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Haemoglobin and Serum Ferritin Levels in Newborn Babies Born to Anaemic Iranian Women: a Cross-Sectional Study in an Iranian Hospital

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Abstract: The purpose of this study was to assess the haemoglobin and serum ferritin levels in newborn babies of anaemic mothers and to determine relationship between maternal iron status with neonatal biochemical and anthropometric characteristics. A total of 70 pregnant women aged between 17 and 40 years were divided into two groups based on their pre-delivery Haemoglobin (Hb) and Serum Ferritin (SF) concentrations; anaemic mothers Hb<11 g/dl and SF $\geq$ 10 ng/ml; normal control group Hb $\geq$ 11 g/dl and SF $\geq$ 10 ng/ml. Maternal biochemical assessments were obtained before delivery and neonatal anthropometric and biochemical measurements were obtained immediately after delivery. Mean maternal haemoglobin and serum ferritin levels were 11.2±1.16 (g/dl) and 45.8±20.8 (ng/ml), respectively. Incidence of anaemia among Iranian pregnant women in this study was 51.4%. Mean neonatal weight, length and head circumference born to anaemic mothers was 2.8±0.23 kg, 47.9±1.0 cm and 31.5±0.9 cm, respectively, while, among neonates born to normal mothers were 3.3±0.1 kg, 49.6±0.8 cm and 33.7±0.6 cm, respectively. No significant correlation were found between neonatal and maternal serum ferritin concentration. Significant differences were found between neonatal haemoglobin levels from normal and anaemic mothers ($p<0.001$). Maternal Hb level showed significant ($p<0.001$) positive correlation with neonatal birth weight ($r = 0.729$), length ($r = 0.665$) and head circumference ($r = 0.762$). However, similar positive correlations were not found between maternal serum ferritin concentration and pregnancy outcome. Neonatal haemoglobin levels were positively correlated with that of their mothers' ($r = 0.423$, $p<0.001$). In conclusion, this study showed that maternal haemoglobin concentration had strong influence on neonatal parameters.

Key words: Anaemia, haemoglobin, ferritin, pregnant women, newborn babies, Iran

INTRODUCTION

Anaemia is a serious problem for women of child-bearing age and it can have devastating effects on their babies. Anaemia is usually caused by deficiencies of iron and, rarely, of folic acid (folate). Some people have anaemia due to more than one of these factors (Collins, 2008). Blood loss is the most common cause of anaemia, especially iron deficiency anaemia. Some factors such as blood loss due to heavy menstrual periods, bleeding of the digestive tract and surgery would result in the reduction of iron stores and consequently, gradual development of anemia (Turgeon, 2004). Women, in general, have smaller stores of iron than men and experience blood loss through menstruation. Therefore, anaemia is more common in women than in men. During pregnancy, iron stores need to support the needs of mother and her growing fetus, which is the required iron for the development of red blood cells, blood vessels and muscles (Turgeon, 2004).

The World Health Organization estimated that about 40% of the world's population (more than 2 billion individuals) suffers from anaemia (World Health Organization, 2000). In Asia, the prevalence of anaemia was estimated to be 44% in non-pregnant women and 60% in pregnant women (Rush, 2000).

Iranian Ministry of Health and Medical Education (1995) reported that the prevalence of anaemia among Iranian women aged 15-49 is 33.34% but there is limited information regarding the prevalence of anaemia in pregnant women. Epidemiological studies which were limited determine the prevalence rate of anaemia on pregnant women, however some showed a rate 51% pregnant women; Childbearing age women generally suffer from anaemia (Abel *et al*., 2000).

This study was carried out to assess the prevalence of anaemia among Iranian pregnant women and determine the haemoglobin and serum ferritin levels in newborn babies from anaemic mothers. This study also determined the relationship between maternal iron

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status with neonatal biochemical and anthropometric characteristics.

MATERIALS AND METHODS

Selection and description of participants: The cross-sectional study was carried out in Aban Hospital (a referral hospital that serves all pregnant women referred from clinics, health care centers and medical practices) in Lahijan, in the north part of Iran in 2008. Of a total of 78 pregnant women, who were referred to the Obstetrics and Gynecology Division, only seventy pregnant women aged 17-40 years consented to participate in the study. All participants were admitted to the labor ward after 37 weeks gestation. Mothers who had hepatitis or renal disorders, thalassemia, parasitic infections and obstetrical complications like preeclampsia, gestational diabetes, preterm delivery and abortion were excluded from the study. The research protocol was approved by the Ethical Committee of Guilan University of Medical Sciences; Iran and written informed consent were obtained from all subjects before inclusion in to the study.

