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Original Article

Association of maternal hemoglobin and iron stores with neonatal hemoglobin and iron stores

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ARTICLE INFO

Article history:
Received 6 June 2019
Accepted 22 November 2019
Available online 18 March 2020

Keywords:
Hemoglobin
Serum ferritin
Soluble transferrin receptor
Maternal anemia
Neonatal anemia

ABSTRACT

Background: One of the commonest causes of anemia in pregnancy is iron deficiency. This study aims at understanding and exploring the association between fetal and maternal iron status. Predelivery maternal hemoglobin (Hb) and iron stores, serum iron, ferritin, and soluble transferrin receptor (sTfR), were assessed and compared to the cord blood Hb and iron stores with an attempt to identify the level of maternal Hb and ferritin at which the fetal iron stores reduce, helping to identify the neonates who will require earlier iron supplementation.

Method: Four hundred eight participants were enrolled, and maternal and cord blood was collected at the time of delivery and tested for Hb and iron parameters. The results were statistically analyzed.

Results: Of all mothers, 27.2% mothers were anemic (Hb less than 11 g/dl). Of all newborns, 15.4% newborns had Hb less than 14 g/dl. There was a significant association between the maternal and cord blood iron, ferritin, sTfR and sTfR/log ferritin index. Eighty-five percent of the babies with cord blood Hb <14 g/dl had maternal serum ferritin (SF) <50 μg/L. Maternal SF <10 μg/l was associated with a significant number of babies with cord blood SF <75 μg/l (77.7%). One hundred sixty six neonates had sTfR 2 μg/ml or more. Of these, 80.7% had maternal SF <50 μg/l. Of the 115 newborns with a high sTfR/log ferritin index (>1.5), 56.5% had raised maternal sTfR (>2μg/ml).

Conclusion: In view of a significant association between maternal and neonatal Hb and iron stores, newborns of mothers with iron deficiency anemia (IDA) during pregnancy should be monitored and followed up after birth for development of IDA and early iron supplementation.

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https://doi.org/10.1016/j.mjafi.2019.11.002

Introduction

Pregnancy is commonly complicated by iron deficiency anemia (IDA). IDA is also prevalent in early childhood especially in developing countries. The physiological changes and metabolic demands of pregnancy cause an increased requirement of iron, which is not met by the normal daily diet. In the absence of adequate supplementation of iron or presence of maternal malnutrition, the risk of developing IDA increases.[1] World Health Organization defines maternal anemia as a hemoglobin (Hb) level of less than 11 g/dl. For newborns, Hb less than 2 standard deviations is taken as anemia which is around 13.5g/dl–14.5 g/dl, subsequently in infants 6–24 months Hb < 11 g/dl is anemia.

Iron is an important micronutrient contributing to neuromotor and emotional development of an infant. Studies have shown that iron deficiency in the form of low iron stores at birth (SF < 75ug/l) could cause neurodevelopmental and cognitive disorders in these infants which may not improve even after the iron deficiency is corrected.[2]

Serum ferritin (SF) is a measure of iron stores of an individual. In IDA, SF is low, except in the presence of inflammation or infection. Siddappa et al.,[3] studied SF in cord blood of preterm and term neonates. He found that cord levels of SF rise with gestational age. The transfer of iron from the mother to the fetus is regulated by the placenta. The rate of iron uptake in the fetus is 1.35 mg/kg/d during the third trimester. Expanding maternal blood volume and fetal red cell mass leads to an increased requirement of iron in the second and third trimesters.[4]

Maternal and neonatal iron demand determines the placental transferrin receptor (TfR) expression. It may be increased in healthy pregnant women as a response to iron deficiency.[5] When the mother is iron deficient, transfer of iron to the fetus by the placental system may be inadequate.[3,6]

Results of studies on maternal–neonatal iron status have been varied. Some studies find no association whereas others have shown that the fetus is predisposed to ID if maternal anemia and iron deficiency is severe. A study by Shao et al.[6] found that despite widespread maternal ID, iron status of fetus was adequate except in situations where maternal iron deficiency was severe (SF<13.6 μg/l).

