CONCENTRATION AND PARTITIONING OF PERSISTENT ORGANIC POLLUTANTS AND HEAVY METALS IN MATERNAL BLOOD, MATERNAL URINE, CORD BLOOD, AND PLACENTA

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Introduction

Many researches have reported that the fetus is exposed to environmental pollutants through umbilical cord. The environmental pollutants including persistent organic pollutants (POPs) and heavy metals in maternal blood immigrate to cord blood through placental membrane, and have adverse effect on growth, development, nervous system, and hormone levels. (Rogan et al., 1986; Berkowitz et al., 2004; Sharpe and Irvine, 2008) However, the behavior of pollutants in maternal-fetal system is complex and biomonitoring methods have many limitations. (T. Arbuckle, 2010)

The aim of this study was to measure the concentrations of environmental pollutants in cord blood, maternal blood, maternal urine and placenta tissue, and to investigate behavior of pollutants in maternal and fetus system. Ultimately, optimal biomarker for prenatal exposure will be suggested.

Materials and methods

20 pairs of cord bloods, maternal bloods, maternal urines, and placenta samples were collected from 21 ~42 aged parturient women and their fetus of South Korea in 2010. The blood samples were devided into two portions, which were 40mL and 10mL, repectively. Serum were seperated by the first portion and the second portion were stored as whole blood. All samples were stored in -40°C unltil chemcal analaysis.

5 groups of POPs and candidate, including polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), polychlorinated biphenyls (PCBs), Polychlorinated naphthalenes (PCN), polybrominated dibenzo-p-dioxins and dibenzofurans (PBDD/Fs) and polybrominated diphenyl ethers (PBDEs) measured. And 4 heavy metals, including lead(Pb), cadmium(Cd), total mercury(Hg), and methyl mercury(MeHg) were masured.

For the analysis of POPs in maternal serum, cord serum and maternal urine, about 10~40mL of samples were spiked with internal standard, and then extracted by liquid-liquid extraction. The extracts were dried and weighed for lipid-adjustment, followed by clean-up with multi-silica column and alumina column. A gas chromatograph (Hewlett-Packard 6890) coupled with a high resolution mass spectrometer (Jeol JMS-800D) were employed for the POPs analysis. The placenta tissues were freeze-dried and grinded, followed by Soxhlet extraction. The extracts from the tissues were cleaned-up and analyzed in same way with fluids extracts.

Cd and Pb were measured in Neodin Medical Institute using GF-AAS with PerkinElmer (Norwalk, CT). Hg and MeHg were analyzed in GIST using cold vapor atomic fluorescence spectroscopy (CVAFS) with .

To compare the concentrations between specimens, we conducted paired t-test and Wilcoxon signed-ranks test. And to the correlation of two specimens, Pearson correlation and Spearman rank test were employed. All statistical test were conducted with SigmaPlot 10.0

Results and discussion

Concentrations of heavy metals present Table 1. Cd was most abundant in placenta, followed by maternal blood. Among the specimens, only maternal urine and cord bloods did not shows significant differences, but have no correlation. Cd in placenta and maternal urine rather have significantly strong correlation. ($r = 0.87$, $p<0.001$)

Pb shows different distribution which the most abundant media is maternal blood and cord blood, followed by placenta and maternal urine. Pb in maternal blood and cord bloods did not show significant difference in statistical test, and besides, have moderate correlation. (r = 0.55, p=0.012)

Total Hg showed the highest concentration is placenta, and next came cord blood, maternal blood, and maternal urine. Every specimen showed significant difference, but have correlations were found from most of specimen except maternal urine. The correlation was moderate in cord bloods between maternal blood (r=0.64, p = 0.002), strong between maternal blood and placenta (r= 0.73, p<0.001), and also strong between cord blood and placenta. (r=0.70, p<0.001)

MeHg concentration was the highest in placenta, and maternal blood and cord blood came next. Maternal blood and cord blood did not showed significant difference each other, but correlation was not significant. Maternal blood and placenta, however, showed significant correlation. (r = 0.82, p<0.001)

Correlations between each specimen imply feasibility as biomarker for fetal exposure. The prenatal exposure of fetus to POPs and heavy metals can be estimated with cord blood which circulates fetal system and be isolated by placental barrier. Sampling of cord blood, however, has limitations, which are small sample size and potential benefit for remedy in the future. Thus, biomarker to estimate fetal exposure as alternative is required. As maternal serum and maternal urine is relatively easy to collect, their correlation with cord blood and placenta presents feasibility as biomarker.

