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Evaluation of the transfer of Metals during Pregnancy from Mother to Baby, using Newborn Hair as an Exposure Biomarker

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Abstract

Introduction content of metals in hair is considered a good biomarker to determine the nutritional status and chronic exposure to metals in occupationally and environmentally exposed populations, however, there is not enough information on exposure to essential and non-essential metals in populations vulnerable as are women in pregnancy. Objective: in the present study was to evaluate the concentration of the main metals (essential and non-essential) in hair samples that are transferred from the mother to the newborn during pregnancy. Method: carried out a cross-sectional pilot study from August to October 2015 at the General Hospital "Dr. José María Rodríguez ", located in the municipality of Ecatepec de Morelos, State of Mexico, place with high traffic flow and industries (11,12), in 96 mothers with a geometric mean of 22 years (95% CI 21.99 - 23.45) and their newborns of 39 weeks (IC 95% 39.03 - 39.49) of gestation, inhabitants of said municipality. After the birth, hair samples were obtained from the mother-neonate pairs within a period no longer than 24 hours after delivery. To determine the concentration of metals in these samples, the method of pre-treatment of acid digestion in microwave was implemented and validated for 25 mg of hair sample for newborns and 100 mg for mothers. This allowed to quantify 21 elements (including rare earths) of the reference sample of trace elements in human hair (NCS DC73347A); however, for the samples of this study, the quantification of rare earths was not performed because they were not of interest for the study objectives. Once the pre-treatment was standardized, the hair samples were digested and the metals were quantified by mass spectrometry with source of inductively coupled plasma (ICP-MS). Results: The results showed metal concentrations from 8 ppb to 1190 ppm in the mothers in the following order: Cd <As <Sb <U <Hg <Pb <V <B <Cu <Zn <Ca, while newborns presented concentrations of 3.4 ppb at 1856 ppm in the following order U <As <Cd <Pb <V <Sb <Hg <B <Cu <Zn <Ca. Analysis: The concentrations of some elements were higher in newborns than in mothers, as is the case of Ca (56% higher), Zn (7%), B (66%) and Sb (26). %), the other elements were found in greater proportion in the mother than in the newborn. On the other hand, a positive correlation was observed between the concentrations of Ca, Cu, Zn, As, B, Hg and U in the hair of the mother and that of the newborn. Conclusions: Our data suggest that some metals can be transferred to the fetus during pregnancy, indicating a similar level of exposure between mothers and newborns. Additionally, some metals are able to cross the placenta more easily, which is why they are found in a greater proportion in newborns, possibly due to the characteristics of each metal. Comment, the hair can be a good indicator of the exposure during pregnancy for at least seven elements that correlated positively in the newborn mother binomial; offering the advantage that by knowing the concentration of elements in the hair of the pregnant mother, the exposure of the developing child can be estimated

Keywords: Transfer, Heavy Metals, Newborn Hair

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Introduction

The content of metals in the hair is considered a good biomarker to determine the chronic exposure to metals considered toxic and the concentration of essential metals. Within the indications of follow-up in countries of the first world it is recommended to have a biomarker that allows to evaluate the exposure to essential and non-essential metals during the uterine life. [3, 4, 6, 15, 17, 18,19]

Exposure to toxic metals and deficiency of essential metals (which can be potentially harmful) has been linked to various conditions, among which neurodegenerative diseases, cardiovascular diseases and cancer, among others [2, 13, 8]. The concentration of metals in the hair is a good biomarker for the evaluation of occupational, environmental and nutritional exposure, due to the advantages it presents in comparison with other biological matrices that include: easy sampling, non-invasive and indicates a chronic exposure; additionally, the concentration of some metals present in the hair has been related to the aforementioned conditions in several case-control studies. Therefore, the importance of knowing the concentration of metals in the hair as a biomarker of exposure and nutrition in early stages such as gestation is to be able to prevent alterations in the state of health in later stages. [1.9.14, 15, 18, 19.21]

Quantification of metals in hair by ICP-MS

The ICP-MS technique is a technique that has many advantages compared to other techniques such as optical emission spectrometry with inductively coupled plasma (ICP-OES) and atomic absorption spectrometry (AAS), since multiple elements can be quantified simultaneously. a short time, with little sample and low detection limits. Therefore, a good pre-treatment of the sample is necessary, this through the decomposition of the matrix by a digestion process to keep the ions in solution [10,19].