Soluble TfR is another marker for anemia which is now gaining importance especially in conditions where tissue iron deficiency is present. It is a complex of transferrin and its receptor. Erythroblasts are the main source of serum sTfR, and levels of sTfR are determined by erythropoietic activity of the marrow. Hence levels of sTfR help in gauging the response to iron therapy even before changes in Hb levels occur. Levels of sTfR may be elevated in IDA but remain normal in the anemia associated with chronic infection and inflammation where ferritin may be normal or increased. Increase in sTfR levels reflect functional iron deficiency, a condition where tissue iron deficiency occurs despite presence of adequate iron stores. The sTfR/ferritin ratio describes iron availability over a range of iron stores. Studies have shown that soluble transferrin receptor (sTfR) and sTfR/log ferritin are increased in neonates of mothers who smoke because of relative tissue iron deficiency.[7] Serum sTfR levels vary between different commercial assays, and hence, we find different ranges in reported studies. The data on sTfR are relatively limited for neonates and further studies are required for establishing standard values for neonates and infants.[3]

As per the recommendations of the American Academy of Pediatrics, 1 mg/kg per day of iron should be supplemented to healthy exclusive breastfeeding infants starting 4 months of age till the time normal diet rich in iron is started. Infants with high risk for development of IDA like preterm and low birth weight should be kept under follow-up and supplemented with iron as per requirement.

The aim of this study was to assess predelivery maternal Hb iron stores and predictors of iron status, serum iron, ferritin, and soluble transferrin receptor (sTfR), and to compare these with similar cord blood variables. The study also aimed to identify the level of maternal Hb and ferritin at which the fetal iron stores reduce (low SF), so as to identify the neonates who will require follow-up in the postnatal period and supplementation of iron earlier than the routine recommendations.

Material and methods

It was a cross-sectional descriptive study carried out from November 2015 to October 2017 in a tertiary care institute. Clearance by institutional ethics committee was taken. Four hundred eight participants based on inclusion and exclusion criteria were enrolled when they presented to the labor room of our hospital for delivery. An informed consent was taken.

The inclusion criteria were as follows: all ladies between 37 and 42 weeks period of gestation with singleton live pregnancy presenting to labor room for delivery and no associated medical or obstetric complications.

The exclusion criteria were as follows: history of blood transfusion and any pregnancy complication such as hypertensive disorders, diabetes, prematurity, fetal growth retardation, and other maternal chronic disease.

Sample size was calculated to detect difference in means of maternal blood and cord blood with 5% level of significance and 95% power. The inputs for sample size calculation were taken from the published study by Shao et al.[6] The minimum sample size worked out to be 251; however, we studied 408 mothers and their neonates.

Maternal blood samples were collected before delivery, and cord blood samples were collected within 60 s of delivery. Paired samples of maternal and cord blood were tested in the laboratory for Hb, serum iron (ferrozine method), ferritin (enzyme-linked immunosorbent assay [ELISA]) and sTfR (ELISA). The results of paired maternal and neonatal samples were statistically analyzed using SPSS 22 software to find an association between the maternal and cord blood iron status. For analysis of the variables, they were further categorized as mentioned in the following paragraph.

Maternal Hb was subcategorized as <11 and >11 g/dl, and cord blood Hb was divided into <14 and >14 g/dl. Serum iron was categorized into four groups from <60 to >200 μg/dl for mother and <20 to >100 μg/dl for cord blood. SF was divided into seven subgroups for mother <10 to >200 μg/l and five subgroups <35 to >370 μg/l for cord blood. sTfR was categorized into four groups <1 to >3 μg/ml for both maternal and cord blood values. sTfR/log ferritin index was subcategorized as <1 to >2 (three categories) for both mother and cord blood. Subsequently, tests for significance and correlation were applied.

Results

The demographic characteristics of the study population are listed in Table 1.

Hb, SF, serumiron, total iron binding capacity (TIBC), sTfR and sTfR/log ferritin index of the mothers and newborn babies (cord blood samples) are shown in Table 2. There was a significant association between maternal Hb, serum iron, SF, and all cord blood parameters except TIBC (Table 3). Maternal sTfR and sTfR/log ferritin index showed association with cord blood ferritin and sTfR and sTfR/log ferritin index (Table 3).

Maternal Hb

One hundred and eleven mothers (27.2% of the study population) were anemic with Hb less than 11 g/dl. Only 63 newborns (15.4%) had Hb less than 14 g/dl. Hb was less than 14 g/dl in newborns of 27% anemic mothers and 11% of nonanemic mothers.

Pearson's chi-square test was significant ($p = 0.000$), depicting an association between the maternal and neonatal Hb.

Of the anemic mothers, 14% had newborns with serum iron content less than 80 μg/dl compared with 11% of the newborns in the nonanemic group. $P = 0.025$ and hence there was an association between maternal Hb and neonatal serum iron levels.