In case of Cd, there was no significant correlation between cord blood and the other samples. But maternal urine can be biomarker of accumulation in placenta. Pb in maternal blood shows significant correlation with cord blood, implying maternal blood can be used biomarker of cord blood. Hg showed many correlations among specimen. Maternal blood can be used as biomarker for cord blood and placenta. MeHg also has no correlation of cord blood with the other specimens, but maternal blood can be used as biomarker of accumulation in placenta.

	n	*Median*	*Range*	*Mean*
Cd				
Maternal urine (ug/L)	18	0.20	0.0 - 0.71	0.26
Maternal blood(ug/L)	20	0.76	0.30 - 1.89	0.80
Cord blood (ug/L)	20	0.21	0.12 - 1.02	0.26
Placenta (ng/g)	20	1.78	0.64 - 5.38	2.12
Pb				
Maternal urine (ug/L)	18	1.21	0.33 – 1.28	0.07
Maternal blood (ug/dL)	20	16.46	4.26 – 20.64	4.18
Cord blood (ug/L)	20	15.61	4.55 – 20.84	5.23
Placenta (ng/g)	20	12.15	3.00 - 13.22	1.07
Hg				
Maternal urine (ng/g)	18	0.28	0.14 – 1.07	0.38
Maternal blood (ng/g)	20	2.55	0.62 – 5.65	2.95
Cord blood (ng/g)	20	3.65	0.46 – 9.32	4.21
Placenta (ng/g)	20	27.42	8.39 -63.53	30.96
MeHg				
Maternal urine (ng/g)	18	0.04	0.02 – 0.15	0.05
Maternal blood (ng/g)	20	2.14	0.57 – 7.55	2.58
Cord blood (ng/g)	17	2.33	1.49 – 6.79	3.36
Placenta (ng/g)	20	19.58	1.97 – 54.92	22.79

Table 1. Concentrations of Cd, Pb, Hg, and Hg in maternal urine, maternal blood, cord blood, and placenta.

Methylation rate of Hg was calculated by dividing MeHg concentration by total Hg concentration. Methylation rate was the highest in maternal blood and followed by cord blood and placenta. Methylation rate of Hg in maternal urine was just 19.8%, while it is over 70% in maternal blood, cord blood, and placenta. It is speculated that Hg which is more hydrophilic than MeHg is more abundant in urine. However, difference between maternal serum and cord serum is uncertain, so require further discussions.

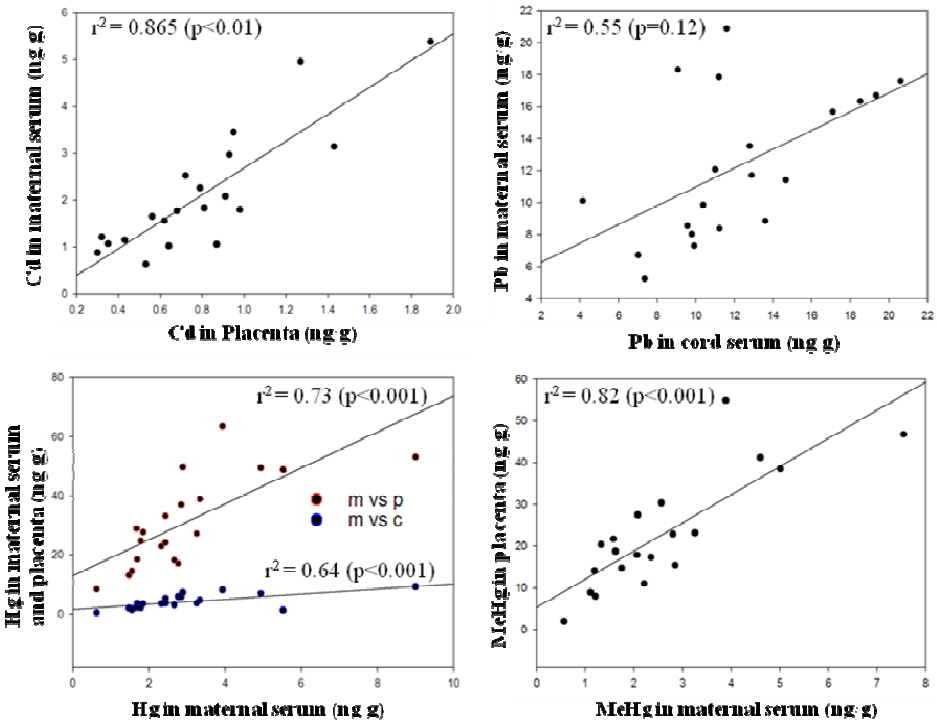

Figure 1. Scatter plots, trend lines, and correlation coefficients of Cd, Pb, Hg, and MeHg concentrations.

	n	*Median*	*Range*	*Mean*
PCDD/Fs (pg TEQ/g lipid)	20	3.31	0.20 – 23.59	5.76
PCBs (pg TEQ/g lipid)	10	0.11	0.06 – 0.15	0.11
PCBs (ng/g lipid)	10	37.6	21.12 – 60.95	38.76
PCNs (ng/g lipid)	10	0.64	0.2 – 1.64	0.707
PBDEs (ng/g lipid)	19	3.04	0.28 - 8.93	3.9305

Table 2. Concentrations of PCDD/Fs, PCBs, PCNs, and PBDEs in cord blood.

Concentrations of POPs in cord serum presents in table 2. The chemical has the highest concentration was PCBs, and PBDEs, PCNs, PCDD/Fs were followed. With regard to TEQ of dioxin-like compounds, PCDD/Fs have 5.76 pg TEQ/g lipid and PCBs have 0.11 pg TEQ/g lipid. PCNs are also known to have potential TEQ value, so further research is needed for evaluating total TEQ values.

Fetus is known to be more vulnerable than adult, because they have small body size and they are on development. To understand behavior and risk of heavy metals and POPs in maternal-fetal system, further research and discussion is required.

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