Subjects were divided into two groups, anaemic and non-anaemic, according to their pre-delivery Haemoglobin (Hb) and Serum Ferritin (SF) concentrations. Based on the World Health Organization (2001) reference, mothers with Hb<11 g/dl, SF $\geq$ 10 ng/ml were categorized in the anaemic group and those with Hb $\geq$ 11 g/dl, SF $\geq$ 10 ng/ml were in the non-anaemic group.

Demographic data including maternal age, maternal residency, education, income, parity, cigarette smoking and alcohol consumption, first prenatal visit and obstetrical history were gathered by interviewing the mothers.

Maternal anthropometric and biochemical data included; height, pre-pregnancy weight, pre-pregnancy BMI, pre-delivery weight, blood pressure, haemoglobin, hematocrit and serum ferritin was measured before delivery. While anthropometric and biochemical assessments of the neonates included length, head circumference, weight, haemoglobin and serum ferritin was obtained after delivery from cord blood.

The mother's body weight was measured to the nearest 0.1 kg using a digital scale (model 782 Seca, Germany). The measurement of height was aided by Seca body meter (model 240 Seca, Germany). According to WHO classification (1998), Body Mass Index (BMI) was calculated from the measured pre-delivery body weight divided by the height squared.

The neonate's weight was measured by using a Salter spring balance (CMS Weighing Equipment Ltd, UK) to the nearest 20 grams. The crown-heel length and head circumference were measured by Portable Pedobaby Babymeter (ETS JMB, Belgium) to the nearest 0.1 cm and fiber glass tape to the nearest 0.1 cm (CMS Instruments, UK), respectively.

Blood sampling: Peripheral vein-puncture blood samples were collected from the pregnant subjects for the determination of haemoglobin and serum ferritin levels before delivery by an experienced laboratory technician. Accordingly, cord blood was collected immediately after placenta delivery for measuring neonate's haemoglobin and serum ferritin levels. Analysis of maternal and cord serum were performed on the same day of collection. Haemoglobin was measured by the standard cyanmethemoglobin technique (PATH, 1996) while, serum ferritin was analyzed by Immune Radio Metric Assay (IRMA) technique (Flowers *et al.*, 1986). Serum ferritin was standardized according to the international standards included with radioimmunoassay kit (Radim Co, Italy) and a gamma counter (Hewlett Packard, Wilmington, Del, USA).

Data analysis: Statistical analyses were performed using SPSS for windows, version 16. The normality was tested by Kolmogrov-Smirnov test. Differences in qualitative variables mean between the two studies groups (anaemic and non-anaemic groups) were tested by using non-parametric test such as Mann-Whitney U test. Quantitative variables were tested by T-test and chi-square test. All data were expressed as mean±S.D. The correlations among maternal iron status, cord blood composition and pregnancy outcome were analyzed by Pearson's correlation analysis. Multiple regressions were carried out to determine any significant relationship between different variables in order to specify the most important risk factors influencing maternal anaemia. A probability value of $p<0.05$ was considered to indicate statistical significance.

RESULTS

The socio-demography of the subjects is presented in Table 1. The mean age of women was 25.6±4.9 years with a range of 17-40 years. Most of women (34.2%) had diploma and 51.4% were employed and considered economically active. Some 48.6% of the subjects were housewives. Most of them were from urban area (54.2%) and were from the middle income groups (50.5%). Mean parity status was 1.4 and 35.7% women were multipara. The mean haemoglobin and serum ferritin levels were 11.2±1.2 g/dl and 45.8±20.8 ng/ml, respectively; while mean value of hematocrit was 33.5±4.6% which was lower than normal range (Table 2).

Table 3 presents the characteristics of mothers by iron status. Based on the WHO (2001) cut off points, 36 of mothers (51%) were classified as anaemic while 34 were non-anaemic (49%). There were significant differences in relation to parity with haemoglobin and hematocrit levels (Table 3). Parity in anaemic mothers was more than non anaemic ones ($p<0.039$). The multiple regression showed that multi-parity was an influencing factors on maternal anaemia (B = -1.446). Haemoglobin and hematocrit concentrations in anaemic

Table 1: Socio-demography of mothers (n = 70)

Characteristics	Value
Age (y)	25.6±4.9 (17-40)
House hold size	3.1±1.8 (2-7)
Parity	1.4±0.6 (1-3)
Education (%)	
Primary	24.3
High school	24.3
Diploma	34.2
Academic education	17.2
Occupation (%)	
Employed	51.4
House wife	48.6
Income (%)	
Low income <306$	31.4
Middle- income 357-510$	50.5
High income >510$	18.1
Residential status (%)	
Rural	45.7
Urban	54.2