The recommendations of the Environmental Protection Agency (EPA) for the microwave acid digestion of organic matrices is to have a minimum of 1 g of sample and bring it to a final volume of 10 ml of oxidizing agent (USEPA, 1996) ; However, these conditions can be modified according to the size and type of sample, and taking into account the characteristics of each team. [1.21]

Characteristics of the study population in relation to the concentration of metals in the hair

Hair color and shape are important characteristics because metals bind to the functional groups of the two types of melanin, and hair shape determines the availability of SH groups of keratin-associated proteins [7, 16,20].

Goals

General purpose

Determine the relationship of the concentration of the main metals (essential and non-essential) in hair samples of the mother and her newborn child.

Particular objectives

• Establish the pre-treatment conditions for acid digestion of hair samples and the quantification of metals by ICP-MS.

• Perform the quantification of metals in hair samples of the mother-newborn pair.

Establish the relationship between the concentrations of the metals in the hair samples of the mother and her son

Material and method

Collection of hair samples

The sample was taken for a period not longer than 48 hours after delivery, in a clean place using gloves and stainless steel scissors to cut approximately 100 to 150 mg of hair from newborns and mothers

Obtaining the maternal hair was as close to the scalp of the posterior area of the head, since in this region is where the hair grows more and more uniformly, there being the largest number of active hair follicles, the same happened with the babies.

Preparation of hair samples

Reagents

Triton X-100 was purchased from Sigma Aldrich (St. Louis, MO).

Beginning

Prior to the quantification of the metals, a hair washing step was performed to eliminate the elements present on the surface of the hair that could interfere with the quantification of the elements of interest.

Process

The hair samples were rinsed with deionized water for 10 min, then in a solution of triton X-100 0.1% for 20 min, then another rinse with deionized water (5 times), and finally dried at room temperature on paper absorbent with little fluff (Kimwipes) (Foo et al., 1993).

Results

Characteristics of the study population

The mothers who agreed to participate in the study were 96, and the general characteristics of the 96 mother-newborn pairs are presented in tables 3 and 4. The newborns had an average age of 39 weeks, a weight of 3073.13 g, a size of 50 cm, a head circumference of 34.98 cm and the APGAR (Appearance, Pulse, Gesture, Activity and Breathing) was 9 for 99% and 8 for 1%. Weight, height, cephalic perimeter, gestational age and APGAR were used to include newborns in the study, because an inclusion criterion was that the newborns had a good state of health. The hair shape of the newborns was lanky in 81.25% and wavy in 18.75% of the children. 87.5% of newborns had dark colored hair and 12.5% light colored hair. (Table 1)

Characteristics		n (%)	Geométric mean (IC 95%)
Hair Color			
	Dark	84 (87.5)	
	Claro	12 (12.5)	
Hair shape			
	Lazio	78 (81.25)	
	Wavy	18 (18.75)	
APGAR			
	8	1 (1.04)	
	9	95 (98.96)	
Gestational age (wk)			39.26 (39.03 - 39.49)
Weight (g)			3076.13 (3005.85 - 3148.06)
Size (cm)			50 (49.48 - 50.53)
Cephálic Perímeter (cm)			34.98 (34.57- 35.41)

Table 1: Characteristics of newborns.

The average age of the mothers was 23 years. For 33% of the mothers, it was their first delivery and 67% of the mothers had had more than one birth. No mother presented her hair dyed. The hair shape of the mothers was lax in 53%, wavy in 41% and curly in 6% of the participants. The hair color of the mothers was 1% blond, 54% brown and 45% black. (table2)

Caracteristícs		Feature n (%)	Geométric mean (IC 95%)
Hair Color			
	Dark	91 (94.79)	
	Claro	5 (5.21)	
Hair shape			
	Lazio	51 (53.13)	
	Wavy	39 (40.63)	
	Rizado	6 (6.25)	
Age (years)			22.71 (21.99 - 23.45)
Númber of births			
	1	32 (33.33)	
	2-4	64 (66.77)	

