Effect of maternal anemia on the status of iron stores in infants: A cohort study

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Abstract:
BACKGROUND: Iron deficiency anemia in pregnant women may affect the iron reserves of their infants and lead to anemia later. The objective of the study was to compare hemoglobin and iron store status of infants born to anemic and non-anemic mothers and to determine any correlation.

MATERIALS AND METHODS: A cohort study was conducted in the Department of Pediatrics of a Teaching hospital after obtaining ethical approval and written informed consent from all participants. Total 180 mother-infant pairs were enrolled in the study were divided into two groups; Group I: 90 term infants born to anemic mothers (Hb <11 g/dl), Group II: 90 term infants born to non-anemic mothers (Hb >11 g/dl). Hemoglobin and ferritin levels were assessed in cord blood at birth and at 14 weeks after birth in the infants of both groups. Data was analyzed using SPSS 20.0; Chi-square test and t-test were applied to test for statistical significance.

RESULTS: The final sample size was 85 for Group I and 78 for Group II. For Group I, mean hemoglobin and ferritin levels in the cord blood of infants at birth were 16.33 ± 1.19 and 135.40 ± 25.94, respectively. For Group II, mean hemoglobin and ferritin levels in the cord blood of infants at birth were 17.62 ± 1.35 and 160.45 ± 28.50, respectively; differences were statistically significant. At 14 weeks, the mean Hb and ferritin was 11.24 ± 1.03 and 55.92 ± 10.44 in Group I and 13.18 ± 0.82 and 63.56 ± 10.15 in Group II; the differences were statistically significant. A significant correlation between maternal and infant hemoglobin and ferritin levels was observed at birth and 14 weeks after birth.

CONCLUSION: Maternal iron deficiency may have an effect on the iron status of their infants. Thus, timely appropriate interventions are necessary.

Keywords:
Anemia, hemoglobin, infants

Introduction
Iron deficiency anemia is the most common micronutrient deficiency with a prevalence of 70% in pregnant women and 55%–60% in children.[1] 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. This is a unidirectional active process independent of maternal iron status even inducing iron deficiency in the mother.[2] However, when the mother becomes anemic, this transfer reduces, and the fetus is then at risk of deficiency.[3] Soon after birth, as a result of the break down fetal red blood cells, iron deposits in the liver, and hematopoietic tissues. However, there may still be a significant decrease in cord hemoglobin (Hb) and iron levels of infants born to iron deficient mothers.[4] This affects the infant’s iron reserves. Delaying the clamping of the umbilical cord in healthy term infants

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increases early hemoglobin concentrations and iron stores in infants.\[^5\]\[^6\]\ Till 6 months of age, the source of iron is breast milk which is highly bioavailable (~50% absorption)\[^6,7\] the iron content of which is at its highest in early transitional milk and decreases steadily over the course of lactation.\[^8\] Moreover, there is increased need for iron from 6 to 12 months, owing to the accelerated velocity of psychomotor growth and development, which depletes the reserves during this period if they are not adequately replaced.\[^9\]

It is logical to hypothesize that the hematological status of mothers might have an effect on the iron reserves of exclusively breastfed infants in the first 6 months. Hence, infants born at term may have insufficient iron stores and by 6–35 months may be overtly anemic in view of high burden of anemia in this age group.\[^10\]

The present study was, therefore, planned to compare the iron store status in full-term infants born to anemic and nonanemic mothers.

**Materials and Methods**

A cohort study was done in the Department of Pediatrics in a Teaching hospital after approval from the Institutional Ethical Committee and written informed consent from all participants were obtained. Mother-infant pairs were recruited. Term infants with birth weight ≥2500 g born to mothers who had had an uncomplicated normal singleton vaginal delivery were included. Mothers with a history of antepartum hemorrhage, severe anemia requiring blood transfusion, and any chronic medical illnesses and infants who needed neonatal intensive care unit admissions and those with suspected chromosomal anomalies were excluded from the study.

The sample size was calculated on the basis of the mean difference in serum ferritin levels in infants, which came out to be 180. The power of the study was 90% and 10% predicted data loss on follow-up. The study participants were divided into two groups. Group I: anemic mothers and infant pairs and Group II nonanemic mothers and infant pairs were analyzed. Maternal anemia was defined as when the Hb level in blood was <11 g/dl.\[^11\] Socio-demographic characteristics of the study participants were collected using pretested questionnaires. Blood samples of mothers were collected at the time of labor for complete blood count and serum ferritin and C-reactive protein (CRP) estimation. Cord blood was collected for the estimation of Hb and red cell indices, CRP, serum iron, total iron binding capacity, and serum ferritin.

Breastfeeding was initiated within 1 h of birth. The follow-up was done at 6, 10, and 14 weeks. All mothers were counseled about exclusive breastfeeding at each follow-up. Infants were immunized as per universal immunization schedule and their anthropometric parameters were recorded at every follow-up.

