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# Iron Status of Pregnant Women and Their Newborns Using a Combination of Hematologic and Biochemical Parameters for the Diagnosis of Iron Deficiency.

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**ABSTRACT**

**Background:** Iron deficiency anemia is the most common nutritional deficiency in the world; estimates suggest that 2 billion persons worldwide are iron deficient. Because of the increased iron requirements of pregnancy and growth, pregnant women and infants are recognized as the groups most vulnerable to iron deficiency anemia. Aim: To determine the relationship between the iron status of pregnant women and their newborns using a combination of hematologic and biochemical parameters for the diagnosis of iron deficiency. **Methods:** The study was conducted on 75 pregnant women either prime or second gravida delivering singleton live births at term gestation (37-41 weeks). The subjects (n=61) were divided into 4 groups: Group 1: Hemoglobin ≤ 6.9g/dl, Group 2: Hemoglobin 7-9.9g/dl, Group 3: Hemoglobin 10-10.9g/dl, Group 4: Hemoglobin ≥ 11g/dl. **Results:** Positive correlation exists between the maternal and the neonatal hemoglobin levels. The serum iron and serum ferritin values of the neonates correlate with the maternal hemoglobin levels and serum ferritin are very low in the neonates of the mothers with severe iron-deficiency. The lower iron and ferritin values of the neonate were not reflected by the neonatal RBC indices, hence they should not be used as a indicator for assessing the iron status. **Conclusion:** Iron related parameters are correlated between pregnant women and their corresponding newborns meaning that iron is transported from mother to fetus in direct proportion with the levels found in the maternal circulation.

***Keywords:*** Iron status, Anemia, pregnancy, Neonatal.

## INTRODUCTION

Anemia is one of the major public health problems in the developing world. More than 70% of pregnant women in South-East Asia region suffer from nutritional anemia.[1]

Iron deficiency anemia is the most common nutritional deficiency in pregnancy, with an impact on fetal and maternal morbidity and mortality. It is regarded as the most important preventable cause of some perinatal complications, such as preterm delivery, intrauterine growth retardation, neonatal and perinatal mortality.[2]

It is still not clear whether deficient iron stores in pregnant women might lead to a deficient iron status of their children. Many studies conducted till now have supported the belief that iron transport from the pregnant women to their fetus occurs independently of maternal iron levels. These studies also point out that it might even induce deficiency in the pregnant women as a result of fetal "parasitism". However, many studies conducted later, have questioned this belief and suggested that iron deficiency in the mother can cause depletion of iron stores in the fetus. No consensus has been reached regarding this subject so far. The difficulty in establishing a correct diagnosis of the iron status of pregnant women represents a major complicating factor in the understanding of the relationship between the maternal and fetal iron levels. The physiological changes that occur during the pregnancy (expanding plasma volume and erythropoiesis) have a significant impact on the hematological and biochemical parameters available for the assessment of iron status in pregnancy. Hemoglobin estimation is the most commonly used parameter to detect anemia in public health care services because of its low cost and the available reference standards. Therefore, a combination of multiple parameters has been proposed in order to improve the diagnosis of iron deficiency in pregnant women.[4-6]

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### Aim

To determine the relationship between the iron status of pregnant women and their newborns using a combination of hematologic and biochemical parameters for the diagnosis of iron deficiency.

## MATERIALS AND METHODS

This cross sectional study was conducted in department of pediatrics in Tirunelveli Medical College Hospital. Inclusion criteria: The study was conducted on 75 pregnant women either prime or second gravida delivering singleton live births at term gestation (37-41 weeks). The pregnant women were selected consecutively.

**Exclusion criteria**

- Premature rupture of membranes (PROM>24hrs)
- Fever
- Foul-smelling liquor
- Ante-partum hemorrhage (APH)
- Pregnancy induced Hypertension (PIH)
- Eclampsia
- Gestational Diabetes-mellitus or Diabetes complicating pregnancy
- Liver disorders
- Kidney disorders
- Women with other systemic illness
- Women who have received blood transfusions.