There was association between maternal Hb and SF of cord blood ($p = 0.001$). Seventy-six of the 408 cord blood values (18.6%) were less than 35 μg/ml and 30 (39%) had maternal Hb less than 11 g/dl. Sixty-one percent of mothers with Hb < 11 g/dl had newborns with SF less than 75 μg/ml but only 38% of those with Hb > 11 g/dl had SF <75 μg/ml.

An association was found between maternal Hb and newborn sTfR. Tests of significance gave a p value of 0.039 ($p < 0.05$). A proportion of 51.3% (57/111) had sTfR >2 in the anemic group but only 36.7% (109/297) had sTfR >2 in the nonanemic group. There was an association between maternal Hb and cord blood sTfR/log ferritin index ($p = 0.018$). Of all anemic mothers, 56.7% (63/111) had sTfR/log ferritin index of the cord blood >1 but only 42.7% (127/297) of non-anemic mothers had the same.

Maternal serum iron

There was an association between maternal serum iron and cord blood Hb ($p = 0.04$). Of the 63 newborns with Hb less than 14 g/dl, 65.07% had mothers with serum iron less than 80 μg/dl. Of the newborns with Hb >14g/dl, only 52.02% mothers had serum iron less than 80 ug/dl.

15% of newborns had low serum iron (<80 μg/dl) in the mothers with low serum iron (<80 μg/dl) whereas in the mothers with serum iron >80 μg/dl, only 8% newborns had low serum iron ($p = 0.001$).

There was a significant association between maternal serum iron and SF of the newborn ($p = 0.000$). Of the 183 neonates with cord blood SF <75 μg/L, 124 (67.7%) had mothers with serum iron <80 μg/dl.

48.1% newborns had cord blood sTfR greater than 2 in the low serum iron mothers, whereas only 31.5% had higher sTfR in those with adequate serum iron. P value (0.035) for association was significant.

Low maternal serum iron was also associated with a higher sTfR/log ferritin index in the baby. P value for significance of association was 0.004.

Table 1 – Population demographics.

Characteristics	Mean	Range
Maternal age	25 yrs	18–37yrs
Period of gestation at delivery	39 weeks	37–41 weeks
Socioeconomic status	59.8% upper middle 36.3% middle 3.9% lower	
Education	40% graduate/postgraduate 26.2% 10–12 class 37.5% < class 10 1.2% illiterate	
Gravidity	42.9% primigravidae 42.2% second gravidae 13% third gravidae 2% fourth gravidae or more	
Mode of delivery	81.6% normal vaginal delivery 1.5% instrumental delivery 16.9% caesarean delivery	
Birth weight of newborns	2.87 Kg 12.3% < 2.5 kg 86.7% 2.5–3.5 kg 1% > 3.5 Kg	1.6–3.9 kg
Newborn gender	50.7% male 49.3% female	

Table 2 – Hemoglobin and iron study of the mothers and neonates (cord blood) at the time of delivery.

Parameter	Source	Mean ± SD	Range
Hemoglobin (g/dl)	MB	11.62 ± 1.35	7.8–16.30
	CB	15.27 ± 1.43	11.1–21.50
Serum iron (μg/dl)	MB	81.94 ± 43.29	11–350.00
	CB	149.74 ± 72.06	3–549
TIBC (μg/dl)	MB	396.02 ± 88.09	211–825
	CB	340.53 ± 91.24	174–898
Serum ferritin (μg/l)	MB	50.25 ± 62.77	1.2–536.5
	CB	118.17 ± 106.05	2.5–593.8
Soluble transferrin receptor (sTfR) (μg/ml)	MB	2.25 ± 1.37	0.37–7.15
	CB	2.14 ± 1.48	0.2–9.45
sTfR/log ferritin index	MB	2.10 ± 2.52	0.163–26.142
	CB	1.31 ± 1.34	0.107–13.727

MB, Maternal blood; CB, Cord blood (neonate).

Table 3 – Association and correlation between maternal and cord blood parameters.

