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Arsenic related hearing loss in miners☆

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ABSTRACT

Purpose: Arsenic is a toxic metalloid that carries number of potential risks to human health, although there is little evidence of the ototoxic effect of arsenic. The aim of this study was to identify the relationship between arsenic exposure and hearing loss by measuring blood arsenic concentrations and hearing among miners.

Materials and methods: This research is a retrospective case control study. Included in the study were miners employed in a single silver mine whose blood arsenic concentrations were high. A comparison was made on the pure tone audiometry measurements taken from miners exposed only to arsenic (Group 1), those exposed to both arsenic and noise (Group 2) and a control group exposed to neither arsenic nor noise (Group 3).

Results: It was found that for both ears at all frequencies, the hearing level of Group 3 was better than the hearing levels of both Group 1 and Group 2. There was no correlation between the blood arsenic levels and hearing levels in both ears.

Conclusion: This study has revealed the ototoxic effects of arsenic. As blood arsenic concentrations do not reflect long-term exposure, no correlation was identified between blood arsenic concentrations and hearing levels. Further studies will be needed to clarify the mechanisms involved in the effect of arsenic on hearing. This paper represents the largest study to date focusing on the isolated effects of arsenic on hearing through the use of a clinical auditory test.

1. Introduction

Arsenic is a toxic metalloid that is found in soil, water, air and rocks, with inorganic arsenic compounds being the most prevalent and toxic. Arsenic leaches from rock formations into water sources, and arsenic pollution of the groundwater is a common problem around the world. Exposure to arsenic occurs via oral, respiratory or dermal routes, and is an

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important issue in public health. The toxicity of arsenic poses a number of potential risks to human health, and there have been numerous studies reporting various health effects of arsenic toxicity, including carcinogenicity, neurotoxicity, diabetes, hematologic disorders, gastrointestinal disorders, cardiovascular disorders and pregnancy complications [1–10].

Although in most of the cases exposure to arsenic occurs via the groundwater, occupational exposure is also common. The US Environmental Protection Agency (EPA) determined the permitted concentration of arsenic in water as 10 μg/L (10 ppb) [11].

In Turkey, the Simav Plain is one of the regions in which concentrations of arsenic are high, being situated in an area with active tectonics. In a study of the area, it was found that the average total arsenic concentrations in samples collected from local groundwater was 99 ppb, with a maximum of 561 ppb [12]. In another study in which soil samples were analyzed for total arsenic content, an average value of 49 ppm and a maximum of 833.9 ppm were found. Based on the knowledge that the world average value for arsenic content in soil is 1.5 ppm, the arsenic content of the soil in this region can be considered extremely high [13]. The region contains a silver mine, and so high levels of arsenic can be expected in miners.

Previous research has suggested that arsenic may be ototoxic in humans, although there is little evidence available charting the association between arsenic and hearing. Studies into the effect of arsenic exposure on hearing function are very limited, and so it is the aim of this study to clarify the relationship between arsenic exposure and hearing loss by measuring blood arsenic concentrations and hearing among the miners employed at the above-mentioned mine.

2. Materials and methods

2.1. *Study design*

This research is a retrospective case control study, and was approved by an ethics review board. The study cases were selected from among the workers treated at the Ankara Occupational Diseases Hospital during a routine occupational health examination between January 1, 2011 and December 30, 2013. The study groups were all miners employed in the same silver mine in the Simav region. Only miners whose blood arsenic concentrations were high among all heavy metals (lead, cadmium, mangan, aluminum, mercury, arsenic) were included in the study. All miners were examined by an otorhinolaryngology specialist, and those with chronic otitis media were excluded from the study. Miners who were exposed to noise higher than the permissible level [14] and in the presence of arsenic were evaluated separately as Group 2. As this was an open mine, none of the workers were exposed to barometric pressure changes. The control group (Group 3), who were exposed to neither ototoxic heavy metals, solvents nor noise, was made up of workers who applied to the center for routine occupational health examinations. The subjects in the control group were not miners and did not work in the mine or in the vicinity, but rather worked as secretaries, office workers, cooks and meal servers. In this regard, the control group was not exposed to noise, heavy metals, solvents, dust or changes in barometric pressure. The only arsenic exposed group (Group 1) consisted of 234 miners, the arsenic and noise exposed group (Group 2) consisted of 20 miners and the control group (Group 3) consisted of 119 workers. All of the subjects in both the study and control groups were male.

2.2. *Data collection*

Personal data, such as smoking habits, detailed history of current and previous occupational jobs, history of chronic drug intake, and any previous ear operations, pus discharge or hearing problems, was obtained from the periodic inspection files. Subjects with a history of chronic illness, such as diabetes mellitus or hypertension, were excluded from the study. The age, number of years working and body mass index (BMI) of the participants were recorded. The elapsed time from the beginning of work until the time of examination was accepted as the duration of arsenic exposure for the miners.

2.3. *Audiometric examination*

All of the subjects were examined by two otolaryngologists, after which a pure tone audiometry was administered using a pure tone manual diagnostic audiometer (Model GSI 61, Grason-Stadler, Inc.) by a single audiologist at the Audiology Laboratory of Ankara Occupational Disease Hospital. The subjects were tested in a sound-isolated chamber, and pure tone audiometries were conducted with the subjects at frequencies of 0.5, 1, 2, 3, 4, and 6 kHz using both air and bone conduction. The subjects were asked to discriminate between low sound levels of different frequency pure tones, and responded by pressing a button. The lowest tone heard at each frequency was considered as the hearing threshold level.

2.4. *Blood test*

Blood arsenic levels of the subjects were measured during a periodic examination day at our institute. The arsenic content of the blood samples was determined using the procedure described earlier [15].

2.5. *Statistical analysis*

Non-parametric statistics were used, as the blood arsenic and hearing levels were found to have abnormal distributions. A Kruskal–Wallis test was used to compare the hearing levels and age among the groups, and a Mann–Whitney U test was carried out to determine the difference between intergroups with a Bonferroni correction. For comparison of the two groups in terms of exposure time and blood arsenic concentration, a Mann–Whitney U test was used, while a chi-square test was applied to determine the difference between groups in terms of smoking. The relationship between blood arsenic levels and hearing levels was determined with an age-adjusted multivariate linear regression analysis. Furthermore, a Spearman correlation test was used to investigate whether a correlation existed between blood arsenic concentrations and hearing levels and exposure time and BMI. A $p < 0.05$ was considered statistically significant. All of the