Environment International 116 (2018) 43–51

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Occurrence of 44 elements in human cord blood and their association with growth indicators in newborns

Raúl Cabrera-Rodríguez[a,1], Octavio P. Luzardo[a,b,*,1], Ana González-Antuña[a], Luis D. Boada[a,b], Maira Almeida-González[a], María Camacho[a], Manuel Zumbado[a], Andrea Carolina Acosta-Dacal[a], Cristian Rial-Berriel[a], Luis Alberto Henríquez-Hernández[a]

[a] Toxicology Unit, Research Institute of Biomedical and Health Sciences (IUIBS), Universidad de Las Palmas de Gran Canaria, Paseo Blas Cabrera s/n, 35016 Las Palmas de Gran Canaria, Spain

[b] Spanish Biomedical Research Center in Physiopathology of Obesity and Nutrition (CIBERObn), Spain

ARTICLE INFO

Keywords:
Heavy metals
E-waste
Rare earth elements
Birth weight
Bismuth

ABSTRACT

There is growing concern about environmental pollution produced by elements, including “emerging” contaminants, such as rare earth elements (REE) and other trace elements (TE), which are extensively and increasingly employed in the manufacture of consumer electronics. Previous research has shown that prenatal exposure to some elements (mainly heavy metals) may be associated with decreased fetal growth and other adverse birth outcomes. Recent studies have also shown that environmental exposure to REE and TE may be related to adverse effects on human health. This cross-sectional study, which included nearly 92% of the births in 2016 in La Palma (Canary Islands, Spain; n = 471), aimed to evaluate the potential adverse health effects exerted by a wide range of elements on newborns. We quantified the levels of 44 elements (including 26 REE and TE) in their umbilical cord blood. Our results showed low or very low levels of most elements. We found an inverse association between antimony (Sb) and birth weight (Spearman's r = −0.106, p = 0.021). A similar trend was observed between nickel (Ni) and birth weight and between chromium (Cr) and birth length, although in this case the significance was borderline. Bismuth appeared as a risk factor for having a birth weight below the tenth percentile in the univariate (OR = 3.30; 95% CI = 1.25–8.78; p = 0.017) and multivariate analyses (OR = 5.20; 95% CI = 1.29–20.91; p = 0.020). When assessing the effect of element mixtures, the sum of Cr, Ni, and Sb appeared as a risk factor for having a birth weight below the tenth percentile in the univariate (OR = 2.41; 95% CI = 1.08–5.35; p = 0.031) and multivariate analyses (OR = 3.84; 95% CI = 1.42–10.39; p = 0.008). Our findings suggest that some inorganic elements—isolated or in mixture—are associated to a lower fetal growth. Additional research is needed to understand the role of inorganic pollutants on fetal development.

1. Introduction

It is clearly established that the period of intrauterine life is extremely vulnerable and sensitive to external changes. For this reason, the study of exposure to environmental pollutants during this time is extremely important, which is why numerous birth cohorts worldwide have studied exposure to different types of chemical contaminants during this period. In addition, many have tried to establish epidemiological relationships between these exposures and alterations in fetal development (Gehring et al., 2013; Kim et al., 2009; Townsend et al., 2016; Vrijheid et al., 2012). Furthermore, it has also been established that the development of many chronic diseases in adulthood may be conditioned by intrauterine life, so that proper fetal development is a determinant of health not only in newborns but also in future adults. Thus, increased risks for cardiovascular disease (CVD), obesity, and cancer have been associated with fetal parameters (Risnes et al., 2011). Birth weight is an indicator of fetal growth and development and depends mainly on genetics, maternal nutrition, and placental circulation (Kontic-Vucinic et al., 2006). It is one of the parameters that have been most related to health outcomes, especially the short-term survival of the newborn, but also the development of future diseases (Wilcox, 2001). The 2020 Healthy People program established a reduction in low birth weight (LBW) rates as one of its priority objectives. According to recent data, the current low birth weight (LBW) rate in developed

* Corresponding author at: Toxicology Unit, Clinical Sciences Department, Universidad de Las Palmas de Gran Canaria, Paseo Blas Cabrera Felipe s/n, 35016 Las Palmas, Spain.
E-mail address: octavio.perez@ulpgc.es (O.P. Luzardo).

[1] Both authors contributed equally to this work and should be considered first authors.

https://doi.org/10.1016/j.envint.2018.03.048
Received 6 December 2017; Received in revised form 30 March 2018; Accepted 30 March 2018

countries stands at 8.2% of births (CDC, 2000; Creel et al., 2017). According to recent data, the low birth weight (LBW) rate in Spain was 8.1% (Ayerza-Casas and Herraiz-Esteban, 2015). No data about birth weight are available through the Canary Institute of Statistics (information at http://www.gobiernodecanarias.org/istac).

Among the environmental factors to which the fetus may be more sensitive is exposure to inorganic elements. On the one hand, adequate exposure to elemental micronutrients is essential, and a balanced diet is required to ensure the correct intake of these elements (Kontic-Vucinic et al., 2006). Marginal or severe trace element imbalances are considered risk factors for several important public health diseases, especially when multiple micronutrient deficiencies, rather than single deficiencies, are encountered (Mertz, 1981). On the other hand, as important as the deficiency of elements—which is rare in developed countries where supplementation is commonly prescribed—is overexposure to some of them. Thus, exposure during gestation to environmental pollutants (such as toxic elements) can lead to serious health problems at birth, and possibly also in adult life, and even in future generations (Gillman et al., 2007; Wigle et al., 2007). Early exposure to elements on pregnancy outcomes and child health were previously investigated (McDermott et al., 2015; Pletz et al., 2016; Wigle et al., 2007). Most of the available studies focused on excess or deficiencies of micronutrients or on a few elements for which evidence of exposure exists (As, Cd, Cr, Hg, Ni, and Pb, among others). However, according to the latest edition of the list of priority pollutants produced by the Agency for Toxic Substances and Disease Registry (ATSDR), there are up to 18 elements whose effects on human and environmental health must be monitored (Camacho et al., 2013; CDC, 2017) based on a combination of their frequency, toxicity, and potential for human exposure at National Priority List (NPL) sites (CDC, 2017). It is noteworthy that this list includes several essential elements, indicating that although these are homeostatically regulated, overexposure to some may represent a threat to human health.

