Original Article

Artigo Original

Hearing thresholds in children exposed to mercury in the prenatal period

Limiares auditivos em crianças expostas a mercúrio no período pré-natal

Marilene Danieli Simões Dutra[1]
Marcia Cavadas[2]
Iracina Maura de Jesus[3]
Elisabeth Oliveira Santos[3]
Evelyn Almeida da Silva[2]
Volney de Magalhães Câmara[1]

Keywords

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ABSTRACT

Purpose: To evaluate hearing thresholds in children with a history of exposure to mercury during the prenatal period. **Methods:** Participants were 90 children of both genders with ages from 8 to 10 years, divided into two groups according to prenatal mercury exposure levels. The study group was composed by 57 children who had mercury levels in the umbilical cord equal or above 8 µg/L, and the comparison group comprised 33 children who had mercury levels in the umbilical cord below 8 µg/L. Investigation procedures included the application of a questionnaire, pure-tone audiometry, speech reception threshold, and mercury level analysis in cord blood collected at birth. **Results:** The study group showed a median mercury level in the umbilical cord of 14.63 µg/L, and the median threshold for 500 Hz, 1 kHz and 2 kHz in pure-tone audiometry was 10 dB for both ears. The comparison group had a median cord blood mercury level of 4.88 µg/L, and the median threshold for 500 Hz, 1 kHz and 2 kHz in pure-tone audiometry was 10 dB for both ears. When the hearing thresholds were compared, both by the tritonal mean and by each frequency separately, there were no significant differences between groups. **Conclusion:** The children had hearing thresholds within normal limits and there was no significant difference between the hearing thresholds of children exposed and not exposed prenatally to mercury.

Descritores

Audiometria
Intoxicação por mercúrio
Mercúrio
Criança
Cuidado pré-natal

RESUMO

Objetivo: Avaliar os limiares auditivos de crianças com histórico de exposição ao mercúrio durante o período pré-natal. **Métodos:** Foram avaliadas 90 crianças com idades entre 8 e 10 anos, de ambos os gêneros, categorizadas em dois grupos de acordo com os níveis de exposição pré-natal ao mercúrio. O grupo de estudo foi composto por 57 crianças que apresentaram níveis de mercúrio no cordão umbilical iguais ou superiores a 8 µg/L, e o grupo de comparação por 33 crianças que apresentaram níveis de mercúrio no cordão umbilical inferiores a 8µg/L. Os procedimentos incluíram um questionário, audiometria tonal liminar, pesquisa do limiar de recepção de fala e análise das doses de mercúrio no cordão umbilical coletadas ao nascimento. **Resultados:** O grupo de estudo apresentou mediana de mercúrio no cordão umbilical de 14,63 µg/L, e mediana dos limiares tonais das frequências de 500 Hz, 1 kHz e 2 kHz de 10 dB em ambas orelhas. O grupo de comparação apresentou mediana de mercúrio no cordão umbilical de 4,88 µg/L, e mediana dos limiares tonais das frequências de 500 Hz, 1 kHz e 2 kHz de 10 dB em ambas orelhas. Quando comparados os limiares auditivos, tanto pela média tritonal quanto para cada frequência isoladamente, não foram observadas diferenças significativas entre os grupos. **Conclusão:** As crianças apresentaram limiares auditivos dentro dos padrões de normalidade e não foi observada diferença significativa entre os limiares auditivos das crianças expostas e não-expostas ao mercúrio no período pré-natal.

Correspondence address:
Marilene Danieli Simões Dutra
Pç. Jorge Machado Moreira, 100, Cidade Universitária, Rio de Janeiro (RJ), Brasil
CEP: 21941-598.
E-mail: lenadutra@uol.com.br

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Study conducted at the Institute of Collective Health Studies, Universidade Federal do Rio de Janeiro – IESC/UFRJ – Rio de Janeiro (RJ), Brasil.
(1) Institute of Public Health Studies, Universidade Federal do Rio de Janeiro – IESC/UFRJ – Rio de Janeiro (RJ), Brazil.
(2) Undergraduate Program in Speech-Language Pathology and Audiology, School of Medicine, Universidade Federal do Rio de Janeiro – UFRJ – Rio de Janeiro (RJ), Brazil.
(3) Environment Section, Instituto Evandro Chagas, Health Vigilance Secretariat, National Health Ministry – SVS/MS – Ananindeua (PA), Brasil.
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INTRODUCTION

Mercury (Hg) is found in nature in different chemical forms. In the Amazon, it is found as metallic mercury, used in the burning of gold amalgam, and that can later be disposed in rivers and, through the biological chain contaminate fish in its most toxic form, methylmercury, exposing the general population through fish consumption[1,2]. Whichever the form of exposure, its effects are extremely toxic, especially to the central nervous system[2,3].