Table 2: Internal and external quality control

The digestion technique was adjusted to 25 and 100 mg of hair sample for the newborn and the mother, respectively, as described in sections 2.6.2 and 2.6.3 of Methods. From the reference sample that was used as internal quality control, the following elements were quantified: Be, B, Ca, Zn, Cu, As, Se, Cd, Sb, La, Ce, Pr, Pb, Tb, Ho, Lu, Hg, Tl, Bi, Th and U (Table 5). The coefficient of variation of the concentration of these elements was from 0.5 to 15.7%, and the recoveries were from 74 to 116%, depending on the element. For the report of the concentrations of elements in the hair samples of the mother-child binomial, rare earths were omitted. (table3)

Element	Concentratión certified (ppb)	Determined concentration (ppb)	Coefficient of variation (%)	Recovery (%)
Be	11 ± 0.7	10± 0.3	3.8	91
B	290 ± 50	271 ± 36	15.7	93
Ca	145,000 ± 20,000	142,810 ± 5,028	4.9	98
V	50 ± 18	57.9 ± 1.98	3.4	116
Zn	13,700 ± 900	12,416 ± 1,391	11	91
Cu	1,4300 ± 160	1,293 ± 84	6	90
As	28 ± 5	21 ±1.6	6.7	75
Se	58 ± 12	62 ± 0.7	1.2	107
Cd	7 ± 1	6 ± 0.3	5.9	86
Sb	6.5	5 ± 0.3	6.3	77
La	16 ± 4	11.9 ± 0.1	1	74
Ce	35	26.6 ± 0.2	1	76
Pr	2.5 ± 0.6	2.4 ± 0.02	1	96
Pb	570 ± 50	617 ± 36	6	108
Tb	0.33 ± 0.09	0.28	0.5	85
Ho	0.46 ± 0.18	0.43	0.6	93
Lu	0.28	0.21	0.6	75
Hg	67 ± 10	61 ± 2.8	7.9	91
Tl	0.77 ± 0.11	0.89 ± 0.01	0.9	116
Bi	2.1 ± 0.2	2.1 ± 0.01	0.6	100
Th	6.4 ± 1.1	4.9 ± 0.03	0.6	77
U	9.9 ± 1.5	11 ± 1	2.0	111

Table 3: Concentration of the metals present in the reference sample of trace elements in human hair (NCS DC73347A).

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Element	Concentration determined (ppb)	Coefficient of variation (%)	Recovery (%)
Be	0.389 ± 0.157	10.7	90
As	19.821 ± 7.152	11.6	119
Cd	21.290 ± 6.026	10.4	102
Sb	68.786 ± 11.031	11.8	111
La	4.614 ± 0.029	0.6	103
Ce	5.013 ± 0.226	1.1	104
Pr	0.475 ± 0.006	0.8	109
Pb	536.068 ± 68.781	10.2	114
Lu	0.016 ± 0.007	0.3	120
Hg	1169.411 ± 82.408	9.7	78
Tl	0.767 ± 0.197	9.4	100
Bi	18.318 ± 3.002	16.1	114
U	140.178 ± 17.961	9.3	118

Table 4: Concentration of metals in samples of donated hair, added with 10 ppb of the multi-element standard.

Element	Certified concentration (ppb)	Determined concentration (ppb)	(%)Coefficient of variation	Recovery (%)
Be	585	466.89 ± 1.55	0.3	80
Zn	217128	168903.88 ± 6720.30	4.0	78
As	2314.41	2630.16 ± 31.72	1.2	114
Se	2701.8	2608.54 ± 64.39	2.5	97
Cd	185.46	160.23 ± 2.37	1.5	86
Sb	1827	1969.14 ± 15.77	0.8	108
Hg	2026.06	1896.04 ± 10.24	0.5	94
Ba	1565.22	1498.88 ± 9.57	0.6	96
Pt	273.14	258.30 ± 2.00	0.8	95

Table 5: Concentration of the metals present in one of the samples of the inter-calibration exercise for trace elements in human hair from the INSPQ Laboratory, Canada.

The recovery of the multi-element standard metals added to the hair samples was 78-120% for Be, As, Cd, Sb, La, Ce, Pr, Pb, Lu, Hg, Tl, Bi and U, and the coefficient of variation was less than 15% (Table 6).

