Correlation between Selected Micronutrient Status in Maternal Blood and Cord Blood of Newborn from a Tertiary Care Hospital in West Bengal, India: A Cross-sectional Study

SANJOY KUMAR KUNTI, SHARMISTHA CHATTERJEE, INDRANIL CHAKRABORTY

ABSTRACT

Introduction: The demand for most micronutrients increases during pregnancy for obvious reasons. Micronutrients like copper and zinc are indispensable co-factors for various enzymes in metabolism. The reduction in the concentration of serum iron and ferritin is a common phenomenon in pregnancy, and early diagnosis is crucial for favourable maternal and foetal outcomes. However, there is a dearth of studies on the metabolism of micronutrients in pregnancy.

Aim: The aim of this cross-sectional study, conducted from July 2018 to February 2019 in the Department of Gynaecology and Obstetrics and the Department of Biochemistry, College of Medicine and Sagore Dutta Hospital, West Bengal, India, was to assess the serum levels of copper, zinc, and iron in maternal serum and foetal cord blood. Additionally, the study aimed to correlate the concentrations of these micronutrients between maternal serum and foetal cord blood.

Materials and Methods: A total of 336 pregnant women of childbearing age, irrespective of gravidity, were included in the study. Blood samples were collected from the pregnant women, and cord blood samples were collected from the foetal end in clot vials for the estimation of copper, zinc, and iron levels. Correlation was assessed between the concentration of these micronutrients in maternal serum and cord blood of the newborn. Data normality was determined using the Shapiro-Wilk normality tests, and the significance level was set at p-value ≤0.05.

Results: The study included a total of 336 pregnant women in the age group of 18-33 years, with a mean age of 29.72±4.39 years. In maternal serum, the mean concentration of copper was 122.79±33.67 μg/dL, zinc was 78.47±27.62 μg/dL, and iron was 114.5±45.05 μg/dL. In foetal cord blood, the mean concentration of copper was 48.02±16.37 μg/dL, zinc was 75.82±27.64 μg/dL, and iron was 185.30±52.74 μg/dL. The correlation coefficients between maternal serum and foetal cord blood concentrations were statistically significant for zinc and iron (p-value<0.05). Additionally, the correlation was statistically significant for copper (p-value=0.030). The mean concentration of haemoglobin in maternal serum was 10.9±1.96 g/dL, compared to 14.05±2.13 g/dL in cord blood. The mean maternal serum ferritin was 73.53±56.15 μg/L, and the mean cord blood ferritin was 147.21±61.13 μg/L.

Conclusion: The study demonstrated a positive correlation between the concentrations of iron and zinc in maternal serum and foetal cord blood, while a negative correlation was observed for copper concentration.

INTRODUCTION

Micronutrients are inorganic elements and vitamins that are needed in very minute quantities but are essential in the human body [1,2]. These micronutrients, namely iron, copper, and zinc, have an important influence on the health of the pregnant woman and the growing foetus. The demand for micronutrients increases during pregnancy for obvious reasons, and suboptimal levels of any of these could affect the progress and outcome of delivery [3,4]. Copper and zinc are important components of metalloproteins that play a vital role in metabolism. Copper and iron are required for the post-translational modification of collagen and elastin, thus being important for the structural integrity of these proteins [2,3]. Minerals such as zinc and manganese have also been demonstrated to play a role in antioxidant mechanisms. This is important because oxidative reactions are more frequent in pregnancy and may contribute to preeclampsia [5,6]. Although iron deficiency is known to be the most common cause of anaemia during pregnancy in India, simple iron supplementation often fails to correct anaemia [7,8]. This may be due to the fact that copper-containing ceruloplasmin plays an important role in iron metabolism [9]. Some studies have demonstrated an improvement in maternal haemoglobin levels with iron supplementation along with zinc [10-13]. Similarly, zinc is also necessary for foetal and neural development [14,15]. There is a lack of studies on the metabolism of micronutrients during pregnancy, mainly due to its inherent complexity. As micronutrients have a profound influence on pregnancy outcomes, including intergenerational ones, the present study was conducted to estimate the concentration of copper, zinc, and iron in maternal serum and foetal cord blood. Additionally, we aimed to investigate whether any correlation exists between maternal serum and foetal cord blood concentrations of copper, zinc, and iron.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Gynaecology and Obstetrics, in association with the Department of Biochemistry, College of Medicine and Sagore Dutta Hospital, Kolkata, West Bengal, India, over a period of eight months, from July 2018 to February 2019. Ethical clearance was obtained from the Institutional Ethical Committee (IEC) (Registration No. ECR/1210/Inst/WB/2019).
Inclusion criteria: Pregnant women of childbearing age group, irrespective of gravida, were included in the study. Only full-term apparently healthy neonates were included. The subjects were selected from those admitted to the maternity wards of the hospital for delivery.

