0 to 9.9 gm/dl as moderate grade, 4.0 to 6.9 gm/dl as severe grade and <4.0 gm/dl as very severe anemia.[2] India has high prevalence of anemia, with nearly 57 percent of pregnant women affected. Twenty to forty percent of maternal mortality in the country are ascribed to anemia. Hemoglobin level <14 gm/100 ml is considered neonatal anemia.

Pregnancy-related iron deficiency anemia is linked to higher morbidity and fetal death rates. Affected mothers commonly experience symptoms like breathlessness, insomnia, dizziness, fatigue and palpitations.[3] Additionally, they face an increased susceptibility to perinatal infections, pre-eclampsia, premature birth, cardiac complications, puerperal sepsis, postpartum hemorrhage, hemorrhagic shock and lactation failure. Furthermore, postpartum cognitive impairment and behavioral challenges have been documented.[4]

Iron deficiency anemia is associated with unfavourable prenatal outcomes, like preterm labor, fetal growth restriction, low birth weight, birth asphyxia, and anemia in newborns. Anemia that develops later in pregnancy has less of an adverse effect on fetal growth than iron deficiency during the first trimester.[5]

Since anemia is highly common in the Indian population, particularly in pregnant women and children under five, this study intends to study the impact of maternal anemia on fetal iron stores as well as the efficacy of mother iron replacement therapy in preserving neonatal iron stores.

METHODS

This was a prospective study which was conducted in the department of obstetrics and gynecology, Government Medical College, Amritsar from January 2023 to March 2024 which included the 200 pregnant women who were admitted in the ward and labour room for delivery at gestation ≥37 weeks after written informed consent and after approval from the institutional ethics committee.

Inclusion criteria

Pregnant females age 20 to 35 years with single live fetus admitted for delivery at ≥37 weeks gestation.

Exclusion criteria

Maternal complication like antepartum hemorrhage, eclampsia, respiratory distress, trauma. Known medical disorders like hypertension, preeclampsia, diabetes mellitus, epileptic patient on anti-epileptic drugs, HIV patient on antiretroviral therapy. Known history of hemoglobinopathy / hemolytic anemia. Premature rupture of membrane (≥18 hours before delivery). Maternal sepsis. Fetal congenital malformation, Intrauterine fetal demise. Rh negative pregnancy. Preterm birth. Associated obstetric risk factors like placenta previa, abruptio placenta, malpresentation, multiple gestation. Maternal age <20 and >35 years. Women in advanced labour were also excluded as there was not sufficient time for counselling and consent of participants.

Eligible candidate was briefed about the study and those giving consent were allotted to group A, group B, group C and group D (50 participants in each group). Group A included non-anemic cases (>11 gm/dl). Group B included cases with mild to moderate anemia (7-10.9 gm/dl). Group C included cases with severe anemia (<7 gm/dl). Group D included treated cases of iron deficiency anemia that had been corrected by therapeutic iron replacement.

Blood samples for serum ferritin levels were collected from pregnant women prior to the onset of active labor, and cord blood was obtained immediately following delayed cord clamping but before the placenta was delivered. The measurement of serum ferritin was conducted using an enzyme-linked immunosorbent assay (ELISA), and the results were standardized according to the international standards provided with the assay kit.

Data analysed with SPSS software version 22. A p value of < 0.05 was considered significant statistically.

RESULTS

Recruitment of participants was as shown in Figure 1.

Demographic profile of study participants in 4 groups shown in Table 1.