At 14 weeks, venous blood from infants of both groups were collected by peripheral venepuncture under all aseptic precautions for the estimation of Hb, red cell indices and serum iron, total iron binding capacity, serum ferritin, and CRP.

The statistical analysis was done using SPSS (Statistical Package for Social Sciences, IBM, SPSS Statistics, USA) Version 20.0 statistical Analysis Software. The values were represented in Number (%) and Mean ± standard deviation. Chi-square test and Independent samples “t”-test were used to compare the data. Bivariate correlation was done between maternal and infant hematological parameters. \( P < 0.05 \) was considered as showing statistically significant association.

**Results**

Of 180 mother–infant enrolled, Group I comprised 90 anemic mother–infant pairs, three infants were lost to follow-up, two not exclusively breastfed. Therefore, 85 were included in the analysis. In Group II, of 90 nonanemic mother–infant pairs, nine were lost to follow-up and three were not on exclusive breastfeeding, therefore, 78 mother–infant pairs were analyzed [Figure 1].

Sociodemographic profiles of mothers such as age, parity, and antenatal check-up status were comparable in both the groups [Table 1]. Infants’ clinical profile like mean birth weight was 2.73 ± 0.13 in Group I and 2.72 ± 0.12 in Group II, which was comparable (\( P = 0.843 \)). The two groups were were similar with regards to age and gender [Table 1]. Mother’s mean hemoglobin and serum ferritin levels were 10.39 ± 0.52 g/dl and

![Flow chart showing study population](image-url)
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54.15 ± 29.67 ng/ml, respectively, in Group I and 12.19 ± 0.49 g/dl and 71.72 ± 10.63 ng/ml, respectively, in Group II; the differences were statistically significant \((P < 0.001)\) [Table 2].

Mean serum hemoglobin and serum ferritin of infants in Group I were found to be significantly lower than that in Group II \((P < 0.001)\) both at birth and at 14 weeks [Table 2]. A significant correlation between maternal and infant hemoglobin levels was observed at birth \((r = 0.338, <0.001)\) and at 14 weeks \((r = 0.776, \ P < 0.001)\) and serum ferritin levels at birth \((r = 0.231, \ P = 0.003)\) and at 14 weeks \((r = 0.269, \ P = 0.001)\) [Table 3].

### Discussion

Our study demonstrated that maternal anemia had an effect on the status of iron stores of full-term exclusively breastfed infants. Hb and ferritin levels in infants born to anemic mothers were significantly lower compared to infants born to nonanemic mothers. Studies\[^{[4,12-14]}\] have found that hemoglobin, S. iron, and serum ferritin in the cord blood of infants were significantly lower in infants of anemic mothers compared to nonanemic mothers. Teixeira Mde et al.\[^{[15]}\] also reported that maternal Hb levels were independent predictors of infants’ hemoglobin levels. However, findings of some studies\[^{[16,17]}\] were contrary to those of the present study thereby suggesting that Hb was not affected by maternal iron status. The difference could be due to heterogeneity in such maternal and infant group parameters as gestational age, birth weight, and feeding pattern of infants, which could have an effect on the hematological status of infants. Moreover, the difference in other studies could be in the estimation of serum ferritin, which is an indicator of iron stores.\[^{[18]}\] Since it is an acute phase protein CRP should be done to rule out infection. Lower maternal serum ferritin levels were present in anemic mothers compared to nonanemic mothers thus establishing iron deficiency as the etiology of the significantly lower ferritin in infants born to anemic mothers. Unidirectional active transfer of iron from the mother to the fetus is a known fact.\[^{[19]}\] Our results show

### Table 1: Summary of demographic and obstetric characteristics of mothers and their newborns

| Characteristic                  | Total \((n=163)\) \(N(\% )\) | Anemic mother infant pair \((n=85)\) \(N(\% )\) | Nonanemic mother infant pair \((n=78)\) \(N(\% )\) | \(P\)-Value |
|--------------------------------|-------------------------------|-----------------------------------------------|-----------------------------------------------|------------|
| Maternal age (years)           |                               |                                               |                                               |            |
| \(\leq 25\)                    | 97 (59.5)                     | 54 (63.5)                                    | 43 (55.1)                                    | 0.689      |
| \(> 25\)                       | 66 (40.5)                     | 31 (36.5)                                    | 35 (44.9)                                    |            |
| Parity                         |                               |                                               |                                               |            |
| Primiparus                     | 94 (57.6)                     | 53 (62.3)                                    | 41 (52.5)                                    | 0.635      |
| Multiparous                    | 69 (42.4)                     | 32 (37.7)                                    | 37 (47.5)                                    |            |
| Antenatal checkup              |                               |                                               |                                               |            |
| Yes                            | 112 (68.7)                    | 63 (74.1)                                    | 49 (62.8)                                    | 0.340      |
| No                             | 51 (31.3)                     | 22 (25.9)                                    | 29 (37.2)                                    |            |
| Newborn’s gender               |                               |                                               |                                               |            |
| Male                           | 84 (51.6)                     | 44 (51.8)                                    | 40 (51.3)                                    | 0.951      |
| Female                         | 79 (48.4)                     | 41 (48.2)                                    | 38 (48.7)                                    |            |
| Mean gestational age at birth±SD (weeks) | 37.98±0.82                  | 38.00±0.80                                   | 37.95±0.84                                   | 0.690      |
| Mean birth weight±SD (kg)      | 2.72±0.13                     | 2.73±0.13                                    | 2.72±0.12                                    | 0.843      |