In addition, there are a number of other elements that have not been classified as toxic or priority pollutants and to which human exposure has been irrelevant in the past because their occurrence in the earth's crust is limited to extremely unlikely. They are the rare earth elements (REE) and other trace elements (TE), to which only those who live near places with the highest concentration of these elements would be exposed in natural conditions. However, this group of elements has begun to be extracted intensively from mines since they are extensively and increasingly used because their properties have made them highly valuable for technological industry (Hussain and Mumtaz, 2014; Tansel, 2017). The mobilization and universal use of these high-tech-related elements has caused people to currently be exposed to them on a daily basis (Henriquez-Hernandez et al., 2017b), mainly due to e-waste dispersed into the environment. In addition, REE and TE are employed in medical (such as gadolinium in magnetic resonance imaging), agricultural (as fertilizers), and zootechnical (such as REE-supplemented diets for rabbits, ruminants, and broiler chickens) applications (Du and Du and Graedel, 2011; Pagano et al., 2015a; Pang et al., 2002; USEPA, 2012). Therefore, the potential health effects of human exposure to these “emerging” pollutants began to worry the scientific community (Henriquez-Hernandez et al., 2017a; Henriquez-Hernandez et al., 2017b; Pagano et al., 2015a; Pagano et al., 2015b). Moreover, animal studies and data from human occupational exposure suggest that some REE/TE-induced tissue-specific bioaccumulation may damage the lungs, liver, and brain (Pagano et al., 2015b). To date, adverse health effects of human environmental exposure to low levels of many of these high-tech-related elements are unknown. However, due to increasing environmental contamination, the potential health risks associated with single or multiple exposures to low levels of chemicals need to be investigate further, especially since the combined action of pollutants varies from the effects of individual exposure (Rivero et al., 2017; Rivero et al., 2016). Moreover, studies on the adverse effects of exposure to these mixtures of elements during intrauterine life for the neonate are even scarcer.

Taking into account all of the above, we have designed this study, in which we: (1) determined the intrauterine exposure to a wide panel of elements (n = 44), including both those elements that are considered as priority in biomonitoring studies and others that we have termed “emerging pollutants” (REE and other high-tech-related TE); and (2) explored the association of intrauterine exposure to these elements with the clinical parameters recorded in newborns, trying to shed light on the possible adverse effects of such compounds on fetal health. In addition, a very important point of this study is that the sampling was conducted in a relatively isolated geographic region, essentially rural in nature. This, in addition to allowing presenting for the first time the values of exposure of many of these elements during intrauterine life, provide a first reference for the background levels of these elements related to natural environmental contamination.

2. Materials and methods

2.1. Study population

This study analyzed a total of 471 umbilical cord blood samples. These samples represented 91.4% of the total number of births recorded during 1 year (March 1, 2015, to April 30, 2016) on the island of La Palma (Canary Islands, Spain). La Palma is considered a rural area with very low level of industrialization. According to official statistics, La Palma has a total of 81,486 inhabitants, and during this study's sample collection period, a total of 516 births were registered on the island (General Hospital of La Palma), which corresponds with the officially recorded birth rate (6.5/1000 inhabitants) (ISTAC, 2015, 2016), so we assume that these 516 represent 100% of births on the island. Overall, 8.6% of births were lost to this study because the mothers refused to participate, no sample was available, or the collection of data at birth was incomplete. Thus, this study provides the rare opportunity to include almost all of the births that occur in a territory in a cohort, thus obtaining a real representation of the study population.

At birth, delivery room staff measured the birth weight, length, and cranial perimeter following standard anthropometric procedures. The score was collected using the Apgar test according to usual practice in neonatology (Apgar, 1966). Data on congenital malformations—mainly cardiac, oral, urogenital, skin, and orthopedic—were detected at birth and identified and recorded. Gestational age was calculated based on the last menstrual period. We collected data regarding the other variables from the mother (such as harmful habits, chronic diseases, food consumption, occupation, socioeconomic status, etc.) using a structured questionnaire. Other anthropometric and biological characteristics of the mother included age, parity, type of delivery, and previous miscarriages.

Three groups of newborns were created based on the growth curve database of Alexander et al. (Alexander et al., 1996): small for gestational age (lower than the tenth percentile, corresponding to 2662 g for newborn baby boys and 2583 g for newborn baby girls; SGA), appropriate for gestational age (birth weight between the tenth and ninetieth percentiles in both genders; AGA), and large for gestational age (higher than the ninetieth percentile, corresponding to 3878 g for newborn baby boys and 3760 g for newborn baby girls; LGA). Fetal size was stratified due to the importance of the prognosis and clinical management of newborns.

Both parents were required to sign informed consent in order to participate in the study. This study was approved by the Ethics Committees of the Hospital of La Palma and the University of Las Palmas de Gran Canaria in accordance with the Declaration of Helsinki. The samples were stored according to the regulations dictated by the Spanish Law of Biomedical Investigation of 2007 (Law 14/2007) and the data were saved according to the Data Protection Act (Ley Orgánica 15/1999).