Values are presented as mean±SD (range) 1USD = 9800 Rs

Table 2: Pre-delivery Maternal Iron Status (n = 70)

Characteristic	Mean± SD	Range	Reference range
Haemoglobin(g/dL)	11.2±1.1	9.3-14.2	11-16[1]
Serumferritin(ng/ml)	40±20	5.5-88.3	9-136[2]
Hematocrit (%)	33.5±4.6	15.7-42	37-48[3]

Sources: [1,3]Huch (1992). [2]Jackson *et al*. (2001)

Table 3: Age, parity and iron status of mothers (mean±SD)

Characteristics	Anaemic n = 36	Non-anaemic n = 34
Age (years)	25.6±5.3	25.2±4.2
Parity	1.5±0.6	1.2±0.5
Haemoglobin (g/dl)	10.2±0.4	12.1±0.8
Hematocrit (%)	30.8± 4.6	36.2±2.4

women were significantly lower than non-anaemic subjects. These values were 10.2 g/dl, 30.8% in anaemic and 12.1 g/dl, 36.2% in non-anaemic group.

The prevalence of anaemia among newborn babies from 36 anaemic pregnant women was 22.2% which three of neonates were female while five of them were male. There were also significant differences in neonatal weight, length and head circumference among anaemic and non-anaemic groups (p<0.001). As shown in Table 4, the neonatal anthropometric parameters from normal mothers were significantly higher than anaemic group. Neonates from normal mothers were 514 g heavier in weight than those from anaemic mothers and their length and head circumference also were 16.9 cm and 21.9 cm more than those in anaemic group.

Neonatal iron status showed that neonatal haemoglobin was significantly lower in anaemic than non-anaemic mothers (p<0.001). On the other hand, serum ferritin concentration in neonates from non anaemic mothers was not significantly different (p = 0.59).

As shown in Table 5 there was a significant relationship between maternal haemoglobin and hematocrit levels with neonatal anthropometric parameters (p<0.001). Accordingly, as maternal haemoglobin and hematocrit levels rise, a considerable increase is observed in the weight, length and head circumference of neonates born to normal mothers than those to the anaemic ones. However no significant relationship was found between maternal serum ferritin level and neonates' anthropometric parameters in these groups (p>0.001).

Table 4: Neonatal anthropometrics and iron status (mean±SD)

Neonatal anthropometric and biochemical assessment	Anaemic mother	Non-anaemic mother
Weight (kg)	2.8 ±0.2*	3.3 ±0.1
Length (cm)	47.9±1.0*	49.6±0.8
Head circumference (cm)	31.5±0.9*	33.7±0.6
Haemoglobin (g/dl)	15.0±1.1*	16.4±1.2
Serumferritin (ng/ml)	207.7 ±108.2	184.8±61.8

SD = standard deviation; *Significant at p<0.001

Correlation of neonatal iron status with maternal iron status illustrated that there was significant correlation between neonatal and maternal haemoglobin (r = 0.423, p<0.000). In fact, such a positive relationship indicates that neonatal haemoglobin level depends on maternal Hb concentration. This variable would increase with a rise in mothers' Hb levels and vice versa. Positive correlation also found among neonatal haemoglobin and maternal Hct but this relationship was not significant (p>0.05). However no significant correlation (p>0.05) was identified between neonatal Hb and maternal SF (Table 4). Not significant relationship (p>0.05) was found between maternal iron status (haemoglobin, hematocrit and serum ferritin) and neonatal SF (Table 5).

DISCUSSION

In this study more than half of the pregnant women were anaemic. This prevalence was high and was similar with a report from India (Ackurt *et al*., 1995). In two separate studies in South Africa and Israel, prevalence of anaemia in pregnant women was 3.0% and 21.6%, respectively (Patwardhan, 1996).

Parity, maternal haemoglobin and hematocrit were statistically significant different between the two groups. Multi-parity and short birth interval (less than 2 years) between pregnancies created a large demand for iron, which was needed to develop the fetus and placenta. Additional iron was lost with blood at delivery and it can appear maternal anaemia. These findings were consistent with another study (Veghari *et al*., 2007). In contrast, in another study, women with parity $\geq$ 2 had higher mean haemoglobin concentration than nulliparous ones (Chandyo *et al*., 2006).

