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Original Article

Maternal and umbilical cord blood levels of mercury, manganese, iron, and copper in southern Taiwan: A cross-sectional study

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Abstract

Background: The effect of maternal exposure to essential minerals and heavy metals on fetus is an important issue, which affects women around the world. Few data are available on the concentration of both essential minerals and heavy metals in maternal/fetal medicine. The aims of this study were to (1) assess the correlation of mercury (Hg), manganese (Mn), iron (Fe), and copper (Cu) in paired maternal/fetal blood samples, and (2) study potential confounding factors during pregnancy.

Methods: Our study recruited 145 healthy pregnant women with a mean age of 28.06 years, gathering information by collecting interviewer-administered questionnaires. Paired maternal/fetal blood samples were collected by delivery.

Results: There was a positive correlation of Hg ($r = 0.78$, $p < 0.001$), Mn ($r = 0.31$, $p < 0.001$), Fe ($r = 0.17$, $p = 0.038$), and Cu ($r = 0.21$, $p = 0.010$) in paired maternal/fetal samples. Prenatal vitamin use (>3 times/wk) was significantly associated with lower maternal Hg (adjusted odds ratio 0.272, $p = 0.005$) and lower maternal Cu (adjusted odds ratio 0.267, $p = 0.004$) levels. Median fetal Hg, Mn, and Fe levels were higher than corresponding maternal levels, while median fetal Cu level was lower than maternal Cu level.

Conclusion: There was a positive correlation of Hg, Fe, Cu, and Mn in paired maternal/fetal samples in this series. Our findings have raised the possibility of reducing maternal Hg and Cu by way of prenatal vitamin supplementation.

Keywords: copper; iron; manganese; mercury; pregnant woman; vitamin use

Conflicts of interest: The authors declare that they have conflicts of interest related to the subject matter or materials discussed in this article.

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1. Introduction

The presence of multiple heavy metal contaminants is of grave concern and has received considerable attention in Taiwan.[1] Heavy metals such as mercury (Hg) are toxic contaminants, which can cross the placenta and affect fetal growth.[2,3] Essential minerals such as iron (Fe), copper (Cu), and manganese (Mn) are both nutrients and potential toxicants, depending on the amount of exposure.[4] These essential minerals are metabolized similarly to the heavy metals,[5] and they are also important metallic cofactors in catalyzing redox reactions.[4] The developing brain is highly sensitive to oxidative damage, so the concentrations of essential minerals play a crucial role in fetal brain development.[6] Few data are available on the concentrations of both essential minerals and heavy metals in maternal/fetal medicine.[7−10] Butler Walker et al[7] reported levels of total Hg and methyl Hg were significantly higher in cord blood than in maternal blood ($p < 0.0001$), whereas maternal Cu levels were significantly higher than those in cord blood ($p < 0.0001$). The confounding factors were not analyzed except for ethnicity and smoking habits; furthermore, they did not evaluate the association of these metals with birth outcome. Rudge et al[8] showed that Hg levels in cord blood were almost twice those of the mothers ($n = 62$), suggesting that the fetus may act as a filter for maternal Hg levels during pregnancy. Mn and Cu levels did not show statistically significant correlations between the two compartments. However, they also did not evaluate the confounding factors or association of these metals with birth outcome. A Taiwanese study ($n = 308$) by Lin et al[9] demonstrated that cord blood lead was lower where the mother had a higher blood concentration of Mn ($p = 0.02$). Kopp et al[10] studied the association of multiple heavy metals and trace elements between maternal and cord blood ($n = 50$). Hg accumulated in the fetus resulting in more than a three-fold increase in fetal exposure compared with maternal exposure. Their results also showed no association between internal exposure to any metals and maternal use of nutritional supplement during pregnancy.[10]

These studies[7−10] demonstrated that the levels of essential minerals in healthy pregnant women were significantly different from those of the general population. There is a need to evaluate more pregnant women, especially from different races, for the purpose of establishing specific normative levels of essential minerals. Although Taiwan is a high-fish-consuming island country, data on the accumulation of Hg in pregnant woman remain limited.[3] Furthermore, there is no Taiwanese information regarding Hg and essential minerals in both mother and fetus. The purposes of this study in south Taiwan were to (1) assess the correlation of the Hg, Mn, Fe, and Cu levels in paired maternal/fetal blood samples, and (2) study potential confounding factors such as socioeconomic factors, smoking, vitamin intake, and seafood consumption during pregnancy.

2. Methods

2.1. Studying individuals and sampling

This study was a prospective cross-sectional study. Women were considered eligible if they were 20−45 years old and pregnant with a term singleton fetus. Women with chronic medical conditions or infectious diseases, or those who reported illicit drug use were excluded. A total of 150 women consented to participate and initially met eligibility requirements. Two women withdrew because of twin fetuses, one withdrew because of stillbirth, and two others withdrew consent prior to being discharged from the hospital.

A total of 145 healthy pregnant women with a mean age of 28.06 years were recruited at the Department of Obstetrics and Gynecology of Fooyin University Hospital in Tong Gang, Taiwan, from September 30, 2010 to May 25, 2011. The city of Tong Gang is a major seaside fishing area in southern Taiwan. The participants received a detailed explanation of the study procedures before consenting to participate. The research protocol was approved by the Institutional Review Board of Fooyin University (FYH-IRB-099-04-02-A), and written informed consent was obtained from all participants. Information on the gestational age, prenatal examination, and characteristics of the birth and newborn, were obtained from the medical records. We used interviewer-administered questionnaires to collect information on demographic characteristics, smoking habits, alcohol drinking habits, betel nut chewing habits, use of Chinese medicine, seafood consumption, nutritional supplement (vitamin), and degree of education. The degree of seafood consumption was defined as the sum scores of seafood consumption items in the questionnaire. A total of nine items were about the amount of fresh fish and seafood consumption of each participant during pregnancy. High sum scores revealed more seafood consumption. The cutoff score of high and low seafood consumption was defined as the median value of the sum scores in the questionnaire. The participants were asked to record their nutritional supplement of vitamin consumption during pregnancy in the questionnaire. Anthropometric measurement of newborns was made by delivery room staff, using standard anthropometric procedures.

2.2. Blood sampling and sample analysis

Umbilical cord blood and maternal venous whole blood samples were collected into 9 mL standard laboratory issued EDTA tubes, separately. All samples were processed within 2 hours of delivery and stored at −80°C. Samples were sent to the Department of Biomedical Engineering and Environmental Sciences, Ultra Trace Micro-Analysis Laboratory at National Tsing Hua University, and were analyzed by a inductively coupled plasma-mass spectrometer (7500ce; Agilent, Tokyo, Japan). The limit of detection was 0.353 μg/L (ppb) for Hg, 0.125 μg/L (ppb) for Mn, 0.061 μg/mL (ppm) for Fe, and 0.00066 μg/mL (ppm) for Cu.[11]

2.3. Statistical analysis

We used Pearson's correlation coefficient to reveal the association between pairs of the following variables: heavy metal concentrations (Hg, Mn, Fe, and Cu) in maternal blood, heavy metal concentrations (Hg, Mn, Fe, and Cu) in cord blood, vitamin, and seafood consumption. Log-transformed data of heavy metals were used to reveal the association between maternal and fetal pairs.

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