From the inter-laboratory exercise in which they participated (as external quality control) with two hair samples provided by the INSPQ Laboratory, Canada, the following elements were validated: Be, Zn, As, Se, Cd, Sb, Hg , Ba and Pt, the results of one of the samples are presented in Table 7. Recoveries were obtained from 78 to 114% and the coefficient of variation was from 0.5 to 2.5%, depending on the element.

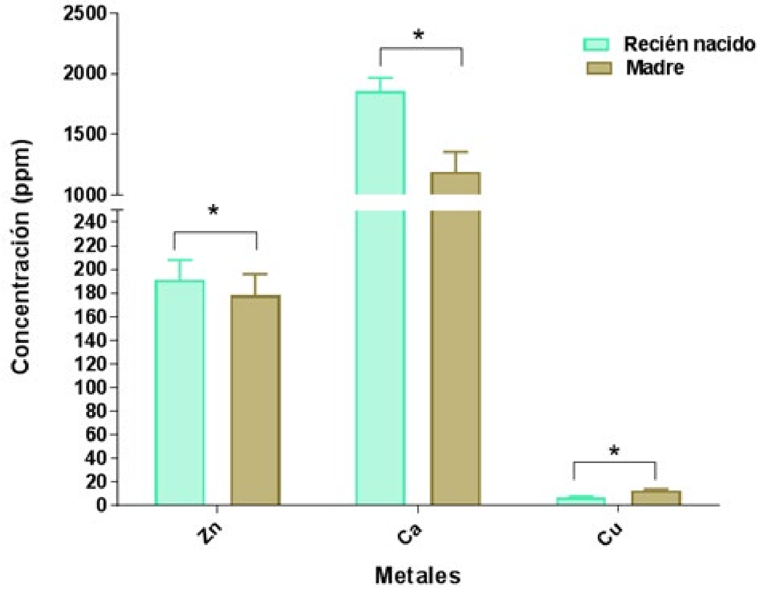

Figure 1: Concentratión of metals esentiales in hair. The results represent the Geométric mean And the IC to 9

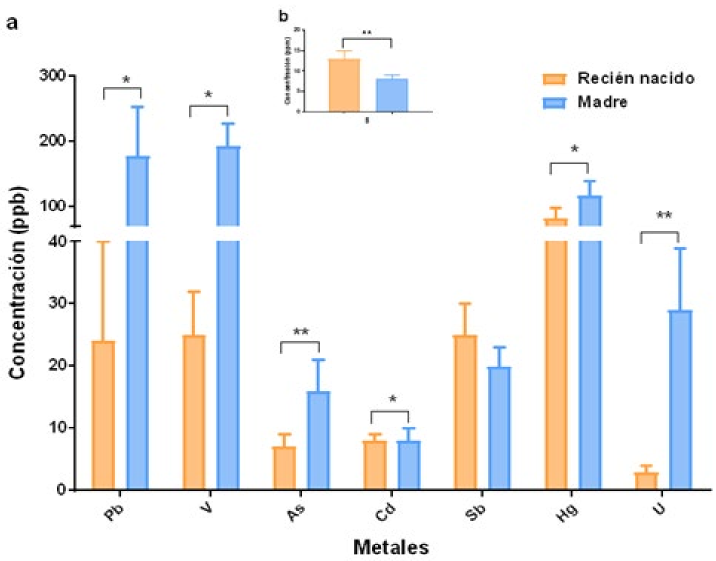

Figure 2: Concentratión of metals no esentiales in Hair. The results represent the Geométric mean and IC al 95 %.a) Concentratión en ppb y b) concentratión en ppm (n=96). * p< 0.05, ** p< 0.001.