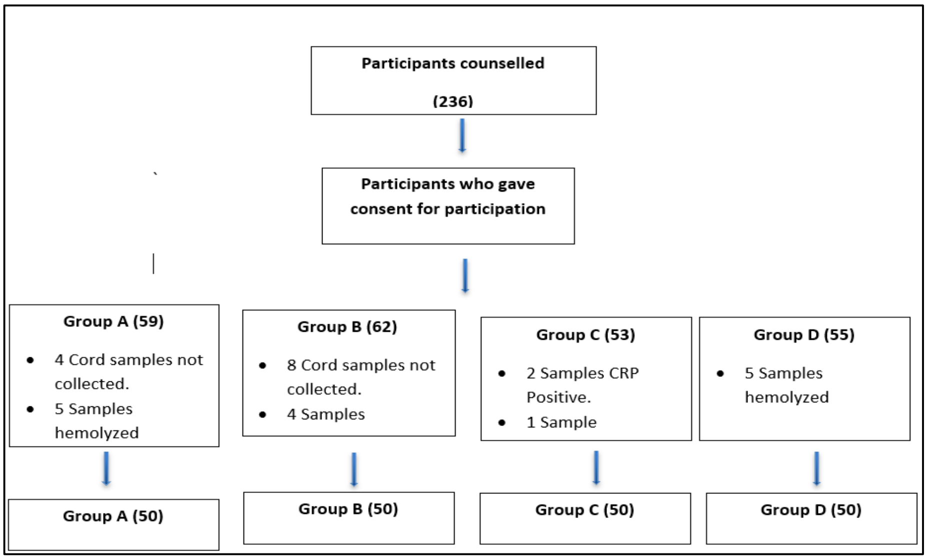

Figure 1: Recruitment of participants.

Table 1: Demographic profile of study participants in 4 groups.

Parameters	Group A (%)	Group B (%)	Group C (%)	Group D (%)
Mean age (in years)	25.36±4.09	25.94±4.44	26.86±3.49	25.30±3.34
Rural area	24 (48)	33 (66)	41 (82)	34 (68)
Urban area	26 (52)	17 (34)	9 (18)	16 (32)
Nulliparous	36 (72)	22 (44)	8 (16)	14 (28)
Parous	14 (28)	28 (56)	42 (84)	36 (72)
Interpregnancy interval <3 years	6 (12)	19 (38)	35 (70)	23 (46)
History of anemia in previous pregnancy	1 (2)	3 (6)	23 (46)	6 (12)

Table 2: Comparison of maternal hemoglobin, ferritin levels and neonatal hemoglobin and ferritin in 4 groups.

Parameters	Group A	Group B	Group C	Group D
Mean maternal hemoglobin (at the time of delivery in gn/dl)	12.3±0.864	9.69±0.682	7.07±1.341	10.35±0.983
Mean maternal serum ferritin levels (in ng/ml)	93.31±62.82	32.81±20.08	19.72±18.92	31.22±45.58
Mean neonatal hemoglobin levels (in gm/dl)	15.84±1.02	14.7±0.91	13.44±0.99	15±1.19
Mean neonatal ferritin levels (in ng/ml)	202.18±56.73	139.08±66.69	79.19±28.04	138.62±52.48

All the four groups were similar in terms of age distribution. Relative risk (RR) of rural women for developing anemia during pregnancy (group B, C and D) compared to urban women was 1.32 (p value =0.0068). RR of rural women for developing severe anemia (group C) was even higher 2.35 (p value =0.0112). RR for anemia among parous women compared to primigravida was 1.606 (p value <0.0001) and it was even higher 3.5 (p value: 0.0005) for severe anemia. We found short inter-pregnancy interval to be a significant risk factor for severe anemia with RR=2.23 (p value =0.0276).

Comparison of maternal hemoglobin, ferritin levels and neonatal hemoglobin and ferritin in 4 groups shown in Table 2.

A significant reduction in maternal serum ferritin levels was seen with increase in severity of anemia (p value =0.0001). By linear regression analysis, there was a positive correlation between maternal hemoglobin levels and maternal serum ferritin levels; although it was a weak correlation (r^2=0.2378, p=0.0001), as shown in Figure 2.

A significant reduction in neonatal ferritin levels was seen with increase in severity of maternal anemia (p value =0.0007). There was a positive correlation between maternal ferritin and neonatal ferritin levels (r^2=0.332, p=0.014) as shown in Figure 3. This indicated that lower maternal serum ferritin levels impact the neonatal iron stores resulting in decreased neonatal ferritin levels at birth.