SD=Standard deviation

### Table 2: Maternal hematological parameters and Infant Hematological parameters at birth and at 14 weeks’ follow-up

| Characteristic                  | Born to anemic mothers \((n=85)\) \(Mean±SD\) | Born to non-anemic mothers \((n=78)\) \(Mean±SD\) | \(P\)-Value |
|--------------------------------|-----------------------------------------------|-----------------------------------------------|------------|
| Maternal hematological parameters |                                               |                                               |            |
| Mean serum Hb±SD (g/dl)         | 10.39±0.52                                    | 12.19±0.49                                   | <0.001     |
| Mean serum ferritin±SD         | 54.15±29.67                                   | 71.72±10.63                                  | <0.001     |
| Infant hematological parameters at birth |                                               |                                               |            |
| Mean serum Hb±SD (g/dl)         | 16.33±1.19                                    | 17.62±1.35                                   | 0.001      |
| Mean serum ferritin±SD         | 135.40±25.94                                  | 160.45±28.50                                 | <0.001     |
| Infant hematological parameters at 14 weeks follow-up |                                               |                                               |            |
| Mean serum Hb±SD (g/dl)         | 11.24±1.03                                    | 13.18±0.82                                   | <0.001     |
| Mean serum ferritin±SD         | 55.92±10.44                                   | 63.56±10.15                                  | <0.001     |

Hb=Hemoglobin, SD=Standard deviation
that iron and ferritin are higher in infants than their mothers emphasizing that iron accretion in utero by fetus is independent of maternal iron status.\textsuperscript{10,13,20-24} In the present study, at 14 weeks, there were significant differences between the two groups for both S. Hb and serum ferritin levels, with mean values being significantly lower in infants born to anemic mothers than to nonanemic mothers. This demonstrates the effect of maternal anemia on iron accretion in their infants. These findings are in agreement with the observations by Meinzen-Derr et al.\textsuperscript{25} and Colomer et al.\textsuperscript{26} who followed the infants of anemic and nonanemic mothers up to 9 months of age and found that maternal anemia was independently associated with a three-fold increased risk of infant anemia. Similar findings were observed by Goldberg and Goldberg and Culhane\textsuperscript{27} who found that lowered iron stores at birth may persist for up to 1 year and result in iron deficiency anemia. In our study, a significant correlation between mother and infant Hb and serum ferritin was observed, at birth and 14 weeks. Although the infants were not anemic at both times, iron stores were lower in the group with maternal anemia. Therefore these infants were more prone to developing anemia later. Terefe et al.\textsuperscript{14} suggested that infants’ ferritin levels were significantly correlated to Hb and ferritin levels of mothers. These findings are in accord with the observations from other studies. As well\textsuperscript{26,28-31} in a case–control study by Kilbride et al.\textsuperscript{32} the relationship between maternal anemia and iron status of newborns at birth, 3, 6, 9, and 12 months of age was assessed. Anemia was higher in children born to anemic pregnant women than in those born to nonanemic pregnant women at all intervals. This supports the positive correlation of maternal Hb level with infants’ hematological parameters. However, contrary to the results of the present study, Dalal and Shah,\textsuperscript{17} found no significant difference in infants’ hematological parameters (Hb, mean corpuscular volume, mean corpuscular Hb [MCH], and MCH concentration) between anemic and nonanemic groups. Low specificity of the above parameters, which may be altered by different conditions such as subclinical infections could be the cause. Weak correlations were also found between the hematological parameters of newborns and their mothers in another study.\textsuperscript{28} This could be due to the difference in the study design, and the heterogeneity of the inclusion criteria.

Although infants born to anemic mothers did not have iron deficiency anemia, they could develop anemia later in infancy This needs further evaluation by follow-up studies. Our study showed that this association was present at 14 weeks in exclusively breastfed infants. On the basis of these findings, it is recommended that that term infants born to anemic mothers should be screened for their iron store status at birth and at 14 weeks for appropriate timely interventions.

### Conclusion

Hb and ferritin of infants born to anemic mothers were significantly lower than those born to nonanemic mothers, and there is a significant correlation between maternal and infant hematological parameters. Maternal iron deficiency may have an effect on the iron status of their infants.

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### Conflicts of interest

There are no conflicts of interest.

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