Studies show that, in the different segments of population, children are potentially exposed to mercury from their conception, either through maternal exposure, through mercury transference through the placental barrier, through nursing, or from high levels of consumption of fish until they are mature[4-7]. Most studies conducted on this subject still regard exposure to mercury and few contemplate clinical assessments[4,5].

In spite of the long term knowledge about the damage caused by the use of mercury, the concern about its use and its effects in the environment has been widely spread after the accidents in the Japanese cities of Minamata and Niigata in the 1950's, when several inhabitants began to suffer from a neurological ailment that became known as Minamata Disease[8,9]. This disease has been associated to the consumption of fish contaminated by methylmercury. Another episode occurred in Iraq in the 1970's, when there were several cases of contamination of agricultural workers and their families who used grains treated with fungicides made from methylmercury as ingredients for home-made bread[9]. In both cases, the follow-up of mothers contaminated with methylmercury, even when not having any signs or symptoms of intoxication, showed that they had children with adverse effects, such as low body weight, muscle hypotonia, delayed neuropsychomotor development, tendency towards having seizures, blindness and hearing impairment. These intoxication data suggest that fetuses and children are especially at risk to develop effects of exposure to methylmercury[1,2].

After these intoxications, two large cohort studies were conducted in populations exposed to methylmercury through fish consumption in the Faroe and Seychelles Islands. In both studies, the levels of mercury were measured at birth, through the umbilical cord, and the children were followed up to adolescence. Even though these populations had lower methylmercury levels that the ones in Minamata, some effects of this prenatal exposure were observed in these children[2]. Among the findings there were abnormal findings in the evoked brainstem auditory potential, indicating methylmercury's neurotoxic effect in these children's auditory system[10].

Therefore, the purpose of the present study was to evaluate hearing thresholds in children with a history of exposure to mercury in their prenatal period.

METHODS

This study was approved by the Research Ethics Committee of the Institute for Collective Health Studies of the Universidade Federal do Rio de Janeiro (protocol 105/2009). Children's parents were informed of the purpose of the study and signed an informed consent term.

A cross sectional study was conducted in 90 children ranging from 8 to 10 year old, of both genders, who lived in Itaituba (PA), Brazil, whose levels of mercury in the umbilical cords were collected at birth, in between the years of 2000 and 2001. The children in the study group (n=57) had average age of 8.79 years; 25 were female and 32 were male. The children in the comparison group (n=33) had average age of 8.85 years; 17 were females and 16 were males.

These children are part of a subsample of a longitudinal study[6] about the correlation of mercury levels in the blood of women and children in this city, that is being conducted by the Evandro Chagas Institute of the National Health Department (IEC/MS) since the year of 2000.

A partnership with the Municipal Education Office of Itaituba was established in order to search for children followed by the IEC/MS and who were enrolled in school in the urban area of Itaituba. This search located 93 children. Inclusion criteria in the study were: residence in the urban area of Itatituba, being part of the group of children followed by the IEC/MS and having no abnormal findings in ear canal inspection. Three children were excluded for not meeting the inclusion criteria (had abnormalities in the ear canal at the moment of evaluation). Thus, the population that composed the sample of the present study was composed of 90 children.

It should be added that the choice for children living in the urban area reinforces the effort to assess the effects of prenatal exposure to mercury, since children living closer to the riverside areas tend to have more fish in their diets[5].

The level of prenatal exposure to methylmercury was assessed through the analysis of mercury levels in the umbilical cord blood. Collection and analysis were conducted by the Evandro Chagas Institute and routine procedures of international quality control programs were followed.

An atomic absorption spectrometer with a cold vapor generating system (CV-AAS), type Automatic Mercury Analyzer Hg-20112 was used in order to determine the presence of mercury in blood and capillary tissue samples. For quality control, certified samples of hair (IAEA-086), with analytic recovery of 99.65% (n=27) and blood (Whole Blood II) with analytic recovery of 98.14% (n=9) were analyzed[6].

In addition to the analysis of the level of mercury in the umbilical cord blood and in samples of hair of these children at birth (2000 and 2001), additional analyses of the levels of mercury in these 93 children's hair were conducted by the Evandro Chagas Institute in the years of 2004, 2006 and 2010. These analyses showed that the exposure to mercury was low, respectively 1.01 µg/g (95%CI: 0.84 to 1.19); 1.18 µg/g (95%CI: 0.78 to 1.58) and 1.18 µg/g (95%CI: 0.98 to 1.40). These data show that significant exposure occurred in the prenatal period, where the average level of mercury was above 10 µg/g, with amplitude close to 60 µg/g.