The participants were selected based on this inclusion and exclusion criteria. Of the 75 participants, 14 had anemia (Hb<11g/dl) with normal iron stores (SF>55ng/ml) pointing towards other causes of anemia and they were not included in the study as the study is on iron deficient anemia mothers.

The subjects (n=61) were divided into 4 groups:

Group 1: Hemoglobin ≤ 6.9g/dl

Group 2: Hemoglobin 7-9.9g/dl

Group 3: Hemoglobin 10-10.9g/dl

Group 4: Hemoglobin ≥ 11g/dl

Gestational age of the pregnancy was calculated from the first day of the last menstrual period. The calculated gestational age was confirmed by the New Ballard score. Informed consent was taken from the pregnant women after explaining the study protocol and the procedures. The study protocol was approved by the ethical committee of the institute.

## RESULTS

61 pregnant women and their newborns were enrolled in the study to determine the relationship between them with regard to their iron status. Only prime and second gravida were included in the study. Group 1 contained 5 pregnant women and they constituted 8.2% of the sample size. Group 2 contained 21 pregnant women and they constituted 34.4% of the sample size. Group 3 contained 19 pregnant women and they constituted 31.1% of the sample size. Group 4 contained 16 pregnant women and they constituted 26.3% of the sample size. This data shows that 78.7% (59 out of 75) of pregnant women studied were anemic. Only primi and second gravida in the age group of 20 to 32 were selected to make the different study groups comparable with respect to age and parity.

Out of the 61 pregnant women studied, 60 had at least 3 antenatal visits and they are booked cases. Only one women was unbooked. Another surprising data in my study is that all women had taken iron tablets including the unbooked case. She was given iron tablets in the last trimester. This shows a good health care system in our state. Even though the number of tablets taken by these women may vary, it is very appreciable fact that all were provided with iron tablets. But all the pregnant women in my study, except a very few had not taken the iron tablets in the prescribed doses.

**Table 1: Iron and Ferritin stores of the mother.**

| Mother hemoglobin category | | IRON | FERRITIN |
|---|---|---|---|
| ≤ 6.9gm% | Mean | 30.100 | 9.040 |
| | Std. Deviation | 4.8229 | 3.0534 |
| 7-9.9gm% | Mean | 46.824 | 14.456 |
| | Std. Deviation | 9.5380 | 3.9742 |
| 10-10.9gm% | Mean | 68.647 | 24.874 |
| | Std. Deviation | 30.4540 | 13.2769 |
| ≥ 11gm% | Mean | 76.038 | 46.100 |
| | Std. Deviation | 25.8380 | 15.4580 |
| Total | Mean | 59.913 | 25.557 |
| | Std. Deviation | 26.5430 | 17.2354 |

Serum iron level which is the circulating form shows a linear relationship with the Hemoglobin levels of the mothers in all the four groups.

**Table 2: Anova table showing the RBC indices and iron stores of the mothers and its significance levels.**

| | | | Mean square | F | Sig. |
|---|---|---|---|---|---|
| HCT* mother HB category | Between groups | combined | 353.936 | 54.959 | .000 |
| | Within groups | | 6.440 | | |
| MCV* mother HB category | Between groups | combined | 724.362 | 18.192 | .000 |
| | Within groups | | 39.817 | | |
| MCH* mother HB category | Between groups | combined | 181.473 | 13.621 | .000 |
| | Within groups | | 13.323 | | |
| MCHC* mother HB category | Between groups | combined | 35.965 | 13.504 | .000 |
| | Within groups | | 2.663 | | |
| Iron* mother HB category | Between groups | combined | 4550.476 | 9.063 | .000 |
| | Within groups | | 502.114 | | |
| Ferritin* mother HB category | Between groups | combined | 3571.058 | 28.627 | .000 |
| | Within groups | | 124.744 | | |

This ANOVA TABLE shows the significance levels of the RBC indices and the iron stores of the mothers

with respect to their hemoglobin levels between the four groups. The significance level is 0.000 (p<0.05) in all the categories. This value shows that there is a significant difference in the RBC indices values and the iron stores of the mothers between the 4 groups.
There is no correlation of the MCHC values of the baby with the hemoglobin values of the mother.
The RBC indices of the baby measured (mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration) shows no correlation with the maternal hemoglobin levels.