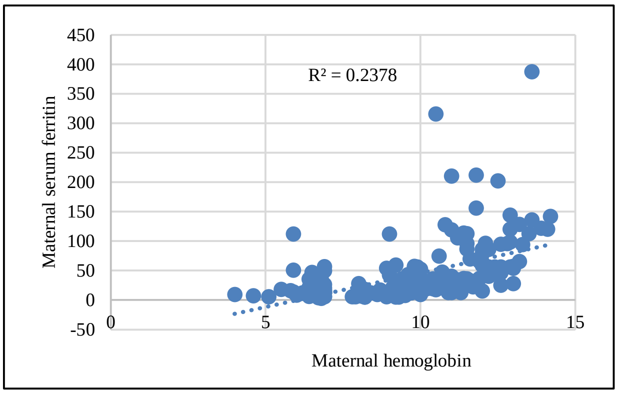

Figure 2: Correlation of maternal hemoglobin with maternal serum ferritin levels.

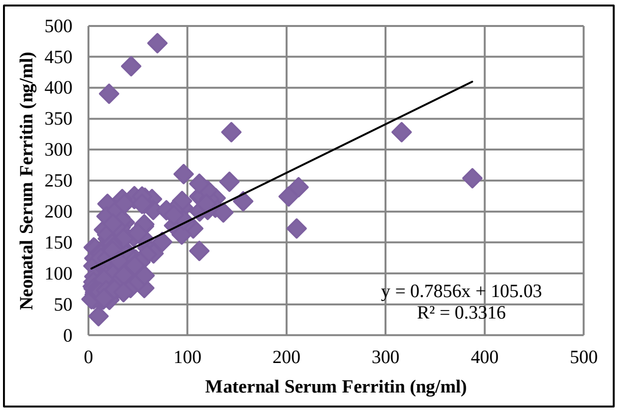

Figure 3: Correlation of neonatal cord ferritin levels with maternal serum ferritin levels.

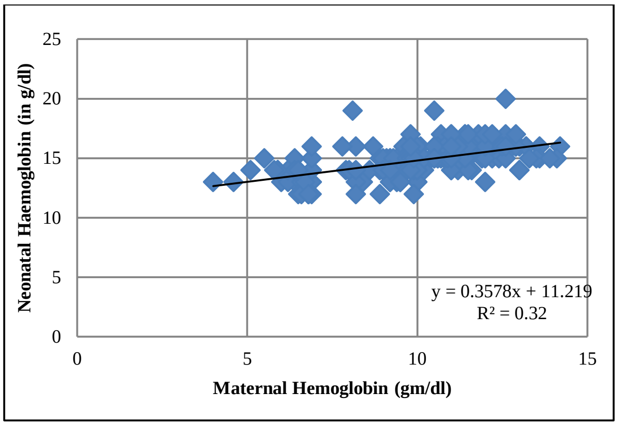

Figure 4: Correlation of neonatal hemoglobin with maternal hemoglobin levels.

A significant reduction in neonatal hemoglobin levels was seen with decrease in maternal hemoglobin levels (p value =0.0048). Odds ratio of neonatal anemia (Hb<14 gm/dl) in newborns of severely anemic participants was 34.043 (p value: 0.0001). We found a positive correlation between maternal hemoglobin levels and neonatal hemoglobin levels (r^2=0.32, p=0.033) as shown in Figure 4.

A positive correlation was seen, although weak between maternal serum ferritin levels and neonatal hemoglobin levels (r^2=0.2387, p=0.0102) as shown in Figure 5 and Table 3.

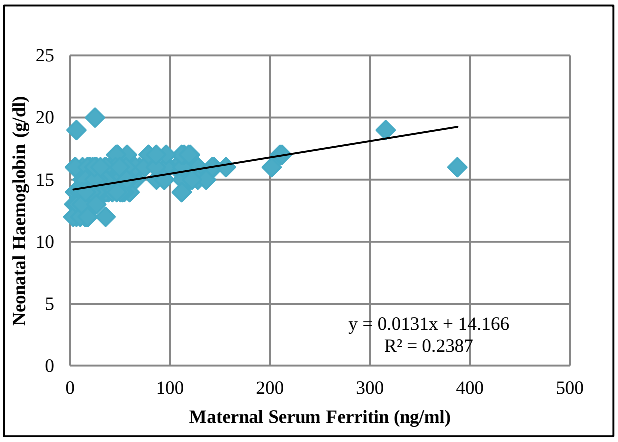

Figure 5: Correlation of neonatal hemoglobin with maternal serum ferritin levels.