Parameters		Hb, B	Serum iron	Serum ferritin B	sTfR B	sTfR/log ferritin B
Hb M	p	0.000	0.025	0.001	0.039	0.018
	r	0.328	0.208	0.228	−0.149	−0.202
Serum iron M	p	0.04	0.001	0.000	0.035	0.004
	r	0.136	0.431	0.288	−0.153	−0195
Serum ferritin M	p	0.032	0.000	0.000	0.015	0.000
	r	0.152	0.315	0.382	−0.168	−0.195
sTfR M	p	0.13	0.51	0.000	0.000	0.000
	r	−0.083	−0.149	−0.150	0.261	0.232
sTfR/log ferritin M	p	0.07	0.000	0.000	0.000	0.000
	r	−0.122	−0.213	−0.228	0.162	0.194

p = p values ($p < 0.05$ significant); r = correlation coefficient; M = maternal; B = Baby; Hb = hemoglobin.

Maternal SF

There was an association between maternal ferritin and cord blood Hb (p = 0.032). Eighty-five percent of the babies with cord blood Hb <14 g/dl had maternal SF <50 μg/L.

There was a significant association between maternal SF and cord blood iron (p = 0.000). Of the 49 babies with cord blood iron <80 μg/dl, 42 (85.7%) had maternal SF <50 μg/l and 19 (38.7%) had maternal SF <15 μg/l. Of the 144 mothers with SF <20 μg/l, 15.9% of the newborns had low serum iron.

A significant association was found between maternal and cord blood SF (p = 0.000). Maternal SF <10 μg/l was associated with a significant number of babies with cord blood SF <75 μg/l (77.7%). Seventy-six babies had SF <35 μg/l and of these 68 (89.5%) had low maternal SF levels<50 μg/l.

Eighty-five (20.83%) mothers had SF <10 μg/l. The mean cord blood SF for this group was 60.53 μg/l, whereas the mean cord blood SF for those mothers with SF >10 μg/l was 134.36 μg/l. This difference was significant (p = 0.0002).

An association was seen between maternal SF and cord blood sTfR (p = 0.015). One hundred sixty six neonates had sTfR 2 μg/ml or more. Of these, 134 (80.7%) had maternal SF <50 μg/l, and 27.7% (46) had maternal SF <10 μg/l.

Higher cord blood sTfR/log ferritin index was associated with low maternal SF levels (p = 0.000). Of the 115 babies with cord blood sTfR/log ferritin index >1.5, 80% (93) had maternal SF <50 μg/L.

Maternal sTfR

There was no association found between maternal sTfR value and cord blood Hb and cord blood iron values (p = 0.13 and 0.51, respectively). There was a definite association between maternal sTfR and cord blood ferritin, sTfR and sTfR/log ferritin index (p = 0.000. 0.000 & 0.000).

Of the 183 newborns with SF <75 μg/L, 54% (99) had increased value of maternal sTfR. One hundred eighty four mothers had a raised sTfR (>2 μg/ml). Fifty-four percent had newborns with low SF (<75 μg/L).

Of the 184 mothers with increased sTfR (>2 μg/ml), 50.5% had newborns with values >2 μg/ml and 56% of the newborns with cord blood sTfR >2 μg/ml had increased maternal values.

56.5% of the 115 newborns with a high sTfR/log ferritin index (>1.5) had raised maternal sTfR (>2μg/ml).

Maternal sTfR/log ferritin index

There was no association found between maternal sTfR/log ferritin index and cord blood Hb (p = 0.07).

There was an association between maternal sTfR/log ferritin index and cord blood iron (p = 0.000). Fifty-seven percent of newborns with serum iron <80 μg/dl had maternal sTfR/log ferritin index>1.5. Of the 183 babies with SF <75 μg/l, 60.65% had increased value of sTfR/log ferritin index >1.5 showing a significant association (p = 0.000). 61.6% of mothers with increased level of sTfR/log ferritin index had babies with low SF.

Of the 180 mothers with increased value of sTfR/log ferritin index (>1.5), 55.55% had increased level of cord blood sTfr (>2 μg/ml). Among the 166 newborns who had increased level of sTfR (>2 μg/ml), 60% had increased value of maternal sTfR/log ferritin index.

Of the 115 babies with cord blood sTfR/log ferritin index >1.5, 61.7% had a similarly increased level of maternal sTfR/log ferritin index.

There was weak correlation between all the maternal and cord blood iron parameters. Pearson correlation coefficient r was less than 1 (Table 3). Maternal values cannot help calculate exact neonatal value.

Discussion

The results of our study revealed a significant association between maternal and cord blood Hb and iron parameters.

The mean maternal Hb was 11.62 g/dl, 27.2% of women in our study were anemic (Hb < 11 gm/dl, mean: 9.92 g/dl). The mean cord blood Hb was 15.27 g/dl, and 15.4% newborns had Hb <14 g/dl. Values were comparable with studies by other authors.