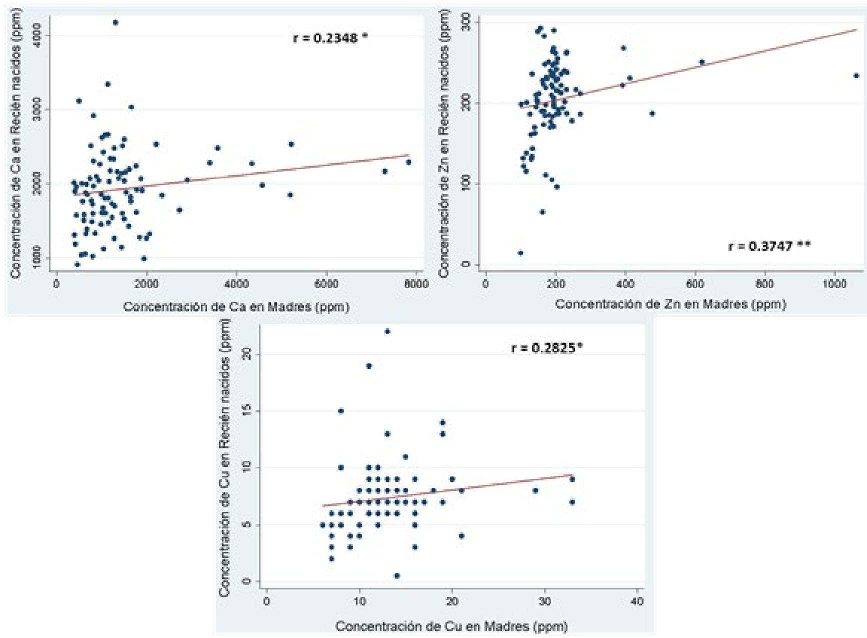

Figure 3: Correlatión enter la concentratión de Ca, Zn y Cu in the mother´s hair and neewborn. We aply test of Spearman, the líne represent tendens of relatión of date, n=96, *p<0.05, **p<0.001.

Concentration of metals in the hair of mothers and newborns

The concentrations of essential and non-essential metals in hair samples of mothers and newborns are presented in Figures 4 and 5, respectively. Significant differences were observed in the concentrations of all metals in the mothers with respect to the concentrations of the metals in the newborns, with the exception of Sb.

Relationship between the concentrations of non-essential metals in the hair of mothers and newborns

To determine the relationship between the concentrations of the same non-essential element between mothers and newborns, the Spearman rank correlation was performed. Significant positive correlations were obtained between hair concentrations of mothers and newborns, which for the case of Hg was high ($r = 0.7061$, $p <0.001$), moderate for As ($r = 4825$, $p <0.001$) and B ($r = 0.6324$, $p <0.001$), and low for U ($r = 0.2198$, $p <0.05$) (Figure 7).

Correlation of quantified metals in the hair of mothers and newborns

The bi-varied analyzes between the elements were carried out, both in the hair metal concentrations of the mothers (Table 6) and of the newborns (Table 7). On the other hand, Table 10 presents a comparative summary of statistically significant positive correlations between the hair elements of mothers and newborns.

In the case of potentially toxic metals, significant associations among the following elements stand out: As-B, Pb-As, Pb-Cd, Pb-Sb and Pb-U, both in the hair of the mother and in the hair of her newborn son, being more robust the association in the hair of the mother. For the case of the essential elements, associations were observed between Ca-Cu and Cu-Zn, in both types of hair being Cu-Zn more robust in the hair of the newborn.

Finally, when evaluating the possible correlation between non-essential and essential elements, a correlation was observed for U-Ca in both types of hair (Table 8).

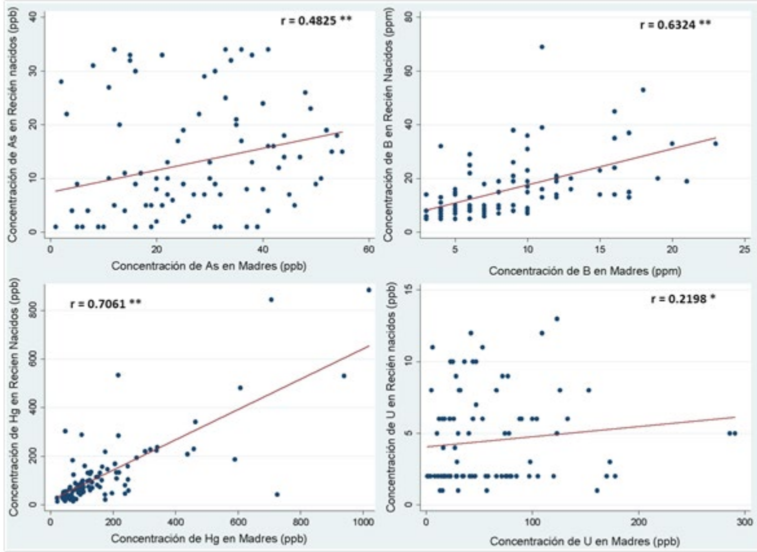

Figure 4: Correlatión between concentratión of Hg, As, U y B in the mothers and newborn. We aply test of correlation to Spearman, the líne represent the tendens of relation of the date, n=96, *p<0.05, **p<0.001.