In order to compare prenatal exposure to mercury and auditory thresholds, the children were divided into two groups, according to the levels of mercury: the study group (SG) was

composed of 57 children whose umbilical cord blood levels of Hg were equal to or higher than 8.0 µg/L; the comparison group (CG) corresponded to 33 children whose Hg levels in umbilical cord blood were lower than 8.0 µg/L. This limit was based on literature findings, mainly on the publication by the World Health Organization[11].

Firstly, the caregivers answered a questionnaire composed of structured, semi-structured and open questions regarding the development of their children's speech, hearing and language, difficulties in learning how to read and write, academic performance and behavioral characteristics, as well as social demographic data and specific questions about eating habits and exposure to mercury, which aimed to characterize the groups and investigate possible confusion variables.

Afterwards, an inspection of the external auditory meatus was conducted in order to verify the absence of cerumen or other elements that would interfere in the auditory assessment. The children with abnormal findings were excluded from the sample and referred to the city health service.

The equipment used in the investigation of auditory thresholds was an audiometer by Interacoustic®, type AC 33, with TDH – 39 headphones and MX-41 pad. The examinations were conducted in a Vibrason® acoustic cabin.

In order to determine the minimum hearing threshold, a basic auditory assessment using pure tone air conduction audiometry was performed in the frequencies of 1 kHz, 2 kHz, 3 kHz, 4 kHz, 6 kHz, 8 kHz, 250 Hz and 500 Hz, tested in this order[12], and where thresholds up to 25dBHL were considered normal[13]. Then, in order to confirm the tonal thresholds, the Speech Reception Threshold (SRT) was assessed. Even though there are several tests that assess the auditory system, audiometry is still one of the main methods used for evaluation of the peripheral auditory system.

The Statistical Package for the Social Sciences (SPSS) software, version 14 was used to perform the statistical analysis. Descriptive statistics was used to characterize the samples' profile according to the different study variables. The non-parametric Mann-Whitney test was used to compare the means of the audiometry in the frequencies of 500 Hz, 1 kHz and 2 kHz and each frequency individually, of left and right ears and in between study group and comparison group. The adopted level of significance was 5%.

RESULTS

In the study group, the median value of mercury level in the umbilical cord blood was 14.63 µg/L (Q1=10.51; Q3=25.75) and the median auditory threshold of frequencies 500 Hz, 1 kHz and 2 kHz in pure ton audiometry was 10 dB in both ears.

In the comparison group, the median value of mercury level in the umbilical cord blood was 4.88 µg/L (Q1=3.42; Q3=6.83), and the median auditory threshold for frequencies 500 Hz, 1 kHz and 2 kHz in pure tone audiometry was 10 dB in both ears (Table 1).

When the auditory thresholds in frequencies 500 Hz, 1 kHz and 2 kHz were compared between the groups, there were no differences, according to the Mann-Whitney test (Table 1). There were also no differences in between the groups when each frequency was compared individually.

DISCUSSION

The evidences of the adverse effects of methylmercury are clear when observing the disasters in Japan and Iraq, since a cause/effect relationship was clearly established in both episodes. The follow-up of contaminated mothers showed that, even in the cases without clinical signs, these women had children with several disabilities. This fact shows that the fetus' brain is susceptible to the adverse effects of methylmercury in lower levels than those that would produce detectable effects in children or in adults[14].

Several studies highlight the relevance of prenatal exposure to methylmercury, since, once in the human organism, it easily crosses the placental barrier, and concentrates mainly on the brain, potentially inhibiting the fetus' brain development. Therefore, women in reproductive age are a risk group for methylmercury contamination[1,2,9,15,16].

In spite of the general agreement on the risk that prenatal exposure to mercury represents to the health of children, safe limits of exposure are still controversial. Important studies in this field use the reference value suggested by the World Health Organization[11], which was therefore used as a cut-off point to characterize the groups as study and comparison groups.

Nowadays, there is a tendency towards a reduction of the exposure to methylmercury through fish consumption, especially in pregnant women[15]. Studies on the effects of exposure to low and medium levels of mercury are controversial, which highlights the need for continued follow-ups, especially of women in reproductive age and of children.

In this group of adverse effects of exposure to methylmercury, hearing impairment is present in a relevant part of the documented cases. However, few studies were found in literature where pure-tone audiometry was used as a tool to evaluate children exposed to methylmercury.

An important study[10] was conducted in a cohort with 878 children exposed to low levels of methylmercury, followed from birth to 14 years of age. Mercury concentration was determined by the umbilical cord, and hair from the mothers and the children. Pure-tone audiometry and brainstem evoked auditory potentials were investigated in these children, in ages 7 and 14. The auditory thresholds observed in audiometry were within normal standards and there were abnormal findings in the brainstem evoked auditory potential.