The mean maternal SF was 50.25 ± 62.77 μg/l, and the mean SF of cord blood was 118.17 ± 106.05 μg/l. 20.83% mothers had SF <10 μg/l. The mean SF of cord blood of these mothers was significantly lower than those with SF >10 μg/l (60.53 μg/l &134.36 μg/l). 44.8% newborns (183/408) had SF <75 μg/l. The percentage of newborns with low SF in our study was higher when compared with other studies from China (Shao et al.)[6], Norway (Hay et al.)[8], or America (Lee et al.).[9] Ilyes et al.[10] reported that the SF concentration of neonates of mothers with ferritin concentrations <10 μg/l was 98.5 ± 50.6 μg/l compared with 147.2 ± 66.0 μg/l in neonates of mothers with normal ferritin concentrations. This was similar to findings of our study. Another study from Ethiopia by Terefe et al.[11] had similar results and observed that iron stores of neonates may be affected by maternal IDA. In their study, levels of SF and Hb were significantly lower in newborns of IDA mothers ($p = 0.017$and $p = 0.024$, respectively). The ferritin and Hb levels of the newborn also showed significant correlation with maternal Hb ($p = 0.018$; $p = 0.039$) and ferritin levels ($p = 0.000$; $p = 0.008$). Mireku et al.[12] reported that the prevalence of prenatal iron deficiency at delivery was 28.4%. Cord blood SF concentrations were similar between iron-deficient and iron-replete pregnant women. From a study conducted in India, Sareen et al.[13] concluded that the cord blood Hb shows a linear relationship with maternal Hb, with cord Hb being less in mothers who have anemia.

Shao et al[6] studied more than 3000 mother–newborn pairs in rural China. 27.5% of the mothers in their study were anemic and 86.9% had SF < 20 μg/L. 5.6% of neonates were anemic (Hb < 13.0 g/dl) and 9.5% had cord blood SF < 75 μg/L. They found a weak correlation between maternal and newborn iron parameters as shown in our study; however, they reported that when mothers were severely iron deficient (maternal SF below 13.6 μg/L), cord SF was 0.17 SD lower than in neonates whose mothers had SF above this threshold (167.6 ± 75 vs. 179.6 ± 80 μg/L). In our study, though we found a weak correlation and a significant association between maternal and cord blood parameters, we could not determine any such threshold of maternal values.

In a study of pregnant adolescents from America, Lee et al.[9] found that 21% of the neonates were anemic (Hb < 13.0 g/dl) and 25% had low iron stores (ferritin <76 μg/l) at birth. They did not find any significant association between cord SF concentrations and gestational age at birth (37–42 wk). However, they reported that a low maternal SF <12 μg/l in midpregnancy was associated with significantly lower SF in neonates ($p = 0.003$), but this association was not seen at delivery ($p = 0.30$). They inferred that inflammation due to labor may cause altered ferritin concentrations leading to this difference.

We studied maternal and cord blood sTfR. The mean maternal sTfR was 2.25 ± 1.37 mg/L (0.37–7.15). Mean sTfR/log ferritin index was 2.10 ± 2.52 (0.163–26.142). Mean cord blood sTfR was 2.14 ± 1.48 mg/L (0.2–9.45) and mean cord sTfR/log ferritin index was 1.31 ± 1.34 (0.107–13.727). Maternal Hb < 11 g/dl was associated with a higher cord blood sTfR 2.51 mg/L and higher ferritin index 1.70 as compared with nonanemic mothers (2.01mgL and 1.16). One hundred eighty four mothers had an increased level of sTfR (>2 μg/ml). Fifty-four percent had newborns with low SF (<75 μg/L). Fifty-six percent of the newborns with cord blood sTfR >2 μg/ml had increased maternal values of sTfR. Higher sTfR/ferritin index was found in newborns with increased level of maternal sTfR. There was a negative association between maternal sTfR/ferritin index and cord iron and ferritin levels, and a positive association with cord sTfR and sTfR/ferritin index. No previous studies for these indices were available from India for comparison. In a study from Norway by Hay et al.,[8] the cord SF and sTfR were studied. The mean cord SF in the study was 196 ± 127 μg/L, mean cord sTfR was 8.0 ± 4.1 mg/L, and sTfR/log ferritin index was 3.8 ± 2.6. They found a correlation between the first trimester body mass index and cord sTfR. Maternal smoking was associated with low cord serum ferritin. They did not find correlation between the maternal first trimester iron stores and cord blood SF and sTfR. Maternal iron supplementation improved neonatal iron stores. Mean values of sTfR may vary between our study and other studies because of different methods of measurement of this parameter and lack of standardization as it is still in the research stage.