Table 3: Correlation between maternal serum and neonatal cord hemoglobin and ferritin levels.

	Maternal hemoglobin	Maternal ferritin
Neonatal hemoglobin	r^2=0.32 p value: 0.033	r^2=0.2387 p value: 0.0102
Neonatal ferritin	r^2=0.347 p value: 0.0347	r^2 =0.332 p value: 0.014

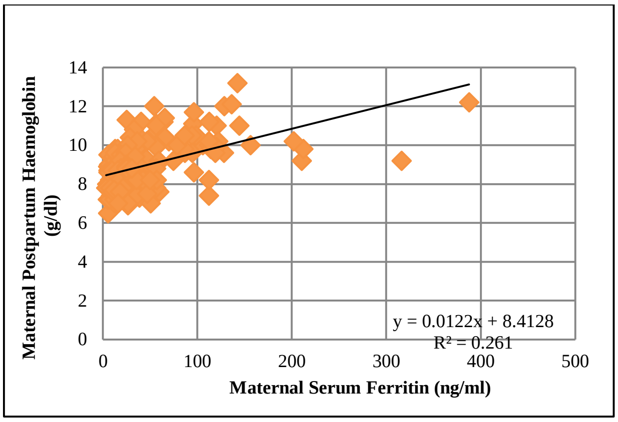

Figure 6: Correlation of postpartum hemoglobin with maternal serum ferritin levels.

On comparing the neonatal outcome, odds ratio of low birth weight (<2.5 kg) among neonates born to severely anemic participants (group C) were 3.63 (p value =0.004). Anemic women were not at increased risk for caesarean section or need of induction of labour (p=0.66). Anemia was not found to be a risk factor for caesarean section for fetal distress or labour abnormalities. The maternal complications which were more prevalent in anemic mothers compared to non anemic mothers were postpartum hemorrhage, surgical site infection and puerperal sepsis. Odds ratio of postpartum hemorrhage was 3.95 (p value =0.029), of surgical site infection was 1.208 (p value =0.824) and of puerperal sepsis was 15.51 (p value =0.0784) for severe anemia.

81.5% participants had immediate postpartum anemia (Hb<10 gm/dl) thus highlighting a high prevalence of postnatal anemia even in women who were antenatally not anemic. There was a weak positive correlation between maternal ferritin levels and maternal postpartum hemoglobin levels (r^2=0.26, p=0.0144), shown in Figure 6.

On comparing results of group D with the results of group B and C, the number needed to treat (NNT) maternal anemia with parenteral iron was 2.2 for preventing 1 case with maternal ferritin levels <30 ng/ml, 2 for preventing neonatal hemoglobin <14 gm/dl, and 1.7 for preventing neonatal cord ferritin <76 ng/ml. For preventing 1 case with neonatal complications such as low birth weight, NNT was 7.1. For preventing maternal complications, NNT was 10 for postpartum hemorrhage, 25 for surgical site infection and 25 for puerperal sepsis.

DISCUSSION

In our study, we found significant reduction in serum ferritin levels with increase in severity of anemia (p value =0.0001). There was a positive correlation present between maternal hemoglobin levels and maternal serum ferritin levels; although it was a weak correlation (r^2=0.2378; p value: 0.0001).

We also found significant reduction in neonatal ferritin levels with increase in severity of maternal anemia (p value =0.0007). There was a positive correlation between maternal ferritin and neonatal cord ferritin levels (r^2=0.332, p=0.014). This indicated that lower maternal ferritin levels impact the neonatal iron stores resulting in lower neonatal ferritin levels at birth.

The comparison of our results with other similar studies from different parts of the country as well as other countries shown in Table 4.

In our study, we found a significant reduction in neonatal hemoglobin levels with decrease in maternal hemoglobin levels (p value =0.0048). We found a positive but weak correlation between maternal serum ferritin levels and neonatal hemoglobin levels (r^2=0.2387, p=0.0102) and a positive correlation between maternal hemoglobin levels and neonatal hemoglobin levels (r^2=0.32, p=0.033). Our result showed that lower value of maternal hemoglobin and iron stores lead to decrease in transplacental iron transfer resulting in lower neonatal hemoglobin levels.