These findings are similar to those in the present study, since all subjects in this study had auditory thresholds within normal standards in the frequencies of 250 Hz to 8 kHz. There were also no differences observed between the auditory thresholds of both groups. Similar results were observed[17] in a study that evaluated adolescents exposed to metallic mercury, showing a better tendency in auditory performance, but no significant difference. In this same study there were abnormal findings in some of the tests that evaluate auditory processing abilities, suggesting the neurotoxic effect of mercury. The same result was observed in individuals exposed to solvents[18].

Table 1. Description of pure-tone thresholds, in dB, for groups SG and CG

Variables	Group	n	Mean	Minimum	Maximum	1st Q	Median	3rd Q	p-value
Mean RE (500 Hz, 1, 2 kHz)	SG	57	10.96	3	18	8.00	10.00	13.00	0.784
	CG	33	10.91	3	15	10.00	10.00	13.00	
Mean LE (500 Hz, 1, 2 kHz)	SG	57	10.25	2	17	8.00	10.00	13.00	0.855
	CG	33	10.55	3	17	9.00	10.00	12.00	
RE 250 Hz	SG	57	15.26	10	20	15.00	15.00	15.00	0.626
	CG	33	14.70	10	20	15.00	15.00	15.00	
LE 250 Hz	SG	57	13.68	5	20	10.00	15.00	15.00	0.476
	CG	33	14.09	5	20	12.50	15.00	15.00	
RE 500 Hz	SG	57	12.98	5	20	10.00	10.00	15.00	0.754
	CG	33	12.88	5	15	10.00	15.00	15.00	
LE 500 Hz	SG	57	11.93	5	20	10.00	10.00	15.00	0.390
	CG	33	12.58	5	20	10.00	15.00	15.00	
RE 1 kHz	SG	57	10.44	0	20	10.00	10.00	12.50	0.712
	CG	33	10.61	0	15	10.00	10.00	12.50	
LE 1 kHz	SG	57	10.09	0	20	10.00	10.00	15.00	0.934
	CG	33	10.00	0	15	10.00	10.00	10.00	
RE 2 kHz	SG	57	9.65	0	20	5.00	10.00	10.00	0.732
	CG	33	9.39	5	15	5.00	10.00	12.50	
LE 2 kHz	SG	57	8.95	0	15	5.00	10.00	10.00	0.801
	CG	33	8.79	0	15	5.00	10.00	10.00	
RE 3 kHz	SG	57	8.46	0	20	5.00	10.00	10.00	0.390
	CG	33	9.24	0	15	5.00	10.00	12.50	
LE 3 kHz	SG	57	8.25	0	15	5.00	10.00	10.00	0.936
	CG	33	8.18	0	15	5.00	10.00	10.00	
RE 4 kHz	SG	57	7.81	0	15	5.00	5.00	10.00	0.364
	CG	33	8.64	0	15	5.00	10.00	10.00	
LE 4 kHz	SG	57	7.37	0	15	5.00	5.00	10.00	0.381
	CG	33	8.18	0	20	5.00	10.00	10.00	
RE 6 kHz	SG	57	9.12	0	20	5.00	10.00	12.50	0.965
	CG	33	8.94	0	15	5.00	10.00	10.00	
LE 6 kHz	SG	57	9.56	0	20	5.00	10.00	10.00	0.622
	CG	33	9.09	0	20	5.00	10.00	10.00	
RE 8 kHz	SG	57	9.12	0	20	5.00	10.00	10.00	0.880
	CG	33	9.09	0	15	5.00	10.00	10.00	
LE 8 kHz	SG	57	9.91	5	20	5.00	10.00	15.00	0.865
	CG	33	10.15	0	20	5.00	10.00	15.00	

Mann-Whitney test ($p<0.05$)

Note: SG = study group; CG = comparison group; Q = quartile; RE = right ear; LE = left ear

Another study[19], about exposure to mercury and the auditory system of children and adults in Ecuador, observed the auditory examinations of 40 individuals (21 children and 19 adults), and found auditory thresholds varying from normal to mildly abnormal in 2, 3, 4, 6 and 8 kHz in children. The correlation coefficient showed a significant relationship between mercury level and hearing level in children only in 3 kHz, in the right ear.

Based on the results of the present study, the groups divided according to the levels of exposure to mercury did not show abnormal hearing thresholds and, when compared amongst themselves, there were no differences (Table 1). It is possible that the levels of exposure were not high enough to cause impact on hearing thresholds. However, knowing that the main adverse effect of mercury occurs in the central nervous system, it is extremely important that studies be conducted in order to evaluate the central auditory system as well.

CONCLUSION

The children had hearing thresholds within normal standards and there was no difference between the auditory thresholds of children who were and who were not exposed to methylmercury in the prenatal period.

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