**Table 3: Serum iron and ferritin values of the baby.**

| Mother hemoglobin category | | Iron | Ferritin |
|---|---|---|---|
| ≤ 6.9gm% | Mean | 124.640 | 52.100 |
| | Std. Deviation | 62.5261 | 13.7971 |
| 7-9.9gm% | Mean | 167.352 | 129.759 |
| | Std. Deviation | 50.5704 | 42.3154 |
| 10-10.9gm% | Mean | 180.453 | 131.284 |
| | Std. Deviation | 50.3678 | 54.8261 |
| ≥ 11gm% | Mean | 186.837 | 127.563 |
| | Std. Deviation | 61.4569 | 42.4874 |
| Total | Mean | 173.043 | 123.292 |
| | Std. Deviation | 55.6157 | 49.2413 |

**Table 4: Anova table showing the RBC indices and its significance.**

| | | | Mean square | F | Sig. |
|---|---|---|---|---|---|
| Baby HB* mother HB category | Between groups | combined | 3.750 | 1.831 | .152 |
| | Within groups | | 2.048 | | |
| MCV* mother HB category | Between groups | combined | 40.971 | 1.745 | .168 |
| | Within groups | | 23.476 | | |
| MCH* mother HB category | Between groups | combined | .833 | .216 | .885 |
| | Within groups | | 3.854 | | |
| MCHC* mother HB category | Between groups | combined | .429 | .169 | .917 |
| | Within groups | | 2.544 | | |
| Iron* mother HB category | Between groups | combined | 5494.020 | 1.852 | .148 |
| | Within groups | | 2966.739 | | |
| Baby HB* mother HB category | Between groups | combined | 9241.693 | 4.473 | .007 |
| | Within groups | | 2065.915 | | |

**Table 5: Correlation between the maternal and baby values and its significance**

| | | Mot HB | HCT | MCV | MCH | MCHC | Iron | Ferritin |
|---|---|---|---|---|---|---|---|---|
| Baby HB | Correlation | .331** | .376** | .284* | .139 | .093 | .216 | .171 |
| | P value | .009 | .003 | .027 | .285 | .477 | .094 | .188 |
| HCT | Correlation | .315* | .356** | .333** | .171 | .157 | .171 | .165 |
| | P value | .013 | .005 | .009 | .18 | .226 | .188 | .204 |
| MCV | Correlation | -.184 | -.152 | -.119 | -.093 | -.028 | -.200 | -.131 |
| | P value | .156 | .242 | .362 | .475 | .833 | .122 | .313 |
| MCH | Correlation | .201 | .205 | .333** | .295* | .154 | .092 | .024 |
| | P value | .120 | .114 | .009 | .021 | .235 | .483 | .857 |
| MCHC | Correlation | .043 | .172 | .171 | .173 | .061 | .090 | -.016 |
| | P value | .741 | .185 | .187 | .183 | .640 | .489 | .900 |
| Iron | Correlation | .270* | .277* | .216 | .340** | .191 | .288* | .194 |
| | P value | .035 | .031 | .095 | .007 | .140 | .024 | .135 |
| Ferritin | Correlation | .329** | .342** | .083 | .235 | .237 | .281* | .257 |
| | P value | .010 | .007 | .525 | .069 | .066 | .028 | .046 |
| ** Correlation is significant at the 0.01 level (2- tailed). | | | | | | | | |
| * Correlation is significant at the 0.05 level (2- tailed). | | | | | | | | |

Hemoglobin and hematocrit values of the baby shows a positive correlation with the maternal hemoglobin values.
RBC indices of the baby (mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration) doesn't correlate with the maternal hemoglobin levels and there is no significance (p value>0.05). Among these MCV values shows a negative correlation, but it is not statistically significant (p>0.05). Serum iron and serum ferritin levels, shows a positive correlation with maternal hemoglobin levels and it is statistically significant (p<0.05)

Even though the hemoglobin and hematocrit values of the baby shows a positive correlation with the maternal hemoglobin levels, there is no significant difference between the groups.