Exclusion criteria: Pregnant women with a history of smoking, hypertension (either chronic or pregnancy-induced), convulsion, gestational diabetes or known diabetes, or with any obstetrical abnormalities were excluded from the study. Newborn babies weighing less than 2.5 kg, gestational age less than 36 weeks, and an APGAR score of less than seven were also excluded.

Sample size: Statistics from previous years showed that the average number of deliveries per month was around 220 in the hospital, which comes to an average of seven per day. The samples were collected two days per week, resulting in 56 per month. Therefore, the sample size was calculated to be 336 (i.e., 56x6) subjects, including mothers and their respective babies over a period of six months.

Data collection: Blood samples were collected from the pregnant women (after obtaining their written informed consent) in a clotted vial for the estimation of copper, zinc, and iron levels. Similarly, cord blood samples were collected from the foetal end in clot vials for the estimation of copper, zinc, and iron levels. The estimation of copper, zinc, and iron was performed using reagents procured from government resources in the Departmental Clinical Laboratory. The serum copper was estimated by a colorimetric method and measured at 580 nm in a semiautomated analyser. The normal reference range of copper in females is 88-155 μg/dL. The serum zinc was estimated by the Ferrozine method and measured at 578 nm in a semiautomated analyser. The normal reference range of zinc in females is 35-145 μg/dL, and in newborns, it is 150-220 μg/dL. The serum iron was estimated by the Ferrozine method and measured at 578 nm in a semiautomated analyser. The normal reference range of iron in females is 114.5-183.5 μg/dL, and in newborns, it is 116.9-154.3 μg/dL.

RESULTS

A total of 336 subjects were enrolled in the study. The mean age of the pregnant mothers was 29.72±3.32 years, with a range of 18 to 33 years. The average birth weight of the newborns was 2.57±0.73 kg, and the mean gestational age was 37.2±0.25 weeks. Out of the 336 neonates, 169 were males, and the remaining were females.

In maternal serum, the mean concentration of copper was 122.79±33.67 μg/dL, zinc was 78.47±27.62 μg/dL, and iron was 114.5±45.05 μg/dL. Copper and zinc followed a parametric distribution, while iron followed a non-parametric distribution.

In cord blood serum, the mean values for copper were 48.02±16.37 μg/dL, zinc was 75.82±27.64 μg/dL, and iron was 185.30±52.74 μg/dL. The mean values of haemoglobin, ferritin, and iron were higher in foetal cord blood compared to maternal serum (Table/Fig-1).

The maternal concentration of iron and zinc positively correlated with the foetal cord blood concentrations, while the copper concentrations in maternal and foetal cord blood were negatively correlated (Table/Fig-2).

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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Correlation</th>
<th>p-value</th>
</tr>
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<tbody>
<tr>
<td>Copper</td>
<td>-0.011</td>
<td>0.030</td>
</tr>
<tr>
<td>Zinc</td>
<td>+0.46</td>
<td>0.012</td>
</tr>
<tr>
<td>Iron</td>
<td>+0.626</td>
<td>0.006</td>
</tr>
<tr>
<td>Ferritin</td>
<td>-0.134</td>
<td>0.002</td>
</tr>
<tr>
<td>Haemoglobin</td>
<td>+0.203</td>
<td>0.001</td>
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</tbody>
</table>

[Table/Fig-3]: Showing the correlation coefficient between maternal serum and foetal cord blood. Pearson’s correlation, p-value, significant if <0.05.