Table 4: Comparison of results with other studies.

Study	Year	Place	Number of participants in the study	Correlation between neonatal ferritin and maternal ferritin	Correlation between neonatal ferritin and maternal Hb	Correlation between neonatal Hb and maternal Hb	Correlation between neonatal Hb and maternal ferritin	Correlation between maternal Hb and maternal ferritin
Present study	2024	Punjab	200 (150 anemic and 50 non anemic)	r^2=0.332 p=0.014	r^2=0.347 p=0.0347	r^2=0.32 p=0.033	r^2=0.2387 p=0.0102	r^2=0.2378 p=0.0001
Bajpai et al[6]	2023	UP	192 (103 anemic and 89 non anemic)	r=0.231 p<0.002	NA	r=0.328 p<0.001	NA	NA
Terefe et al[7]	2011	Ethiopia	89 (21 anemic and 68 non anemic)	r=0.38 p<0.001	r=0.25 p=0.018	r=0.22 p=0.039	r=0.28 p=0.008	NA
Akhter et al[8]	2014	Bangladesh	50 (18 anemic and 32 non anemic)	r=0.94 p<0.001	NA	NA	NA	r=0.92 p<0.001
Bernhadt et al[9]	2021	Karnataka	60 (30 anemic and 30 non anemic)	NA	r=0.87 p<0.05	r=0.87 p<0.05	NA	P=0.06
Kakkar et al[10]	2022	Maharashtra	112 (all anemic)	r^2=0.741 p<0.05	r^2=0.763 p<0.05	r^2=0.836 p<0.001	r^2=0.810 p<0.05	r^2=0.966 p<0.05
Aster et al[11]	2012	Selam and Gulelie health centre	95 patients	r=0.366 p=0.0003	r=0.256 p=0.012	r=0.226 p=0.0279	r=0.268 p=0.0086	NA

Bernhardt et al showed similar results in their study, in which maternal hemoglobin showed positive linear correlation with neonatal cord hemoglobin and ferritin levels (r=0.87, p<0.05).[9]

Hadipour et al also found a significant correlation between neonatal and maternal hemoglobin (r=0.423, p<0.000).[12]

In our study, odds ratio of low birth weight (<2.5 kg) among neonates born to severely anemic participants (group C) was 3.63 (p value =0.004).

In a study done by Tarek et al birth weight of neonates reduced significantly with increased severity of maternal anemia during pregnancy (p=0.000).[13]

Hadipour et al in their study also showed a significant positive correlation between maternal Hb levels and neonatal BW (p<0.001, r=0.729).[12]

In our study, maternal complications were more prevalent in anemic mothers compared to non-anemic mothers. Odds ratio of postpartum hemorrhage in severely anemic participants (group C) was 3.95 (p value =0.029). Nair et al in their study on pregnancy outcome in anemic patients found that pregnant women with moderate to severe anemia had a higher risk of postpartum hemorrhage (aOR=9.45; 95% CI 2.62 to 34.05).[14]

In our study, group D (comprising anemic patients treated with parenteral iron therapy) showed higher levels of neonatal hemoglobin and neonatal ferritin compared to group C (severely anemic patients who underwent blood transfusion). We didn't find any similar Indian study done in recent past.

Strengths of this study are: we included only term deliveries and ruled out sepsis in all participants to prevent confounding factors like gestational age and sepsis. Study also evaluated the effect of parenteral iron therapy during antenatal care in decreasing maternal/neonatal complications and improving the fetal iron stores.

Limitation of this study is there is no long-term follow up for effects of maternal and neonatal anemia on the development and growth of children.

CONCLUSION

Neonatal hemoglobin as well as iron stores have a positive correlation with maternal hemoglobin and iron stores. Thus, appropriate management of maternal anemia can play a major role in reducing anemia in future generations.

Widespread availability and safety of parenteral iron therapy is a very useful tool in management of anemia in pregnancy and should be continued even in postpartum period to replenish the iron stores of the mother.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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