	As	B	Cd	Hg	Sb	Pb	V	U	Ca	Cu	Zn
As	1										
B	0.2142 *	1									
Cd	0.2	0.1615	1								
Hg	-0.0564	-0.1039	-0.0577	1							
Sb	0.0843	0.0174	0.6243	0.0525	1						
Pb	0.3801**	0.2238*	0.4593**	0.1016	0.3255 *	1					
V	0.191 *	0.2767 *	0.3108 *	0.0505	0.2241 *	0.2434*	1				
U	0.2744 *	0.2882 *	0.2771 *	-0.0038	0.1218	0.3827**	0.5155**	1			
Ca	-0.0947	0.1492	0.1209	0.122	-0.047	-0.0039	0.5142**	0.2874 *	1		
Cu	0.1683	0.0057	0.2135 *	0.0439	0.0512	0.2717 *	0.2379*	0.2192 *	0.272 *	1	
Zn	0.0413	-0.0953	-0.0324	-0.0575	-0.159	-0.0178	0.0733	0.0327	0.3775**	0.3422 **	1

n=96, * p ≤ 0.05, ** p ≤ 0.001

Table 6: Correlatión between metals presents in Mother´s hair.

	As	B	Cd	Hg	Sb	Pb	V	U	Ca	Cu	Zn
As	1										
B	0.2765*	1									
Cd	-0.1052	0.0886	1								
Hg	0.1641	0.1352	0.0903	1							
Sb	0.2172*	-0.0351	-0.084	-0.0488	1						
Pb	0.1722	-0.0021	0.2094*	-0.1876	0.2158*	1					
V	-0.0933	-0.1104	0.1123	-0.1591	-0.1797	0.0406	1				
U	0.1092	-0.0928	0.0725	-0.0671	-0.0291	0.2650*	-0.0115	1			
Ca	0.1437	0.2831*	-0.0804	0.2501	0.0528	0.1587	-0.0831	0.3367**	1		
Cu	0.1234	-0.0639	-0.0523	-0.0466	0.0222	0.2416*	0.0099	0.2621*	0.216 *	1	
Zn	0.1491	-0.0693	0.0775	-0.0687	0.2167*	0.3992**	-0.1167	0.3372**	0.2613*	0.406**	1

n=96, * p ≤ 0.05, ** p ≤ 0.001

Table 7: Correlatión between metals presents in newborn´s hair.

R < 0.3=low, r=0.3 - 0.69=moderathe, r> 0.69=hight. In bold we present the correlations significants (p< 0.05) in binomious.

Correlatión	Mother´s hair	Newborn´s hair
Elements esentiales		
low	Ca-Cu Cu-Zn	Ca-Cu Ca-Zn
Moderathe	------	Cu-Zn
tóxics Elements		
low	As-B As-V As-U B-V B-U Cd-U Cd-V Sb-V Pb-V	As–B As–Sb Pb-As Pb-Cd Pb-Sb Pb–U
Moderathe	Pb-As Pb-Cd Pb-Sb Pb-U V-U	
Elements esentiales and tóxics		
low	Cd-Cu Pb-Cu V–Cu U –Ca	B –Ca, Sb –Zn U–Cu
Moderathe	V-Ca	U–Ca U–Zn Pb–Zn

Table 8: Correlatión between metals presents in the hair of mother and newborn binomious.

Discussion

Exposure to toxic metals and deficiency of essential metals (which can be potentially harmful) has been linked to various ailments, including neurodegenerative, cardiovascular and cancer diseases, among others (24). The concentration of metals in the hair is a good biomarker for the evaluation of occupational, environmental and nutritional exposure, due to the advantages it presents in comparison with other biological matrices that include: easy sampling, non-invasive and indicates a chronic exposure; In addition, the concentration of some metals present in the hair has been related to the aforementioned conditions in several case-control studies [13,24]. Therefore, the importance of knowing the concentration of metals in the hair as a biomarker of exposure and nutrition in early stages such as gestation is to be able to prevent alterations in the state of health in later stages.