In a similar study, to evaluate the impact of maternal anemia on cord blood iron, Choi et al.[14] found that newborns of anemic mothers had significantly lower serum iron and ferritin levels but when these values of neonates from iron-deficient and non–iron-deficient mother were compared, the difference was not significant. Sweet et al.[15] reported that iron deficiency in mothers was associated with decreased cord ferritin (113 v 171 μg/l) and cord Hb (15.6 v 16.8 g/dl); however, no change was observed in sTfR or TfR-ferritin index. They found that maternal smoking was associated with decreased ferritin and increased TfR-ferritin index in the cord blood.

Table 4 – Comparison of parameters between different studies and our study.

Study	Sample size of study	*Cord Hb (g/dl)	*Cord ferritin (μg/l)	*Cord sTfR (μg/ml)	*Cord sTfR/ferritin index	*Maternal Hb (g/dl)	*Maternal ferritin (μg/l)	*Maternal sTfR (μg/ml)	*Maternal sTfR/ferritin index
Sweet et al.[15]	67	16.1	132	8.5	3.8	12.1	14	3.5	3.5
Choi et al.[14]	527	15.8	183.3	5.7					
Siddappa et al.[3]	457		157						
Shao et al.[6]	3702	15.4	170			11.6	18.6		
Rehu et al.[19]	191		140.2	1.9					
Terefe et al.[11]	89	16.2	187.6			12.2	47		
Hay et al.[8]	363		196	7.1	3.8				
Lee et al.[9]	193	14.4	117	7.6		11.5	21.8	5	
Eravasti et al.[16]	199	15.9	198	2.0	0.9				
Young et al.[17]	19	13.4	135	8.4		11.1	25.4	5.5	
Soumenin et al.[18]	75					11.7	26.7	2.43	2.11
Our study	408	15.3	118.17	2.14	1.31	11.6	50.25	2.25	2.10

* Mean values from the studies have been mentioned.

Their study concluded that iron deficiency in mothers is associated with reduction in fetal iron storage, but there may be negligible effect in free iron availability. Maternal smoking is associated with relative fetal iron deficiency due to increased requirements leading to increased sTfR in these cases.

Table 4 shows a comparison with parameters between different studies and our study.

All our subjects had received their usual iron supplements during pregnancy; and hence, mean maternal ferritin level in our study was higher than some of the others. We did not separately study for inflammatory factors which could confound interpretation of SF levels; however, sTfR can be used in these cases to diagnose iron deficiency.

The strength of this study was its sample size and the number of parameters evaluated. However, blood samples were only collected at delivery for both mother and cord blood. Follow-up for the subsequent changes in parameters of the newborns was not carried out, neither were mid gestation values obtained as in other studies.

We studied the relationship of maternal and cord blood sTfR which is a relatively new marker with limited number of studies from our country. The major limitation of sTfR measurement was absence of standardization of the assay techniques and the presence of discrepancies between results of various commercially available tests.

Conclusion

There was significant association found between maternal and neonatal Hb, iron stores and predictors of IDA. Mothers with Hb <11 g/dl or SF of <10 μg/l had lower mean cord blood ferritin as compared withthose with adequate stores. sTfR and sTfR/log ferritin index values were higher in cord blood of mothers with low serum iron or ferritin or high sTfR and sTfR/log ferritin index. Hence, newborns of iron-deficient mothers may be deficient in iron stores and are likely to develop IDA earlier than healthy newborns of noniron deficient mothers. Such infants may benefit from follow-up in the first few months of life and addition of iron supplementation before the recommended guidelines of 4–6 months.

There was a weak correlation (the correlation coefficient r was less than 1) between all maternal and neonatal variables, thus exact neonatal values cannot be predicted on the basis of maternal values. We did not find a specific value of maternal SF or sTfR (deflection point) below which the neonatal values were definitely low.

More research is required for routine use of sTfR as a marker for maternal and neonatal iron deficiency. Further studies involving iron studies in infants of iron deficient mothers may help in strengthening the findings of this study.

Acknowledgement

This paper is based on Armed Forces Medical Research Committee Project No. 4648/2015 granted and funded by the office of the Directorate General Armed Forces Medical Services and Defence Research Development Organization, Government of India.

Conflicts of interest

The authors have none to declare.

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