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Mercury concentrations in human placenta, umbilical cord, cord blood and amniotic fluid and their relations with body parameters of newborns

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ABSTRACT

Studies were conducted on samples taken from giving birth women ($n = 40$) living in Poland, representing three age groups: 19–25, 26–30 and 31–38 years old. Mercury concentrations were measured with CV-AAS in placenta, umbilical cord, cord blood and amniotic fluid.

The placentas weight did not exceed the 750 g value and was heavier than 310 g. Mean values of Hg concentrations in blood, placenta and umbilical cord were similar (c.a. 9 μg/g). High levels of mercury were noted in cord blood which in 75% of all observations exceeded (up to 17 μg/L) the safe dose set by US EPA (5.8 μg/L). No statistically significant differences in medium level of Hg in all the studied tissues among age groups of women were observed. Positive correlations between Hg concentrations in placenta and umbilical cord and cord blood were revealed as well as some negative ones between mercury concentrations and pregnancy parameters.

1. Introduction

Prenatal period is considered to be the most sensitive phase in human development. During this time fetal cells are the subjects of division and differentiation. This is the reason of high susceptibility of fetus to neurotoxic stressors which can easily cause developmental alterations (Wells et al., 2010; Goldman and Shannon, 2001). One of the strongest neurotoxin is mercury (Nordberg et al., 2007). Because of its strong toxicity, the US EPA established a safe limit of daily maternal mercury intake which is 0.1 μg/kg (Counter and Buchanan, 2004). Higher intakes of this metal lead to increased Hg absorption by the organism which can be dangerous to the fetus (Weil et al., 2005; Schettler, 2001). The report of CDC concluded that many women at childbearing age have high mercury level which may have a negative impact on the developing fetus (CDC, 2001). Some studies reported that mercury causes many dysfunctions and anomalies like: a small size of fetus, anemia, cataracts, hearing deficiency, microcephaly, cerebral palsy, mental retardation, convulsions, and diffuse brain damage (Thorp et al., 1992; Myers et al., 2003; Ramirez et al., 2003). This element may also have detrimental effects on hormone synthesis even at very low concentrations and consecutively on reproductive physiology (Knazicka et al., 2013). During pregnancy, there is no barrier preventing transmission of mercury from mother to fetus (Harada, 1995; Davis et al., 1994) and from blood to brain (Grandjean et al., 1998; Stern and Smith, 2003), which may result in Hg deposition in the central nervous system (Clarkson, 2002).

In the human organism mercury may be present as an inorganic, metallic and organic (methylmercury – MeHg) form. The major source of metallic and inorganic mercury in the environment are chemical industry and coal-burning power plants, where mercury is emitted into air, next enters into water and finally is converted to MeHg by microorganisms (Clarkson, 1997). The main source of

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exposure to MeHg is seafood, especially fish consumption (Clarkson and Magos, 2006; Bjornberg et al., 2003). Next to water and air pollution, in general population the main sources of inorganic Hg are skin-lightening creams and teething powder (WHO, 1991; US EPA, 2002). These products are often used by women including mothers, and they also may cause neurological, nephrological, and dermatological disorders (Counter and Buchanan, 2004). Common metallic sources include also dental amalgams (Goldman and Shannon, 2001; WHO, 1991) and other: cathode ray tubes, such as those used for computer screens or industrial switches (US EPA, 2002).

Bytom is a city in the Upper Silesia Region – area with high industrialization and the highest emission of air pollutants including toxic gases with mercury in Poland (Michalska, 2010). The emission of particulates for all the area run up to 12.7 thousand tons (just for Bytom 0.6) and of gases (excluding CO_2) 656 thousand tons (for Bytom 6.8) in 2011. Since 2005 a slight decrease in pollution is being observed (CSO, 2012).

Many various factors may have a significant influence on the prenatal concentrations of toxic metals, e.g. smoking during pregnancy, maternal age, gestational age (Wells et al., 2011). It seems to be meaningful to know how the above-specified factors are related to the concentrations of mercury in tissues connected with the fertility which can be significantly disturbed by the exposition to metals (Kolesarova et al., 2010; Roychoudhury et al., 2010). The aim of the study was to check if there are any differences in mercury accumulation in human placenta, umbilical cord, cord blood and amniotic fluid of women of different age groups. The potential relationships between mercury concentrations, newborn's parameters and pregnancy details were also inquired.

2. Materials and methods

Forty healthy women living in the Upper Silesia Region in Poland (Fig. 1) participated in these research studies in years 2010–2012. The samples of placenta, umbilical cord, cord blood and amniotic fluid were taken just after the delivery in the Department of Gynecology and Obstetrics in Bytom (Poland). Samples were collected to plastic bags, frozen (−18 °C) and transported to the laboratory (Institute of Biology, Pedagogical University of Cracow, Poland). Women were divided into three groups depending on the age: 19–25 years old (n = 11), 26–30 years old (n = 18) and 31–38 years old (n = 11). Each sample was supported with the questionnaire including the data of pregnancy number, delivery number, delivery week, weight of placenta, newborn's parameters (body weight, body length, head circumference, Apgar score) and sex of the child. Information about mother's diet (including fish consumption) and dental amalgam fillings was not collected. All the women participating in the study were in good health condition and had no complications during the pregnancy. Conditions and health of these women were regularly monitored in the clinic.