Quantification of metals in hair by ICP-MS

The ICP-MS technique is a technique that has many advantages compared to other techniques such as optical emission spectrometry with inductively coupled plasma (ICP-OES) and atomic absorption spectrometry (AAS), since multiple elements can be quantified simultaneously. A short time, with little sample and low detection limits. Therefore, a good pre-treatment of the sample is necessary, this through the decomposition of the matrix by a digestion process to keep the ions in solution [18,19] in this work the pre-treatment of the sample of hair with some modifications that included different amounts of the sample, addition of different volumes of HNO_3 and H_2O_2 and variation of the conditions of temperature and time of digestion, being finally the following conditions: 3 ml of HNO_3, 300 µl of H_2O_2, 150 ° C and 25 min. Very similar digestion conditions have been described (final volume of 3 ml and digestion temperatures) and with a small amount of sample (Wang et al., 2009). The recommendations of the Environmental Protection Agency (EPA) for the microwave acid digestion of organic matrices is to have a minimum of 1 g of sample and bring it to a final volume of 10 ml of oxidizing agent (USEPA, 1996); However, these conditions can be modified according to the size and type of sample, and taking into account the characteristics of each team. The amount of newborn hair sample was the main reason to adjust the aforementioned conditions and be able to quantify the elements of interest present in trace levels. For quality control, we used the reference material DC73347A Human hair, which has previously been used as a reference material for the determination of Hg and As (Gault et al., 2008, Martínez et al., 2012), highlighting that it was achieved Validate the quantification of 21 elements, from which good recoveries were obtained, ranging from 74 to 116% and coefficients of variation less than 15.7%. With this, we were able to ensure the quantification of 11 elements in 96 pairs of hair samples from mothers and children, using the concentrations of metals in hair as an indicator of exposure in the gestational stage.

Characteristics of the study population in relation to the concentration of metals in the hair

Hair color and shape are important characteristics because metals bind to the functional groups of the two types of melanin, and hair shape determines the availability of SH groups of keratin-associated proteins [22]. However, these characteristics did not present significant differences in our population, except for the color that had a significant difference with respect to the concentration of Ca in the hair of the newborn, finding higher concentrations of Ca in dark hair (1902.16 vs 1565.43 ppm), similar results were obtained in melanosomes of dark hair finding higher concentration of Ca, due to the binding of Ca to the carboxyl groups present in DHICA (5,6-dihydroxyindole-2-carboxylic acid) of eumelanin, a compound lacking in the pheomelanin (Hong & Simon, 2007). Of the characteristics of the mothers, the number of births presented a significant difference with respect to the content of Zn, observing higher concentrations of Zn in the hair of mothers with a delivery (203.08 ppm), than in mothers with more than one birth (182.42 ppm). This is consistent with a review carried out by Salgueiro in 2002, where he mentions that women with multiple pregnancies are more at risk of developing Zn deficiency during pregnancy, perhaps due to the low availability of accumulated Zn in mothers with multiple births [25].

Concentration of the elements in the hair of the mother-child binomial

In this study the following number of times was obtained plus the concentration of toxic elements in the hair of the mother with respect to that of the newborn: 0.81 of Cu, 0.43 of Hg, 1.24 of As, 6.39 of Pb, 7.51 of U and 6.63 of V. The rest of the metals were presented in greater proportion in the newborn than in the mother. Similar results were observed in a population of mothers and children in the United Kingdom (n = 82), where Cu, Cd and Pb were found mostly in the hair of the mother and Zn in the newborn (Razagui & Ghribi, 2005). In another population of Tehran, Iran (n = 6) environmentally exposed to high concentrations of metals reported higher concentrations of Cu, Zn, B, Cd and Hg in the newborn compared to the mother, only the Zn and B behaved similarly to the present study [21].