[Table/Fig-3] depicts the positive correlation between the maternal serum zinc concentration and foetal cord blood zinc concentration. [Table/Fig-4] illustrates the negative correlation between the maternal serum copper concentration and foetal cord blood copper concentration. [Table/Fig-5,6] show the correlation between maternal serum iron and foetal cord iron, and maternal serum ferritin and foetal cord ferritin, respectively.
be explained by the fact that the mean serum copper concentration in maternal serum increases during pregnancy. This increase is attributed to an increase in ceruloplasmin synthesis, induced by oestrogen during pregnancy, along with an increased binding affinity of ceruloplasmin with copper. As a result, only a small amount of copper passes through the placenta and reaches the foetus. The serum levels of copper may also be influenced by the mobilization of copper from maternal tissues to the foetus [20,21].

A study conducted by Jariwala M et al. found that the cord blood concentration of copper was only 28% of the maternal serum concentration of copper [22]. However, a positive correlation was found between copper concentration in maternal serum and foetal cord blood in an Egyptian study [23].

The distribution of zinc in maternal serum and foetal cord blood was also found to be parametric. The correlation coefficient of zinc was found to be 0.46 (p-value <0.05, significant), indicating a positive correlation. A similar significant positive correlation was found between zinc levels in neonates and their mothers in a study conducted by Abdellatif M et al. [23]. Usually, there is a passive transplacental transfer of zinc from mother to foetus. The zinc binding capacity decreases during pregnancy, which may facilitate the efficient transfer of zinc to the foetus. Similar findings have been observed in a few other studies conducted in Jordan, although a negative correlation was also observed in another study [24,25]. On the contrary, another study reported significantly higher cord blood levels of zinc and significantly lower cord blood levels of copper compared to maternal levels [23].

A significant finding in this study was the positive correlation coefficient (+0.626, p-value <0.05) between iron levels in maternal serum and foetal cord blood. This suggests that iron concentration in maternal serum directly affects the iron levels in cord blood. Furthermore, mothers with sufficient iron stores tend to have babies with adequate iron levels in their cord blood. These findings align with previous studies [26,27]. Upadhyay C et al. also reported a strong positive correlation between iron levels in mothers and cord blood [28].

Additionally, the levels of ferritin and haemoglobin in newborns can be compared to those in maternal serum. The distribution of ferritin and haemoglobin in both maternal serum and foetal cord blood was found to be symmetrical. The mean values of ferritin and haemoglobin in maternal serum were 73.5±56.15 μg/dL and 10.9±1.96 g/dL, respectively, while in foetal cord blood, they were 147.2±61.13 μg/dL and 14.05±2.13 g/dL, respectively. In these parameters, cord blood exhibited higher concentrations than maternal serum. This can be explained by the significant transfer of iron stores from mothers with sufficient iron levels to their foetuses. The transplacental transfer of iron is also influenced by hepcidin, a protein involved in regulating placental iron uptake. Additionally, there is maximal stimulation of erythropoiesis towards the end of the gestational period, which may explain the high ferritin index observed in other studies [29,30].

**DISCUSSION**

The present study aimed to identify the correlation among the levels of selected micronutrients, namely copper, iron, and zinc, in maternal serum and foetal cord blood.

Firstly, the distribution of copper in both maternal serum and foetal cord blood was found to be parametric. In this study, the correlation coefficient of copper between maternal serum and foetal cord blood was found to be negative (-0.011, p-value <0.05). This can

**Limitation(s)**

In the present study, no information was collected regarding the socioeconomic status and dietary habits of the pregnant mothers. Secondly, since this was a hospital-based project, the results of the present study cannot be generalized. Thirdly, due to the inclusion of only full-term healthy babies, statistical analysis regarding the newborn variables was not possible.
CONCLUSION(S)

In the above study, the concentration of iron and zinc in foetal cord blood was similar to that in the mother, but the concentration of ferritin and haemoglobin was higher in foetal cord blood. Furthermore, a negative correlation was observed between the concentration of copper in maternal serum and that in foetal serum. Thus, it can be concluded that the micronutrient status of the newborn is largely influenced by that of the pregnant mother. Larger, well-designed studies are needed to establish proper reference intervals for micronutrients, which would enable the development of appropriate methods and dosages for supplementing these micronutrients during pregnancy, ultimately leading to healthier outcomes.

REFERENCES