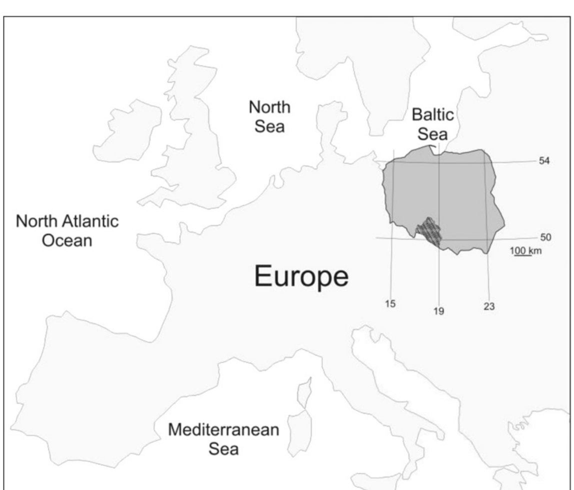

Fig. 1. Research was carried out in Upper Silesia Region (lines) of Poland (dark grey), central-eastern Europe.

Concentrations of total mercury in samples were measured with cold vapor atomic absorption spectrometer (Nippon Instrument Corporation MA-2). 30–50 mg of placenta tissue and umbilical cord, 50 μL of cord blood and amniotic fluid were used in the protocol. The material was not mineralized before the measurement and the analyses were performed with the wet weight (w.w.) of the material. The samples were supplemented with two additives: additive M (Wako Pure Chemicals Industries Ltd. for NIC 286-61845) and additive B (Wako Pure Chemicals Industries Ltd. for 282-62665) to minimize potential interferences. Limit of detection established for the whole procedure was 0.170 ng of total Hg. The accuracy of the method was checked against the certified reference material (BCR-463) samples (n = 8, mean recovery 97.29%, RSD = 2.7%) as well as spikes and control solutions analysis (the results were positive). Final results were given in μg/g w.w. for placenta and umbilical cord and in μg/L for amniotic fluid and cord blood.

The assumptions of the parametric test were checked with Shapiro Wilk test (for normality) and Levene test (for homogeneity of variance). Because the assumptions for mercury concentrations and Apgar score were not fulfilled, non-parametric analyses were performed: Kruskal–Wallis test and Spearman rank correlation (Quinn and Keough, 2002). Analyses for other variables were done with parametric test – factorial ANOVA. In all the statistical analyses, the significance level was established at 0.05 level. All the calculations and analyses were performed with Microsoft Excel 2010 PL and Statistica 10 EN (StatSoft).

3. Results

Among 40 patients, 20 women were nulliparous (with no previous children) and 20 multiparous mothers. One mother had born twins and 10% of the mothers had miscarried one time. The average gestational age was 38.3 weeks (range 36–42 weeks; estimation based on the onset of the last menstrual period).

Characteristics of newborns were analyzed separately for different child sex in the respect of possible differences caused by the mother's age (Table 1). Generally, the lowest body weight was noted among girls – 2200 g, whereas in boys the adequate value was 2760 g. The same children had also the lowest body length – respectively 48 and 50 cm. The head circumference parameter revealed very small variation – the lowest value was 33 cm and the biggest 36 cm. Mother's age was not an influential factor for mentioned parameters, but in the case of body weight the statistically significant differences occurred in respect of sex of the child – girls were lighter (Table 1). The median of the Apgar score was lower than 10 only in the case of girls born by women in the age 26–30 years old. These differences were not statistically significant (Table 1).

The remaining results were not divided with regard to child sex. The placenta weight varied between 310 g and 750 g (both women younger than 26 years old). The medians in age groups were consecutively: 430, 530 and 485 g (Fig. 2). The differences were not statistically significant (Table 2).

The highest variation of mercury concentrations in placenta and umbilical cord were observed in tissues of women from the 1st to 2nd age group (Fig. 3). The median concentrations in the 1st group were the highest. Slightly higher medians and variations of mercury concentrations were noted in the cord blood samples than in the amniotic fluid ones (Fig. 4). Because no statistically significant differences in the aspect of mother's age factor were found in placenta weight and mercury concentrations, data were combined and presented without the mentioned division (Table 2). The highest mercury concentrations were noted in placenta tissue (up to 0.104 μg/g) and in umbilical cord (0.064 μg/g). Mean values of mercury concentrations in blood, placenta and umbilical cord were similar (Table 2). The lowest mean as well as minimum value occurred in the case of amniotic fluid (5.0 and 2.0 μg/L respectively). All measured concentrations were above the detection limit of the used method.

Correlations between mercury concentrations in cord blood and placenta, cord blood and umbilical cord, umbilical cord and