Similarly serum iron which shows a positive correlation with the maternal hemoglobin levels, does not show a significant difference between the groups.
Serum ferritin alone shows a positive correlation with the maternal hemoglobin levels, as well as a significant difference between the groups. (Sig 0.007 which is <0.05 in the ANOVA.

**Table 6: Hemoglobin levels in maternal and cord blood**

| Study group | Range of maternal Hb g/dl | Hb g/dl mother | Hb g/dl cord blood |
|---|---|---|---|
| Group 1 | ≤ 6.9 | 6.36 | 15.8 |
| Group 2 | 7-9.9 | 8.22 | 16.2 |
| Group 3 | 10-10.9 | 10.53 | 16.3 |
| Group 4 | ≥ 11 | 11.8 | 17.1 |

These values show that hemoglobin values are more in the cord blood than the maternal blood.

**Table 7: Serum iron levels in maternal and cord blood**

| Study group | Range of maternal Hb g/dl | Serum iron ug/dl mother | Serum iron ug/dl cord blood |
|---|---|---|---|
| Group 1 | ≤ 6.9 | 30.1 | 124.6 |
| Group 2 | 7-9.9 | 46.8 | 167.3 |
| Group 3 | 10-10.9 | 68.6 | 180.4 |
| Group 4 | ≥ 11 | 76.0 | 186.8 |

These values show that serum iron values are more in the cord blood than mother.

**Table 8: Serum ferritin levels in the maternal and the cord blood.**

| Study group | Range of maternal Hb g/dl | Serum ferritin ng/ml mother | Serum ferritin ng/ml cord blood |
|---|---|---|---|
| Group 1 | ≤ 6.9 | 9.0 | 52.1 |
| Group 2 | 7-9.9 | 14.4 | 129.7 |
| Group 3 | 10-10.9 | 24.8 | 131.2 |
| Group 4 | ≥ 11 | 46.1 | 127.5 |

These values show that serum ferritin values are more in the cord blood than the maternal blood.

**Table 9: Maternal and neonatal RBC indices**

| | MCV | | MCH | | MCHC | |
|---|---|---|---|---|---|---|
| Groups | Mother | Baby | Mother | Baby | Mother | Baby |
| 1 | 75.8 | 107 | 20 | 33.9 | 27.6 | 32.1 |
| 2 | 73.9 | 109.4 | 22.9 | 33.7 | 29.6 | 32.2 |
| 3 | 82 | 106.4 | 26.8 | 34.2 | 30.6 | 32.5 |
| 4 | 88.8 | 106.2 | 29.3 | 33.9 | 32.2 | 32.3 |

This shows that the RBC indices values are higher in the cord blood than the maternal blood.

**Table 10: Anthropometric measurements of the baby**

| Mother hemoglobin category | | HC | Length | CC | Weight |
|---|---|---|---|---|---|
| ≤ 6.9gm% | Mean | 32.800 | 50.000 | 30.000 | 2.5700 |
| | Std. Deviation | .8367 | 2.6458 | 1.5811 | .30332 |
| 7-9.9gm% | Mean | 32.762 | 50.000 | 30.548 | 2.7629 |
| | Std. Deviation | 1.3749 | 1.3784 | 1.7314 | .42092 |
| 10-10.9gm% | Mean | 33.053 | 49.842 | 31.053 | 2.9992 |
| | Std. Deviation | 2.0131 | 2.1412 | 2.1206 | .34126 |
| ≥ 11gm% | Mean | 32.963 | 49.906 | 31.075 | 2.7988 |
| | Std. Deviation | 1.2500 | 1.5080 | 1.7234 | .31549 |
| Total | Mean | 32.908 | 49.926 | 30.798 | 2.8301 |
| | Std. Deviation | 1.5163 | 1.7460 | 1.8367 | .37623 |

The anthropometric measurements of the baby (head circumference, length, chest circumference and birthweight) shows a significant difference between the groups. (p>0.05)