Our findings regarding significant relationship between neonatal anthropometric characteristics and maternal iron status were consistent with (Gomber *et al*., 2002) which studied Indian mothers. They observed that birth weight, crown heel length and head circumference of the neonate increased significantly with rising maternal haemoglobin levels. Previous researcher (Singla *et al*.,

Table 5: Correlation of neonatal anthropometric characteristics and neonatal iron status with maternal iron status

	Maternal Hb (g/dl)	Maternal Hct (%)	Maternal SF (ng/ml)
Neonatal weight	0.729*	0.521*	0.022
Neonatal length	0.665*	0.423*	0.038
Neonatal head-circumference	0.762*	0.568*	0.097
Neonatal Hb	0.423*	0.228	0.061
Neonatal SF	-0.057	0.008	0.013

*Correlation is significant at the 0.001 level (2-tailed)

1997) have reported that the birth weight, head circumference, chest circumference, mid-arm circumference and crown heel length were significantly lower in infants born to mothers with moderate and severe anaemia, in comparison to infants born to non-anaemic mothers. In contrast, another study showed that the babies of iron-deficient anaemic mothers had greater head circumference and were heavier than those from non-anaemic non-iron-deficient mothers (Emamghorashi and Heidari, 2004). It may be interpreted that the effect of maternal anaemia on intra-uterine growth is attributed to chronic deprivation of oxygen to the developing fetus (Pollack and Divon, 1992). In addition, maternal anaemia may be a marker for nutritional, social and environmental deprivations which may independently influence fetal growth.

Another interesting finding of the present study indicated a significant relationship between neonatal haemoglobin ($p<0.001$) but not serum ferritin ($p = 0.59$) from anaemic and non anaemic mothers ($p<0.001$). Our results were partially similar to other studies (Singla *et al*., 1996). They found that the levels of haemoglobin, serum iron; transferrin saturation and ferritin were significantly low in the cord blood of anaemic women than non anaemic ones, indicating that, iron supply to the fetus was reduced in maternal anaemia. In contrast Kilbride *et al*. (1999) showed that iron content in cord blood were similar in anaemic and non-anaemic pregnant women, with no significant difference in haemoglobin, hematocrit, mean corpuscular volume, mean corpuscular haemoglobin, mean corpuscular haemoglobin concentration or plasma ferritin.

Our study could show significant relationship between maternal haemoglobin and hematocrit with neonatal body composition ($p<0.001$). However, no significant relationship was found between maternal serum ferritin and neonates' body composition. This relationship was demonstrated by Msolla and Kinabo (1997) and Bai *et al*. (2002). Nahum and Stanislaw (2004) found that birth weight correlates negatively with maternal haemoglobin concentration. This was consistent with the well-known effect of high-altitude exposure during pregnancy, which increases both hematocrit and blood viscosity and lowers birth weight. These findings indicate that birth weight of newborn is dependent of multiple factors such as maternal iron status during pre-pregnancy, body size, general nutritional status. Although for women who enter pregnancy with low iron stores, insufficient intakes of iron during pregnancy can produce undesirable pregnancy outcome.

Our results showed similar significant relationship between neonatal length and maternal iron status as was reported by Lee *et al*. (2006). Among Korean and Indian women similar outcome were also shown (Gomber *et al*., 2002; Singla *et al*., 1997).

Our result regarding positive correlation between neonatal Hb and maternal haemoglobin and hematocrit are in keeping with previous study. Although correlation between neonatal Hb and maternal Hct and SF was not significant. A study by Singla *et al*. (1978) showed that maternal haemoglobin had a linear correlation with haemoglobin and iron levels in the cord blood and placental tissue. Some studies showed negative association of hematocrit, haemoglobin and plasma iron measures between mothers and infants (Sichieri *et al*., 2006). Our results were different from Turkey *et al*. (1995) which did not find correlation between maternal haemoglobin and ferritin at 16 and 34 weeks' gestation and newborn haemoglobin parameters. It may be interpreted that, iron stores in the fetus are not adversely affected by mild-to-moderate anaemia in the mother; thus supporting the theory that (for women with mild-to-moderate anaemia) the placenta and fetus have a special affinity for iron in the mother's circulation and iron is transported through the placenta irrespective of the concentration gradient (Turkey *et al*., 1995).

Our results regarding significant correlation between neonatal serum ferritin and maternal iron status was similar with Emery and Barry (2006), however did not support Mexican study (Vásquez-Molina *et al*., 2001).

Conclusion: Prevalence of anaemia is high in the north of Iran and parity is one of factors that could have an influence on anaemia. Maternal haemoglobin and hematocrit concentrations during pregnancy have strong influence on neonatal anthropometric parameters and neonatal haemoglobin, while, such relationship was not seen between maternal and neonatal serum ferritin. New strategies are need for ensuring that mothers take iron supplementation regularly and nutrition education may be beneficial to improve the dietary intake of pregnant mothers.

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