The concentrations of the essential elements observed in the hair of mothers and newborns living in Ecatepec were in the following order: Ca> Zn> Cu (Figure 4). As regards the potentially toxic elements, the concentration in the mothers was V> Pb> Hg> U> Sb> As> Cd, and in the hair of the newborns they were Hg> Sb> V> Pb> Cd> As> U (Figure 5). In a study conducted in populations of eleven cities in China not exposed to a specific source of metals, Pb> As> Cd was found in hair [26], following this same order of concentration in the mothers. According to data obtained in our laboratory, the levels of metals adsorbed in the PM of the Ecatepec region showed the presence of several metals in the ambient air: up to 0.5 µg / m^3 of Mn, Pb and Cu, and up to 0.15 µg / m^3 of V, Ni, Cr and Cd (Alvarado-Cruz et al., 2017). This order of abundance in the environment for Cu, V and Cd coincides with the levels of metals in the hair present in both the mother and her son, suggesting that hair is a good indicator of environmental exposure.

Comparing the concentrations of metals in the hair of newborns with the values established for children of three years, we found that the geometric means of the concentrations of As, Cd, V and Cu in the hair of newborns were found below the minimum reference value, however in all these elements were atypical values, except for the As that is within the reference range, the concentrations of Pb and Hg were lower than established as a maximum (3 and 1 ppm, respectively) , while Ca and Zn were above the maximum concentration. For the mothers, the geometric means of the concentrations of As, Cd, Hg, Cu and Zn were below the maximum value, but atypical values were found in As, Cd, Cu and Zn. For the case of V the geometric mean is almost four times above the maximum reference value for adults).

Similarly there are concentrations in the hair for some elements considered at risk in exposed populations (ATSDR, 2010). The toxic concentration in the hair for As, Hg and Pb is of 1, 5 and 8 ppm, respectively, comparing these concentrations with those quantified in the hair of the mother-child binomial of this study, these were found far below the values considered toxic. For the normal values reported by the INSPQ, Canada, the geometric means of all the elements are within the reference limit both mothers and newborns, but individually comparing the values of mothers and children with the normal values for the INSPQ are atypical data for 22.9% of newborns in Sb. Regarding the atypical concentrations in mothers, 57.3, 15.6, 6.2 and 1% were taken for V, U, Zn and Cu, respectively. Because specific hair reference values are lacking for newborns and pregnant women, it is difficult to make a comparison for all the elements, since the mineral composition of the hair is dependent on age and gender.

Analysis

The concentrations of some elements were higher in newborns than in mothers, as is the case of Ca (56% higher), Zn (7%), B (66%) and Sb (26%). , the other elements were found in greater proportion in the mother than in the newborn. On the other hand, a positive correlation was observed between the concentrations of Ca, Cu, Zn, As, B, Hg and U in the hair of the mother and that of the newborns. They presented higher concentrations in 1.5 times.

Conclusions

1. The methodology for the digestion of the hair with acid digestion in closed system was standardized for 25 and 100 mg of sample of the newborn and the mother, respectively.
2. The quantification of 21 elements of the reference material by ICP-MS (including some rare earths) was validated, with good percentages of recovery (74 to 119%) and low coefficients of variation (less than 15.7%).
3. Significant differences were observed between the concentrations of Cu, Ca, B, As, Hg, Cd, Pb, V, U and Zn in the hair samples of the mother-newborn pair, with the exception of Sb.
4. A positive correlation was observed between the concentrations of As, B, Hg, U, Ca, Cu and Zn in the hair of the mother with those of the hair of the newborn, indicating that the mother's exposure is reflected in her son.
5. The concentrations of metals in the hair of the mother and the newborn suggest that the metals are transferred during pregnancy and stored in the hair of the newborn, which represents a risk to the health of the children.
6. Of the toxic elements in the hair of the mothers, 15.6 and 57.3% of the samples are above the normal value of U and V, respectively. For the hair of the newborns, 22.9% of the samples were above the normal value of Sb. However, information on concentrations considered toxic of these elements in hair is lacking.
7. The concentrations of metals in the hair of the mother can be a good indicator of the exposure of the fetus during pregnancy for at least seven elements: As, B, Ca, Cu, Hg, Zn and U.
8. The positive correlations observed in the mother-newborn pair offers the advantage that by knowing the concentration of elements in the pregnant mother's hair, the exposure of the developing child can be estimated.

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