**Table 11: Anova table showing the anthropometric measurements of the babies and its significant levels**

| | | | Mean square | F | Sig. |
|---|---|---|---|---|---|
| HC* mother HB category | Between groups | combined | .317 | .132 | .941 |
| | Within groups | | 2.403 | | |
| Length* mother HB category | Between groups | combined | .094 | .029 | .993 |
| | Within groups | | 3.204 | | |
| CC* mother HB category | Between groups | combined | 2.320 | .677 | .570 |
| | Within groups | | 3.429 | | |
| Weight* mother HB category | Between groups | combined | .331 | 2.514 | .067 |
| | Within groups | | .132 | | |

## DISCUSSION

Iron deficiency anemia is the most common nutritional deficiency disorder affecting the pregnant women in our country with a significant impact on maternal and fetal mortality and morbidity.

The values of hemoglobin, serum iron and serum ferritin in the cord blood were higher than the maternal blood. Similar results were obtained in the studies conducted by

In the study conducted by Shyamala et al, in Mangalore there was no significant difference in the neonatal hemoglobin levels between the case group (neonates of anemic mothers) and the control group (neonates of non-anemic mothers). But they divided the mothers into two groups (anemic and non-anemic).[7] The hemoglobin values of the babies in all the four groups were in the normal range. But they showed a correlation with the maternal hemoglobin levels.

In the study, conducted by Kumar et al in Varanasi he took many women with severe anemia and he got a similar result.[8]

Even though the hemoglobin values of the babies showed a correlation with the maternal hemoglobin values, they do not show any statistical difference between the four groups in present study, i.e. the hemoglobin values do not fall or rise with the severity of anemia. Similar results were obtained in the two studies conducted by Shyamala et al in India.[7] In this regard, the results of the study conducted by Kumar et al. is contradicting the present study.[8]

The mean serum iron and serum ferritin values of the neonates showed a positive correlation with the maternal hemoglobin levels with statistical significance. (Serum iron p 0.035, serum ferritin p 0.010), whereas serum ferritin showed a significant difference between the groups than serum iron. The serum ferritin level was very low in the group of newborns born to severely anemic mothers compared to the other three groups.

In a case control study by Kilbride et al. carried out in Jordan, he investigated the relationship between the maternal anemia and neonatal iron status at birth, 3-4, 6, 9 and 12 months of age. He did not find any correlation between the maternal anemia and neonatal iron status.[9]

In the studies by Rios et al no significant correlation was found between the maternal anemia and the umbilical cord ferritin levels.[10]

Serum iron values showed a significant correlation between the mother and the neonate. (p 0.024)

In the study by Shyamal et al, they have reported that the mean serum iron in the cord blood of anemic mothers was less than the serum iron in the cord blood of non-anemic mothers.[7]

Serum ferritin levels showed a positive correlation between the maternal and neonatal blood with statistical significance ($p<0.05$). There is a significant difference in the serum ferritin values of the cord blood of the babies in the four groups.

The results in the present study were similar to those of the Indian study conducted by Kumar et al in Varanasi.[8]

Scholl et al. showed that pregnant women with iron-deficiency anemia had a three times increased risk of giving birth to neonates with low birth weight.[11]

In contrast, in a study by Preziosi et al, no significant difference was found between birth weight of the neonates and the maternal iron status. The effect of iron deficiency in mothers on fetal growth has been reported to be significant especially in the teenage mothers.[12]

Micronutrient consumption during pregnancy has a significant impact on the neonatal growth and development. Pregnant women who received iron supplements have been reported to have heavier babies by Cogswell et al.[13]

In the study by Emamghorashi et al. they have reported a significant correlation between the neonatal head circumference and the maternal anemia.[14] However, they did not report any correlation between the birth weight and the maternal anemia.

## CONCLUSION

In conclusion, the data of the present study indicate that maternal iron-deficiency adversely affects the cord blood iron status. Improving the iron status of pregnant women by improving the nutrition as well as the regular intake off iron supplements will have a favorable impact on maternal, fetal and infant iron nutrition. Another approach to improve the iron status of the neonates is to delay the clamping of the cord after birth.

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